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NAS WILLOW GROVE
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REMEDIAL INVESTIGATION REPORT
FOR
Site 5 – FIRE TRAINING AREA
NASJRB WILLOW GROVE,
PENNSYLVANIA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION - NAVY (CLEAN) CONTRACT

Submitted to:
Engineering Field Activity Northeast
Environmental Branch, Code 18
Naval Facilities Engineering Command
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EXECUTIVE SUMMARY

Tetra Tech NUS, Inc. (TtNUS) has prepared this Remedial Investigation Summary Report for the Naval Air Station Joint Reserve Base (NASJRB) Willow Grove under Contract N62472-90-D-1298, Comprehensive Long-Term Environmental Action Navy (CLEAN). This work is part of the Navy's Installation Restoration Program (IRP), which is designed to identify and characterize contamination of Navy and Marine Corps facilities resulting from past operations and to institute corrective measures as appropriate.

IRP activities are typically performed in four distinct phases. The first phase consists of a preliminary assessment (PA), and the second phase consists of a site inspection (SI). The third phase is a remedial investigation/feasibility study (RI/FS), which is intended to characterize the physical and chemical parameters and risks associated with the facility. The fourth phase, if required, may include remedial action that is designed to control and mitigate contamination.

The following summary provides conclusions and recommendations resulting from the Navy's investigation of conditions at the NASJRB Willow Grove Site 5 environmental study site. Background historical and environmental setting information and a discussion of the process used to arrive at these conclusions and recommendations begin on page ES-2.

PURPOSE AND OBJECTIVES

The purpose of this report is to present the methods and results of the Phase II RI activities and subsequent investigations conducted at NASJRB Willow Grove Site 5. IRP Site 5 was previously investigated as part of the PA, SI, and RI processes. Initial Phase II RI field activities were conducted from March through July 1997 in accordance with the Phase II RI Work Plan submitted by TtNUS in May 1997. The draft Phase II Report was submitted for review in April 1998. Informal comments from the United States Environmental Protection Agency (EPA) were addressed through a series of additional investigations conducted from 1998 through 2000. Final field activities were conducted at Site 5 from June 2000 through October 2000 in accordance with the Work Plan Addendum for Site Investigation at Site 5, submitted by TtNUS in May 2000. This report combines the results from the draft Phase II report and previous findings for Site 5 with the results of the activities performed from April 1998 through October 2000.

The RI objective was to characterize the nature and extent of contaminants at Site 5 and gain additional understanding of the physical parameters affecting contaminant fate and transport. The results presented in the final RI report summarize RI activities and provide the necessary data to evaluate human health risk and

ecological risk screening against current benchmark values and move into the feasibility study and/or remedial action phases of the RI program.

SITE LOCATION AND DESCRIPTION

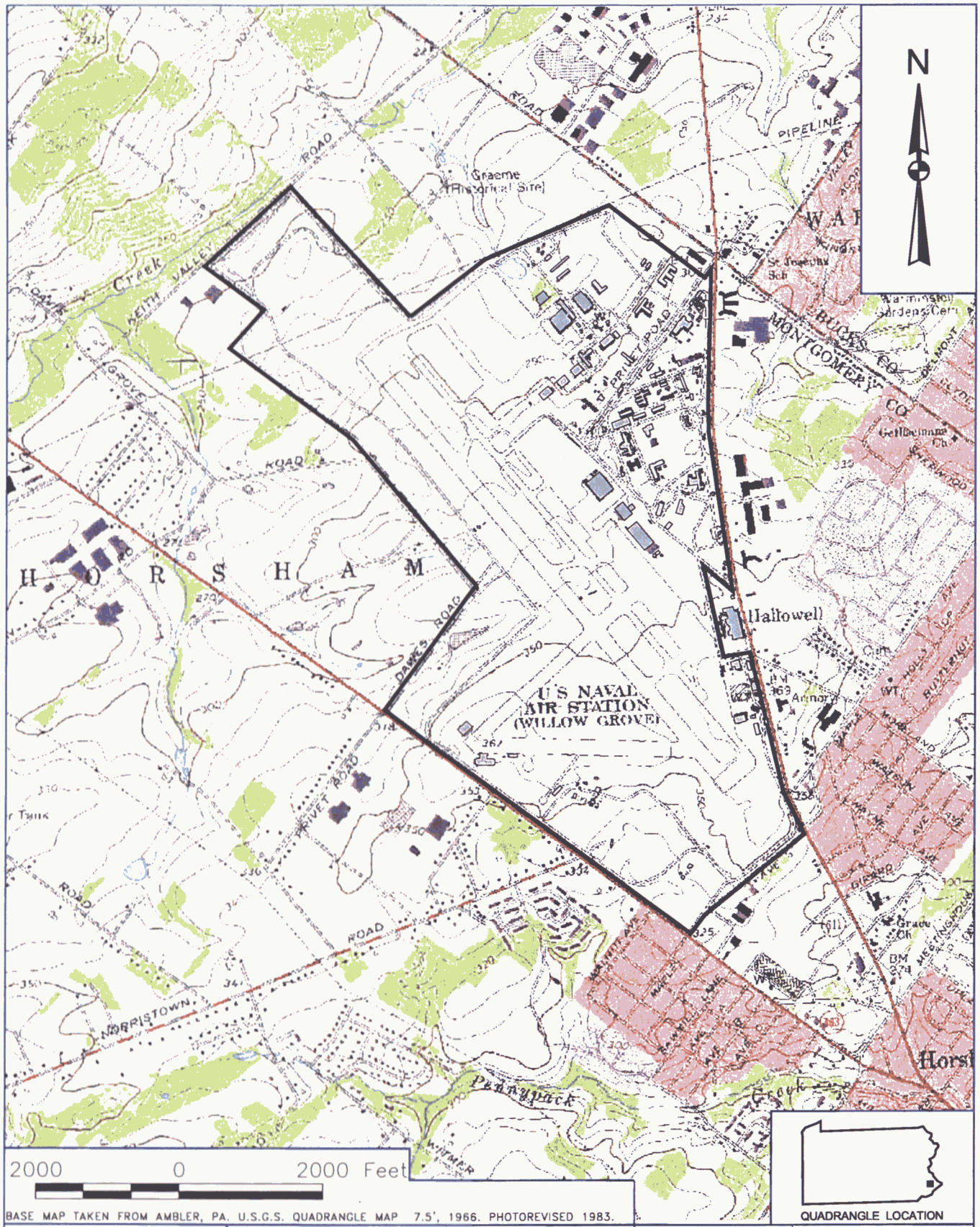
Naval Air Station Joint Reserve Base, Willow Grove, Pennsylvania (formerly NAS, Willow Grove) is located in Horsham Township, Montgomery County in southeastern Pennsylvania, approximately 15 miles north of the city of Philadelphia (Figure ES-1). The base occupies approximately 1,000 acres of flat to slightly rolling terrain and is generally bounded by State Route 611 to the east, State Route 463 to the southwest, and Keith Valley Road to the north.

The primary mission of NASJRB Willow Grove is to provide support for operations involving aviation activities and to train Navy reservists. NASJRB Willow Grove supports other tenants such as the Marines, the Air Force, and the Army. The base provides facilities, services, materials, and training in direct support of all assigned units. These units include antisubmarine warfare squadrons, a helicopter squadron, a fleet logistic support squadron, and other Navy and Marine units. The Willow Grove Air Reserve Station (ARS) occupies approximately 162 acres of land in the northeastern section of the NASJRB and shares common facilities with the NASJRB.

The four sites included within the scope of the IRP are two landfill areas [Antenna Field Landfill (Site 2) and Ninth Street Landfill (Site 3)], a waste transfer station [Privet Road Compound Site (Site 1)], and a former fire protection training area [Fire Training Area (Site 5)]. The relative locations of the sites are shown on Figure ES-2. Activities potentially resulting in site contamination occurred at different time periods between 1942 (the first Fire Training Area exercises) and 1975 (last use).

SITE 5 - THE FIRE TRAINING AREA

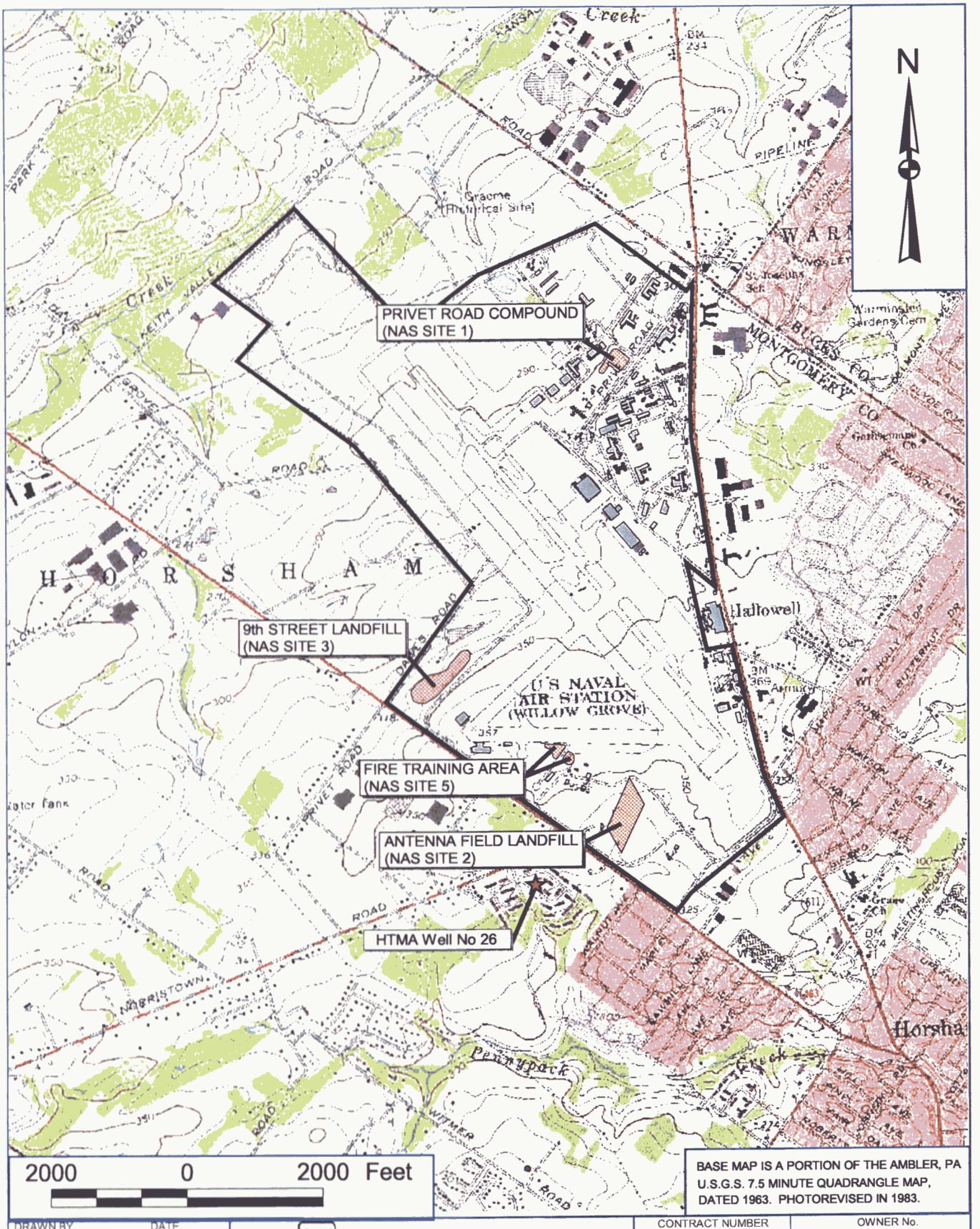
The Fire Training Area is located in the south-central portion of the Naval Air Station, approximately midway between Runway 10/28 and State Route 463. The site is located south of Taxiway Juliet and covers an irregularly shaped area of approximately 1.25 acres. The training area was used from 1942 to 1975 for large-scale fire fighting exercises, which included the disposal and burning of flammable liquid wastes generated by the Naval Air Station. Wastes including solvents, paint chemicals, xylenes, toluene, and various petroleum compounds were consumed at the rate of at least 4,000 gallons per year in these fire fighting exercises (EA, May 1990). The area was also reportedly used for drum storage of these flammable materials during the periods between burning exercises.



BASE MAP TAKEN FROM AMBLER, PA. U.S.G.S. QUADRANGLE MAP 7.5', 1966. PHOTOREVISED 1983.

QUADRANGLE LOCATION

DRAWN BY LDL	DATE 1/18/02	Tetra Tech NUS, Inc.	CONTRACT NUMBER 5466 / OWNER No. 2207 (ES SITE 5)
CHECKED BY RET	DATE	LOCATION MAP NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	DWG INFORMATION: LAYOUT: FIG ES-1 SITE 5 NASJRB_WillowGrove.apr LDL 8/14/01
COST/SCHEDULE-AREA			APPROVED BY RET / DATE
SCALE AS NOTED			DRAWING No. FIGURE ES-1 / REV



BASE MAP IS A PORTION OF THE AMBLER, PA U.S.G.S. 7.5 MINUTE QUADRANGLE MAP, DATED 1963. PHOTOREVISED IN 1983.

DRAWN BY LDL	DATE 1/18/02	Tetra Tech NUS, Inc.	CONTRACT NUMBER 5466 / OWNER No. 2207 (ES SITE 5)
CHECKED BY RET	DATE	LOCATION OF RI SITES SITE 5 - FIRE TRAINING AREA NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	DWG INFORMATION: LAYOUT: FIG ES-2 SITE 5 NASJRB_WillowGrove.apr LDL 8/14/01
COST/SCHEDULE-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING No. FIGURE ES-2 / REV

The Fire Training Area is primarily covered by grasses, with some woody and brushy vegetation present within the southern portion of the area. The burn area is located in the south-central portion of the site. Two small ponds are immediately south of the former burning area.

Topography and Surface Water Hydrology

The ground surface in the vicinity of the Fire Training Area slopes toward the south at a grade of approximately two percent. Runoff during normal precipitation events should be minimized by the relatively gentle slope and the abundant vegetation, which serves to decrease runoff velocity and increase infiltration. Two small ponds are located within 100 feet of the site in the downslope direction. The two small ponds do not always contain water and tend to dry out.

Based on the local topography, any runoff from the site area may be expected to flow off base through a small intermittent drainage that crosses the base boundary approximately 2,000 feet south of the Fire Training Area. This drainage, which also carries runoff from the Antenna Field Landfill, flows into Pennypack Creek approximately 3,000 feet from the base property line.

Groundwater Flow Patterns

The sandstones, shales, and conglomerates of the Triassic Basin are relatively good water-bearing formations. They generally yield abundant supplies to wells (Hall, 1934). The groundwater ranges from soft to hard, and the average hardness is greater than that of most other formations in southeastern Pennsylvania.

The major source of groundwater in the vicinity of NASJRB Willow Grove is the fractured bedrock of the Stockton Formation (Earth Data Incorporated, 1985). These rocks form a multi-aquifer system of relatively discrete water-bearing zones separated by less permeable zones. Transmissivity and groundwater movement within water-bearing zones are greater parallel to bedding than across bedding. Groundwater can generally be found between 5 and 25 feet below ground surface (bgs).

The former fire training area is situated atop a southwest-northeast-trending ridge that is the highest topographic feature within the region. This ridge serves as a divide for the regional surface water bodies (watershed divide); surface water to the north of the divide flows toward the Little Neshaminy Creek, and surface water to the south of the divide flows toward the Pennypack Creek. A USGS interpretation of a regional groundwater study indicates that the regional groundwater divide trends southwest-to-northeast in the vicinity of Site 5 and passes directly beneath the Fire Training Area.

Soils

Soils observed at the NASJRB Willow Grove during current and previous RI fieldwork ranged from 4 feet to more than 15 feet in thickness. Generally, the soils included brown, yellowish-brown, reddish-brown, and orange mixtures of silt, clay, and sand with finer-grained materials dominant.

The Soil Survey of Montgomery County (United States Department of Agriculture, 1967) indicates that five major soil series are mapped within the boundaries of the four RI sites. The soil series include the Lansdale, Lawrenceville, Chalfont, and Readington silt loams and the Lansdale loam. Minor areas of other soil series, composed chiefly of silt loam materials, are developed in small, low-lying areas. In general, these soils have a moderate to slow permeability that encourages rapid runoff during normal precipitation events.

Most of the soil within the boundaries of the air station has been disturbed. In addition, large areas have been filled with shale and sandstone mixed earth materials. These soils, known as made land, vary widely in depth and drainage potential.

Geology

The geologic interpretation of the Fire Training Area is based on the subsurface data (boring logs and geophysical logs) obtained during site investigations. These data indicate that the local geology beneath this site is generally consistent with the regional geology.

NASJRB Willow Grove is located within the Triassic Basin of southeastern Pennsylvania. The bedrock underlying the NASJRB consists of the middle arkose member of the Late Triassic age Stockton Formation. The Stockton Formation locally is about 5,000 feet thick and is unconformably underlain by Ordovician to PreCambrian age basement rocks. Current and previous environmental investigations indicate that the top of bedrock at the air station is generally found in the range of 5 feet to 25 feet bgs.

The numerous soil borings encountered a variably thick overburden section underlain by weathered siltstone and sandstone. The overburden generally consisted of silty clay and clay, with minor amounts of silty sand. The thickness of the overburden (or the depth to the top of the weathered bedrock) ranged from 9 to 18 feet.

The maximum depth of the monitoring well boreholes at Site 5 is 261 feet (the monitoring wells generally are shallower than the total depth of the borehole because the boreholes typically were backfilled in order to screen the most significant water-bearing zone, which was not necessarily at the bottom of the borehole).

The bedrock to this depth typically consisted of alternating sequences of siltstone and sandstone. Thin but laterally consistent beds of mudstone and claystone were encountered within the lower portions of the penetrated section. In general, the bedrock beneath this site was characterized by its predominantly coarse-grained lithology.

Meteorology

NASJRB Willow Grove is located about 70 miles west of the Atlantic Ocean, which tends to have a moderating effect on temperatures. Normal minimum and maximum daily temperatures range from 24°F in February to 86°F in July. The average annual rainfall is 44.5 inches. The average annual snowfall is 21.5 inches. Precipitation is fairly evenly distributed throughout the year, with an increase in rainfall during the summer months. Average annual and extreme frost penetrations are 20 inches and 30 inches, respectively.

Mean annual relative humidity ranges from 54 percent in the early afternoon to 78 percent before dawn. The mean annual Class A Pan Evaporation is about 42 inches per year. The prevailing wind direction at the base is southwesterly during the summer and northwesterly during the winter. The mean annual wind speed and direction are approximately 9 miles per hour from the west-northwest.

Ecology

The natural environment at NASJRB Willow Grove has been altered by development ever since the facility was first commissioned in 1942 as an airport. Buildings and paved roadways are concentrated mainly in the eastern portion of the facility. Due to the development on the base, the land has not retained a natural vegetation cover. The vegetative communities that remain are limited and generally include lawn areas maintained by activity personnel, old field, immature forest, and wetland.

Except for old field scrub/shrub, maintained grassy field is probably the most common vegetative cover at the base. Most of this habitat is located west of the runways. Wooded areas occur mainly along the western boundary of the activity and serve as a buffer between the Activity and residences along Route 643 and the neighboring golf course/commercial complex. Wetland habitat is rare within the base area. According to the National Wetlands Inventory map of this area (United States Department of Interior, undated), five wetlands exist on the base. Two small ponds near the southeastern corner of the base are classified as palustrine, open water, intermittently exposed, excavated wetlands. Two small (man-made) ponds (approximately 80 feet long by 20 feet wide) are present at the central area of Site 5 (Fire Training Area). These small ponds are not mapped as wetlands but have become established with marsh grasses and sedges.

COMPARISON TO BACKGROUND

Compounds of potential concern (COPC) selection is based on a series of statistical tests and comparison to background samples. Background samples were collected in and around NASJRB Willow Grove from media similar in characteristics to on-site samples but from areas outside the known or suspected areas of influence of the sites. Site sampling data were compared to background to determine if contaminants are elevated at a site.

COMPARISON TO ARARs and TBCs

All data were evaluated by comparison to applicable or relevant and appropriate requirements (ARARs) or criteria to be considered (TBCs). The following ARARs and TBCs were used in this evaluation:

- Surface and subsurface soils:
  - Risk-based concentration (RBC) for residential soil ingestion
  - RBC for industrial soil ingestion
  - Pennsylvania Department of Environmental Protection (PADEP) soil residential direct contact Medium Specific Concentration (MSC)
  - PADEP soil non-residential MSC

- Surface water:
  - Ambient Water Quality Criterion (AWQC) freshwater aquatic life
  - AWQC ingestion of water and fish
  - PADEP Water Quality Criteria (WQC); continuous concentrations
  - PADEP WQC; human health criteria

- Sediment
  - Sediment ecological toxicity threshold values

- Groundwater
  - Maximum Contaminant Level (MCL)
  - Drinking water health advisory
  - PADEP groundwater MSC
  - RBC for tap water consumption

HUMAN HEALTH RISK ASSESSMENT

The human health risk assessment was performed to estimate the actual or potential risks to human health resulting from the presence of contamination in surface soil, subsurface soil, sediment, groundwater, and surface water and to provide the basis for determining the need for remedial measures.

Three major aspects of chemical contamination must be considered when assessing public health risks: contaminants with toxic characteristics must be found in environmental media and must be released by either natural processes or by human action; potential exposure points must exist either at the source or via migration pathways if exposure occurs at a remote location other than the source; and human or environmental receptors must be present at the point of exposure. Risk is a function of both toxicity and exposure; without any one of the three factors listed above, there is no risk.

The risk assessment estimated the potential for human health risk attributable to each NASJRB Willow Grove site. The risk assessment process used at NASJRB Willow Grove was in accordance with current EPA risk assessment guidance and was performed according to methods established in the NASJRB Willow Grove Work RI Work Plan (1997), which was reviewed and approved by EPA Region III and the PADEP.

Potential Receptors

The receptors chosen for the sites at NASJRB Willow Grove are presented in this section. All of the receptors listed below are applicable to every site because all selected media were sampled at each site. A full discussion of the assumptions and procedures used in human health risk assessment can be found in Section 3.1 of this report.

The current exposure scenarios applied are as follows:

- Occupational Worker - The full-time on-site worker is an adult who works at NASJRB Willow Grove year round. This receptor is potentially exposed to COPCs in surface soil via ingestion, dermal contact, and inhalation.
- Adolescent and Adult Trespasser - A trespasser is an adult or adolescent who trespasses at NASJRB Willow Grove. These receptors are potentially exposed to COPCs in surface soil via ingestion, dermal contact, and inhalation and to COPCs in surface water via ingestion and dermal contact. Cancer and non-cancer risks were estimated separately

for adolescent and adult trespassers.

Future exposure scenarios are as follows:

- Future Excavation Worker - A future excavation worker is an adult who is assumed to work at NASJRB Willow Grove in the future during any type of excavation activity. This receptor is potentially exposed to COPCs in surface and subsurface soil via ingestion, dermal contact, and inhalation. Additionally, this receptor is potentially exposed to VOCs in shallow groundwater via inhalation.

- Future Resident - A future resident is a person who will live in a residence at or near NASJRB Willow Grove in a hypothetical future scenario. This receptor resides at a residence as a child (from age 0 to 6 years) and as an adult (for 24 years exposure duration). This receptor is potentially exposed to COPCs in groundwater via ingestion, dermal contact, and inhalation (adult resident only) and to COPCs in surface soil via ingestion, dermal contact, and inhalation. Non-cancer risks will be estimated separately for child and adult; cancer risks are considered cumulative (risks are summed over child and adult periods of exposure). Potential exposure to subsurface soils following real estate development will be discussed qualitatively.

- Future Child Recreational Receptor - A future recreational receptor is a child who participates in recreational activities at NASJRB Willow Grove in a hypothetical future scenario. This receptor is potentially exposed to surface soil via ingestion, dermal contact, and inhalation and to surface water and sediment via ingestion and dermal contact.

Exposure Routes by Medium

There are five environmental media at NASJRB Willow Grove through which potential receptors (see previous section) can be either directly or indirectly exposed to site-related COPCs: surface soil, subsurface soil, sediment, surface water, and groundwater. Potential exposure routes include ingestion, dermal contact, and inhalation.

ECOLOGICAL RISK ASSESSMENT

Ecological receptors at NASJRB Willow Grove may be at risk from contaminants associated with Site 5. Accordingly, an ecological risk assessment (ERA) was performed to characterize the potential risks from

site-related contaminants to ecological receptors that inhabit the installation. This section provides an outline of the approach that was taken to assess the impacts of site contamination on ecological receptors and the habitats that support these organisms. This assessment followed a two-step process, as follows:

Step 1: Preliminary Problem Formulation and Ecological Effects Evaluation

- Preliminary Problem Formulation - This first phase of an ERA discusses the goals, breadth, and focus of the assessment. It includes general descriptions of NASJRB Willow Grove sites, with emphasis on the habitats and ecological receptors present. This phase also involves characterization of site contaminants, contaminant sources, migration routes, and an evaluation of routes of contaminant exposure. Assessment and measurement endpoints that will be evaluated are also selected. Finally, a conceptual model is developed that describes how contaminants associated with Site 5 may come into contact with ecological receptors.

- Preliminary Ecological Effects Evaluation - In this component, medium-specific ecological benchmarks for each potential contaminant of concern (PCOC, i.e., concentrations of each contaminant above which adverse effects to ecological receptors may occur) are identified. This step is undertaken concurrently with the exposure assessment, described below.

Step 2: Preliminary Exposure Assessment and Risk Characterization

- Preliminary Exposure Estimate - This portion of the ERA includes identification of contaminant concentration data used to represent ecological exposure in various media and the selection of exposure point concentrations from the data.

- Preliminary Risk Calculation – In this step, exposure point concentrations are compared to screening levels in order to characterize potential risks to ecological receptors of concern. Analytes found to pose potential risk after these comparisons are selected as ecological COPCs.

When these two steps are completed, the results are interpreted and the uncertainties associated with the ERA are addressed. The process follows the ERA approach in EPA guidance (EPA, 1997), which was the basis for the ERA methodology. Furthermore, the ERA was conducted in accordance with EPA Region III BTAG ERA guidelines (EPA, 1994), other ERA guidance documents (EPA, 1992; Wentsel et al., 1996), and recent publications (Suter, 1993; Calabrese and Baldwin, 1993). Due to the potential complexity of ERAs,

they are often conducted using a tiered approach and punctuated with Scientific/Management Decision Points, which are meetings involving the risk assessors, risk managers, and client, to control costs, prevent unnecessary analyses, and ensure that the ERA is proceeding in an efficient, timely manner. Information analyzed in one tier is evaluated to determine whether the objectives of the study have been met and then may be used to identify the data required for the next tier, if necessary. This ERA can be considered a "screening-level" assessment, or "Tier 1" assessment, since it is based on only a conservative initial screening of contaminant concentrations against contaminant-specific benchmarks (EPA, 1994).

DISCUSSION OF RESULTS AT SITE 5 – FIRE TRAINING AREA

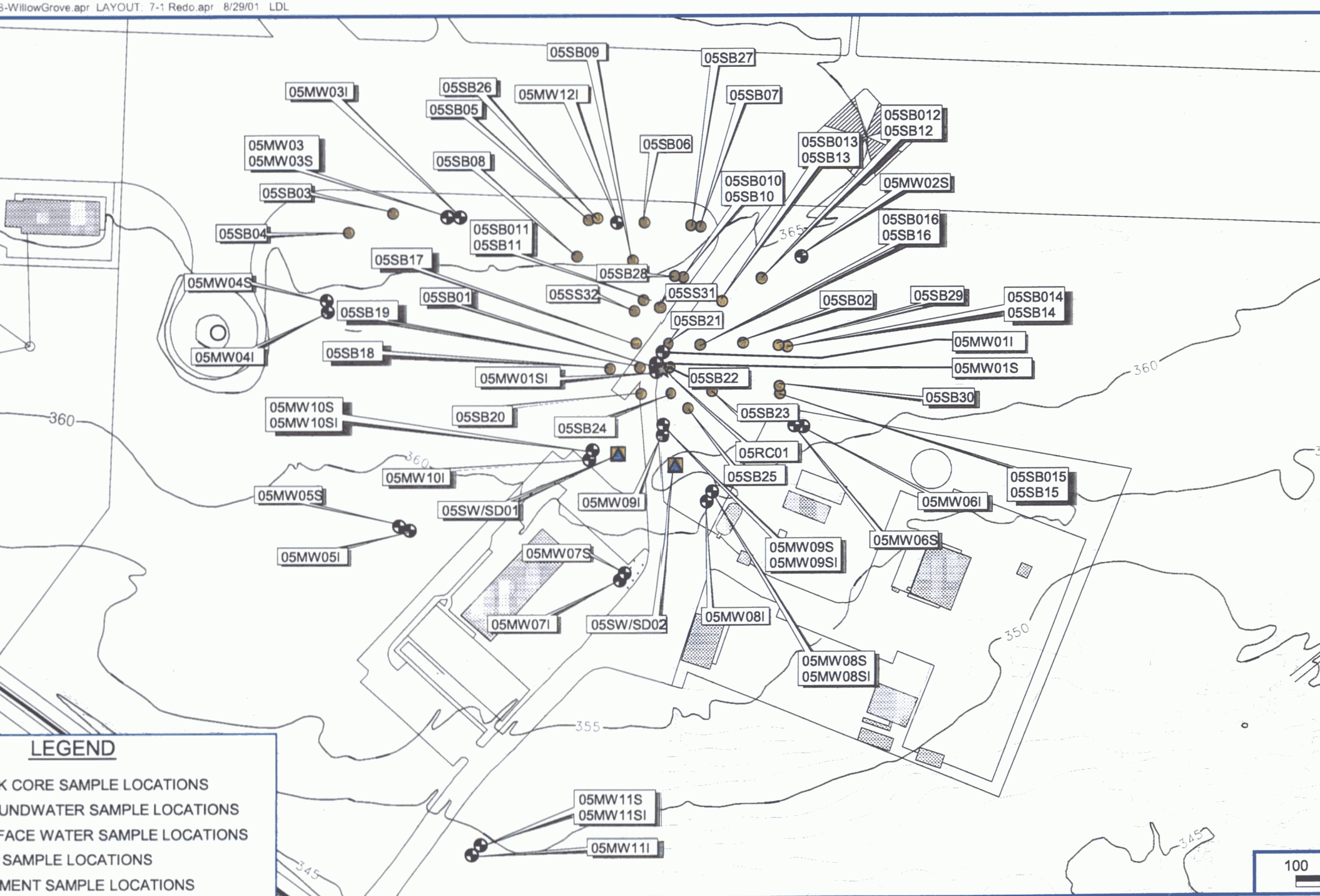
The principal contaminants associated with Site 5 are VOCs in groundwater, polycyclic aromatic hydrocarbons (PAHs) in soils and sediments, and PCBs in soils. Pesticides were detected in sediment samples but do not appear to be site related. Sample locations are presented in Figure ES-3.

Consistent with EPA guidelines, the "reasonable anticipated future land use" exposure scenario is Occupational Worker. Under the current occupational worker exposure scenario, the human health risk assessment estimated that carcinogenic risks are within the EPA's acceptable range for all media. Also, there is no estimated human health noncarcinogenic risk [Hazard Index (HI)] greater than 1 for this exposure scenario. The result of the human health risk assessment found that the site does not pose a threat to current or reasonably anticipated future human receptors. However, ecological risk screening concluded that risks from surface soils may be a concern, and other issues or guidelines in law must be considered, as discussed by medium below.

Soils

No further action is recommended.

> PAHs identified in soils (mostly in the area of the former burning ring, but also at other discrete areas) were deemed by earlier investigations to present potential exposure risk to ecological receptors such as small mammals or birds. However, significant regrading of the site surface for the installation of a runway area security fence system has since covered these potential hot spot areas with at least several inches of soil.



LEGEND

K CORE SAMPLE LOCATIONS
UNDWATER SAMPLE LOCATIONS
FACE WATER SAMPLE LOCATIONS
SAMPLE LOCATIONS
MENT SAMPLE LOCATIONS

REVISIONS	BY	CHKD	APP'D	REFERENCES

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SCALE AS NOTED	

Tetra Tech NUS, Inc.

SAMPLE LOCATION MAP
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT N 5466
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Sediments and Surface Water

No further action is recommended.

Potential ecological risk to aquatic or semi-aquatic receptors in or near the two (sometimes dry) ponds appears to be low. It does not appear that contaminants from the burn area have migrated to the ponds. Regrading the site area and covering the potential hot spot areas with soil has addressed the marginal risk to sediments and surface water by dealing with the source of PAHs, ensuring no future migration to surface water or sediment.

Groundwater

Based on data obtained to date, an FS is recommended to evaluate options for Site 5 groundwater.

Chlorinated VOC compounds were found in groundwater at concentrations above MCLs. A feasibility study is recommended to evaluate remedial alternatives for groundwater.

Conclusions

VOCs historically disposed at the site have impacted the groundwater. However, low levels of residual VOC soil contamination are not considered to be a continuing source of VOCs to groundwater.

PAHs appear to have transported via erosion and runoff of sediments of nearby surface waters. This transport mechanism is probably minimal at present due to the heavy vegetation and flat topography of the site. In addition, the few potential PAH hot spots in the area of the former burning ring have been regraded as part of the installation of a runway perimeter security fence and now are covered by at least several inches of clean soil. Continued PAH transport is considered to be unlikely.

PCB contamination does not appear to have migrated from the site.

Human Health Risk Assessment

The total cumulative carcinogenic risk for the current occupational worker is within EPA's acceptable risk range at Site 5 for the reasonable maximum exposure (RME) scenario. Noncarcinogenic HIs for the potential receptors at Site 5 are less than 1.0 under the current occupational worker exposure scenario. Dioxins and furans and carcinogenic PAHs are the main COPCs selected at Site 5. These contaminants

are consistent with past practices at Site 5, which was a fuel burning area (solvents, paint chemicals, xylenes, toluenes, and petroleum compounds). VOCs are the main COPCs in groundwater and these contaminants are also consistent with past practices of the site.

For the reasonable anticipated land use risk scenario, human health risk assessment indicates that exposure to groundwater would result in estimated risk levels within EPA's acceptable risk range. However, VOCs have been detected at levels above MCLs, which are federal concentration limits for drinking water.

Ecological Risk Assessment

Several inorganic and organic contaminants were present in Site 5 surface water, sediment, and surface soil samples at concentrations in exceedance of ecological screening levels and were therefore retained as PCOCs. Several other contaminants were retained as PCOCs since no screening levels were available. Most of these contaminants were eliminated as COCs in the risk management phase of the assessment for one or more reasons, including low frequency of detection, maximum concentrations comparable to or below background (primarily inorganics) or alternative screening levels, and spatial analysis of detections.

Potential risks to aquatic receptors that inhabit the two small ponds southwest of the burn pit appear to be low. Therefore, no COCs were selected for surface water and sediment in the ponds. It also does not appear that contaminants have migrated to the ponds from the burn pit area.

No inorganic COCs were selected for Site 5 surface soil, and organics, except for PAHs, do not appear to pose potential risks to terrestrial receptors on and near Site 5. However, concentrations of several PAHs in Site 5 surface soils were significantly elevated. Concentrations of PAHs in surface soil samples collected west of the access road that borders the burn area were only slightly elevated and that area may receive PAH inputs from the taxiway to the north. Conversely, concentrations of several PAHs in samples collected around the burn pit significantly exceeded screening levels for individual and total PAHs. Therefore, these PAHs are selected as COCs in Site 5 surface soils around the burn area, which is considered a hot spot of PAH contamination. Although terrestrial habitat in this area is marginal, it may attract ecological receptors such as small mammals and birds. Since the area of highest PAH contamination is relatively small and has been covered by soil during the construction of the runway perimeter security fence project, no significant adverse impact on potential ecological receptors is deemed probable.

1.0 INTRODUCTION

Tetra Tech NUS (Tt NUS), formerly Brown & Root Environmental, submits this remedial investigation (RI) report for Installation Restoration Program Site 5 at the Naval Air Station Joint Reserve Base (NASJRB) Willow Grove in response to Contract Task Order No. 277 under Contract N62472-90-D-1298, Comprehensive Long-Term Environmental Action Navy (CLEAN). This work is part of the Navy's Installation Restoration Program (IRP), which is designed to identify and characterize contamination of Navy and Marine Corps facilities resulting from past operations and to institute corrective measures as appropriate.

IRP activities are typically performed in four distinct phases. The first phase consists of a preliminary assessment (PA), and the second phase consists of a site inspection (SI). The third phase is a remedial investigation/feasibility study (RI/FS), which is intended to characterize the physical and chemical parameters and risks associated with the facility. The fourth phase consists of remedial action that is designed to control and mitigate contamination. This report was prepared under Phase 3 IRP activities (RI/FS). The first phase of RI activities were performed in 1991, and the final report was issued in February 1993.

In addition to meeting the objectives of the Navy's IRP, the purpose of the RI is to meet the requirements of CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act of 1980), as amended by SARA (Superfund Amendments and Reauthorization Act of 1986). The RI investigates the nature and extent of contamination associated with all hazardous substance releases at the facility that are not regulated and are not being investigated under the authority of the Clean Air Act, the Clean Water Act, the Resource Conservation and Recovery Act (RCRA), or other federal statutes.

1.1 PURPOSE AND OBJECTIVES

The purpose of this report is to present the methods and results of the Phase II RI activities and subsequent investigations conducted at NASJRB Willow Grove Site 5. IRP Site 5 has been previously investigated as part of the PA, SI, and RI processes. Initial Phase II RI field activities were conducted from March through July 1997 in accordance with the Phase II RI Work Plan submitted by Tt NUS in May 1997. The draft Phase II Report was submitted for review in April 1998. Informal comments from the Environmental Protection Agency (EPA) were addressed by a series of investigations from 1998 through the year 2000. Final field activities were conducted at Site 5 from June 2000 through October 2000 in accordance with the Work Plan Addendum for Site Investigation at Site 5 submitted by Tetra Tech NUS in May 2000. This report combines the results from the draft Phase II Report and previous findings for Site 5, with the results of activities performed from April 1998 through October 2000.

The RI objective was to characterize the nature and extent of contaminants at Site 5 and gain additional understanding of the physical parameters affecting contaminant fate and transport. The results presented in this Final RI report summarize RI activities and provide the necessary data to evaluate human health risk and ecological risk screening against current benchmark values and move into the feasibility study and/or remedial action phases of the RI program.

1.2 SITE LOCATION AND DESCRIPTION

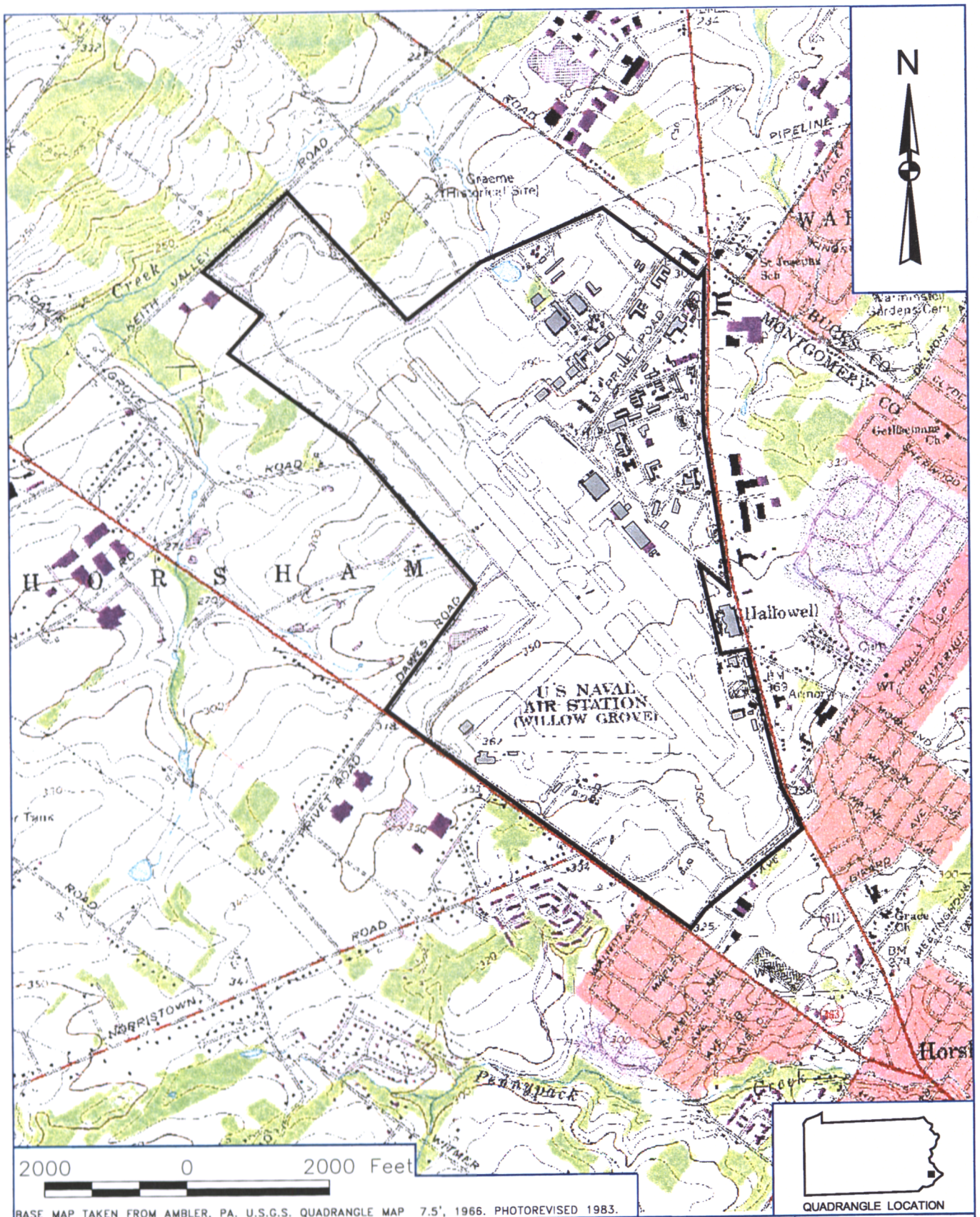
Naval Air Station Joint Reserve Base, Willow Grove, Pennsylvania (formerly NAS, Willow Grove) is located in Horsham Township, Montgomery County in southeastern Pennsylvania, approximately 15 miles north of the city of Philadelphia (Figure 1-1). The base occupies approximately 1,000 acres of flat to slightly rolling terrain and is generally bounded by State Route 611 to the east, State Route 463 to the southwest, and Keith Valley Road to the north.

The primary mission of NASJRB Willow Grove is to provide support for operations involving aviation activities and to train Navy reservists. NASJRB Willow Grove supports other tenants such as the Marines, the Air Force, and the Army. The base provides facilities, services, materials, and training in direct support of all assigned units. These units include antisubmarine warfare squadrons, a helicopter squadron, a fleet logistic support squadron, and other Navy and Marine units. The Willow Grove Air Reserve Station (ARS) occupies approximately 162 acres of land in the northeastern section of the NASJRB and shares common facilities with the NASJRB.

The four sites included within the scope of the IRP are two landfill areas [Antenna Field Landfill (Site 2) and Ninth Street Landfill (Site 3)], a waste transfer station [Privet Road Compound Site (Site 1)], and a former fire protection training area [Fire Training Area (Site 5)]. The relative locations of the sites are shown on Figure 1-2. Activities potentially resulting in site contamination occurred at different time periods between 1942 (the first Fire Training Area exercises) and 1975 (last use of Privet Road Compound). Descriptions of the former Fire Training Area - Site 5 are provided in Section 4.1.

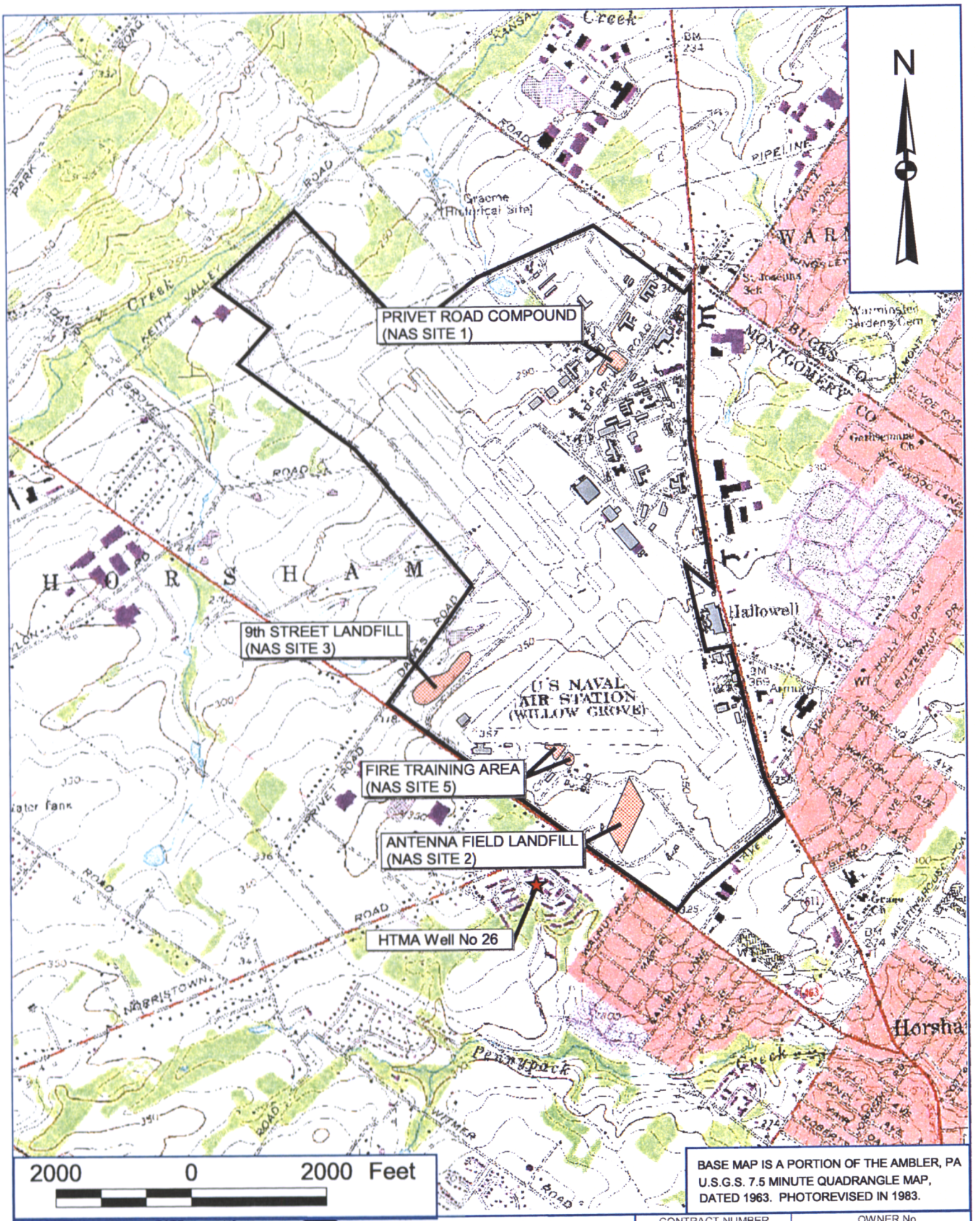
1.3 PREVIOUS INVESTIGATIONS

Previous work at the NASJRB Willow Grove includes the PA, SI, and first-phase RI. The PA, formerly identified as the Initial Assessment Study, identified 16 sites, including seven sites at the Air Reserve Facility in 1984 (Weston, 1984) and nine sites at the NAS in 1986 (RGH, 1986). One additional site, the Navy Fuel Farm, was added to the program in 1988. Of the 17 sites included within the PA program, SI work was performed at 12 sites and RI/FS activities have subsequently been completed or are underway at eight sites.



BASE MAP TAKEN FROM AMBLER, PA. U.S.G.S. QUADRANGLE MAP 7.5', 1966. PHOTOREVISED 1983.

DRAWN BY LDL	DATE 1/18/02	Tetra Tech NUS, Inc.	CONTRACT NUMBER 5466 / OWNER No. 2207 (RI SITE 5)
CHECKED BY RET	DATE	LOCATION MAP NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	DWG INFORMATION: LAYOUT: FIG 1-1 RI SITE 5 NASJRB_WillowGrove.apr LDL 8/14/01
COST/SCHEDULE-AREA			APPROVED BY RET / DATE
SCALE AS NOTED			DRAWING No. FIGURE 1-1 / REV



BASE MAP IS A PORTION OF THE AMBLER, PA U.S.G.S. 7.5 MINUTE QUADRANGLE MAP, DATED 1963. PHOTOREVISED IN 1983.

DRAWN BY LDL	DATE 1/18/02	Tetra Tech NUS, Inc.	CONTRACT NUMBER 5466 / OWNER No. 2207 (RI SITE 5)
CHECKED BY RET	DATE	LOCATION OF RI SITES SITE 5 - FIRE TRAINING AREA NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	DWG INFORMATION: LAYOUT: FIG 1-2 RI SITE 5 NASJRB_WillowGrove.apr LDL 8/14/01
COST/SCHEDULE-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING No. FIGURE 1-2 / REV

In addition, extended site inspections were performed at two sites, NAS Site 7 (Abandoned Rifle Range No. 2) and ARS Site 4 (Washrack Area). Work at three of the eight RI/FS sites was completed under a program managed by the Air Force. Phase I RI activities were completed for four of the remaining five RI/FS sites and reported in 1993 (HNUS, 1993). Results of the Phase I RI characterized the physical and chemical nature of these four sites and identified data gaps requiring further study. Recommendations for further investigation included in the Phase I RI were incorporated into subsequent planning discussions for additional work and have led to the Phase II activities that are reported in the Phase II RI report.

1.4 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

A description of the regional or general physical characteristics of NASJRB Willow Grove has been prepared on the basis of published information, reports of previous site studies, and information obtained and interpreted during the course of the Phase II RI. Site-specific physical characteristics for the Site 5 are discussed in Section 4.

1.4.1 Meteorology

NASJRB Willow Grove is located about 70 miles west of the Atlantic Ocean, which tends to have a moderating effect on temperatures. Normal minimum and maximum daily temperatures range from 24° in February to 86°F in July.

The average annual rainfall is 44.5 inches. The average annual snowfall is 21.5 inches. Precipitation is fairly evenly distributed throughout the year, with an increase in rainfall during the summer months. Average annual and extreme frost penetrations are 20 inches and 30 inches, respectively.

Mean annual relative humidity ranges from 54 percent in the early afternoon to 78 percent before dawn. The mean annual Class A Pan Evaporation is about 42 inches per year.

The prevailing wind direction at the air station is southwesterly during the summer and northwesterly during the winter. The mean annual wind speed and direction are approximately 9 miles per hour from the west-northwest.

1.4.2 Topography And Surface Water Hydrology

NASJRB Willow Grove lies within the Triassic Lowlands Section of the Piedmont Physiographic Province. This section is characterized by rolling topography. Broad northeast-southwest-trending ridges in the area reflect resistant conglomeratic sandstone beds or diabase dikes. The base occupies a relative topographic

high, which for the most part precludes surface water flow onto the facility from surrounding areas. Surface elevations range from a high of approximately 370 feet above mean sea level (MSL) in the vicinity of Taxiway Juliet to a low of approximately 240 feet above MSL in the northern portion of the base. Slopes are generally less than three percent. In areas where the land has been regraded, however, the slopes may be steeper.

NASJRB Willow Grove is situated within an upland area that forms a local drainage divide between the Little Neshaminy Creek drainage basin to the north and the Pennypack Creek drainage basin to the south. Both of these local drainage basins lie within the regional drainage basin of the Delaware River. Most of the activity drains toward the north through several unnamed ephemeral, intermittent, and perennial drainageways into Park Creek, which is a tributary of Little Neshaminy Creek. The extreme southern portion of the base, including the Antenna Field Landfill and a portion of the Fire Training Area, lies within the Pennypack Creek drainage basin.

There are reportedly no flowing or perennial streams within the base boundaries. During heavy rainfalls, very local flooding conditions are associated with various swales and man-made drainage ditches.

Runoff from surface areas is primarily channeled through open drainage swales and enclosed storm sewers to one of five primary outfall areas. Three of these outfalls drain to Park Creek. The fourth outfall is an intermittent stream that flows into Pennypack Creek. The fifth outfall is a direct connection to the Northern Storm Sewer System.

The receiving waters for storm water runoff derived from the base are fished. The Pennsylvania Department of Environmental Protection (PADEP) designates Pennypack Creek as a warm-water fishery. Little Neshaminy Creek is stocked with trout.

1.4.3 Soils

Soils observed at the NASJRB Willow Grove during current and previous RI fieldwork ranged from 4 feet to more than 15 feet in thickness. Generally, the soils included brown, yellowish-brown, reddish-brown, and orange mixtures of silt, clay, and sand with finer-grained materials dominant.

The Soil Survey of Montgomery County (United States Department of Agriculture, 1967) indicates that five major soil series are mapped within the boundaries of the four RI sites. The soil series include the Lansdale, Lawrenceville, Chalfont, and Readington silt loams and the Lansdale loam. Minor areas of other soil series, composed chiefly of silt loam materials, are developed in small, low-lying areas. In general, these soils have a moderate to slow permeability that encourages rapid runoff during normal precipitation events.

Most of the soil within the boundaries of the air station has been disturbed. In addition, large areas have been filled with shale and sandstone mixed earth materials. These soils, known as made land, vary widely in depth and drainage potential.

1.4.4 Regional Geology

NASJRB Willow Grove is located within the Triassic Basin of southeastern Pennsylvania. The bedrock underlying the NASJRB consists of the middle arkose member of the Late Triassic age Stockton Formation. The Stockton Formation locally is about 5,000 feet thick and is unconformably underlain by Ordovician to PreCambrian age basement rocks. Current and previous environmental investigations indicate that the top of bedrock at the air station is generally found in the range of 5 feet to 25 feet below ground surface (bgs).

The Stockton Formation is composed of fine- to coarse-grained arkosic sandstones and conglomerates that are interbedded with finer grained shales and siltstones. These sediments were deposited by a series of coalescing alluvial fans that deposited materials eroded from highlands to the south (Sloto and Davis, 1983). Bedding is very irregular throughout the Stockton Formation, although coarse-grained units commonly overlie fine-grained units. Beds commonly pinch out or form gradational contacts with overlying or underlying beds over lateral distances greater than several hundred feet (Rima et al., 1962). Based principally on dominant grain size and lithology, the Stockton Formation is divided into lower, middle, and upper members.

The middle member of the Stockton Formation is approximately 4,200 feet thick and consists of fine- to medium-grained arkosic sandstone interbedded with shale. Beds of shale and siltstone are common in the upper portion of the member, and coarser grained units are more common in the lower portion of the member. The rocks of the middle member are well sorted and weakly cemented, which creates a relatively high porosity compared to the lower and upper members of the formation (Rima et al., 1962). The middle member of the Stockton Formation typically weathers to a depth of 15 to 35 feet.

The lower member of the Stockton Formation is composed primarily of coarse-grained arkosic sandstone and conglomerate and, to a lesser extent, medium-grained arkosic sandstone. Locally, the lower member is less than 1,500 feet thick.

The upper member of the Stockton Formation is not present in the vicinity of NASJRB Willow Grove. The upper member is composed primarily of shale, siltstone, and fine-grained arkosic sandstone. In general, the grain size within this unit decreases in a stratigraphically upward direction, with the fine-grained sandstone occurring most commonly in the lower portion of the unit.

Regionally, the sedimentary beds of the Stockton Formation strike to the northeast and dip at an average rate of 12 degrees to the northwest. Based on subsurface correlations made during this current investigation, the bedrock strike was calculated to be N 76°E and the dip was calculated to be 7° to the northwest. At another government installation located approximately 3 miles northeast of the site, strikes ranging from north 64 degrees east to north 71 degrees east and dips ranging from 5 degrees to 9 degrees to the northwest were calculated from subsurface correlations of geophysical borehole logs for the middle member of the Stockton Formation (HNUS, 1995).

A northeast-southwest-trending, nearly vertical igneous diabase dike bisects the Stockton Formation and passes just south and east of the NASJRB Willow Grove boundary. The thickness of this dike is approximately 90 feet (Rima et al., 1962). Figure 1-3 is a general geological map of the NASJRB Willow Grove vicinity.

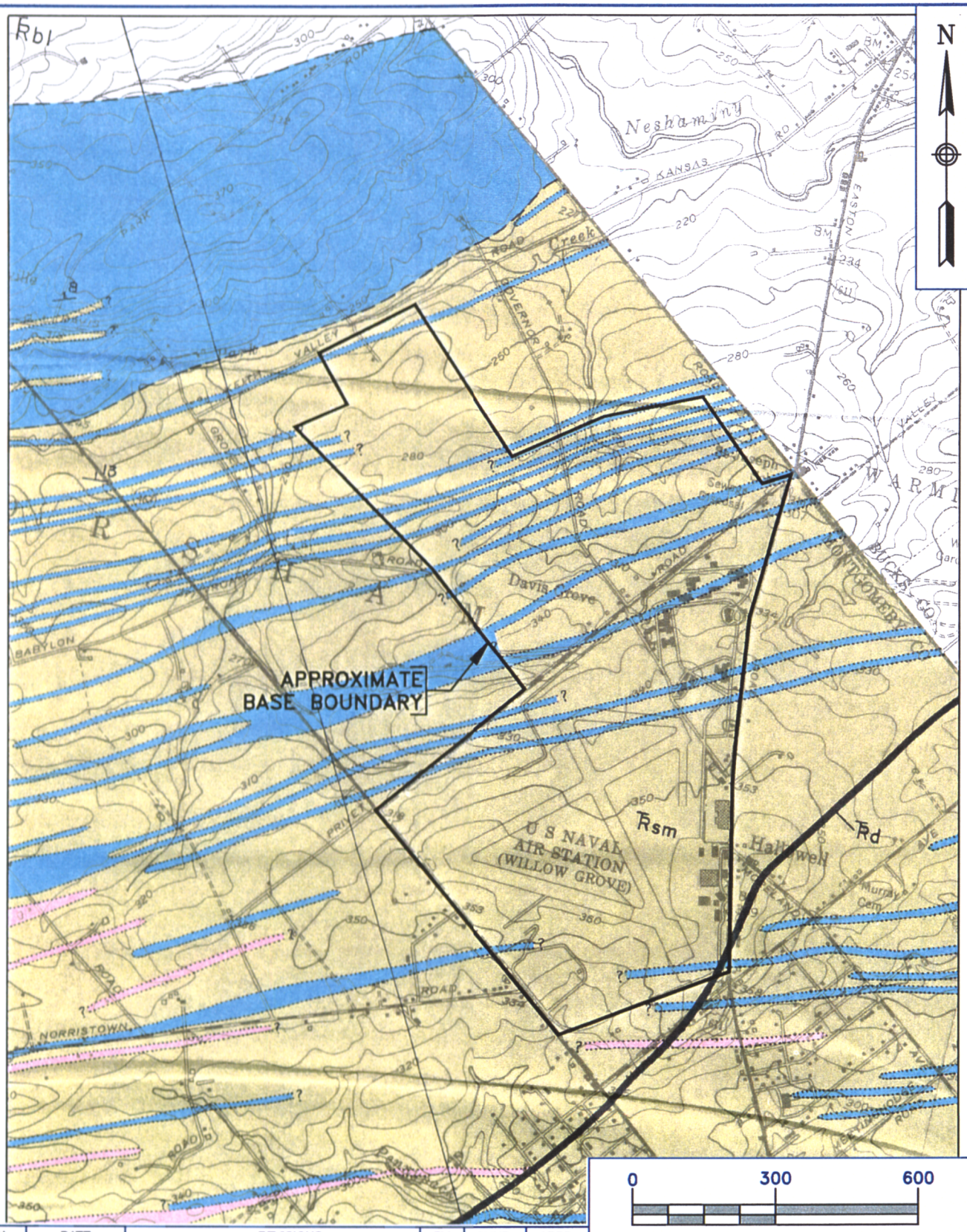
1.4.5 Regional Hydrogeology

The sandstones, shales, and conglomerates of the Triassic Basin are relatively good water-bearing formations. They generally yield abundant supplies to wells (Hall, 1934). The groundwater ranges from soft to hard, with the average hardness being greater than that of most other formations in southeastern Pennsylvania.

The major source of groundwater in the vicinity of NASJRB Willow Grove is the fractured bedrock of the Stockton Formation (Earth Data, Incorporated, 1985). These rocks form a multi-aquifer system of relatively discrete water-bearing zones separated by less permeable zones. Transmissivity and groundwater movement within water-bearing zones are greater parallel to bedding than across bedding. Groundwater can generally be found between 5 and 25 feet bgs.

Groundwater within the Stockton Formation locally occurs under both unconfined and confined conditions. The unconfined conditions generally extend to a subsurface depth of about 75 to 100 feet, depending on the local lithologies. Confined conditions are generally encountered below a depth of about 150 feet. A semi-confined or transitional aquifer lies between the unconfined and confined aquifers. Vertical or nearly vertical fractures that cut across bedding and the weathering of various beds are expected to permit varying degrees of leakage between individual water-bearing zones, particularly at shallower depths.

Although significant amounts of groundwater may be held in storage within the primary porosity of the fine- to medium-grained sandstones, groundwater migration is chiefly through the secondary porosity created by fractures and joints and along bedding-plane partings. The finer grained shale and siltstone beds typically



No	DATE	REVISIONS	BY	CHKD.	APPD.
1	8/31/01	REDRAWN AND UPDATED.	LDL		

DRAWN BY A.S.M. DATE 11/10/97	Tetra Tech NUS, Inc.	GENERAL GEOLOGICAL MAP APPROXIMATE AREA OF INTEREST SITE 5 – FIRE TRAINING AREA NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	CONTRACT NO. 5466
CHECKED BY DATE			OWNER NO. 2207
REVISED BY DATE			APPROVED BY DATE
SCALE NONE			DRAWING NO. FIGURE 1-3 (PAGE 1) REV. 1

5466gm01_FIG1-3(Page1).dwg 11/10/97 ASM

5466gm01_FIG1-3(Page1).dwg

5466gd01_FIG1-3(Page2).dwg 11/10/97 ASM

TRIASSIC

Ŧd

Diabase
Not tapped by wells in this area.

Ŧbl

Brunswick and Lockatong formations, undifferentiated; gray to black, and red shale and sandstone; the water-bearing properties of these formations have not been studied for this report.

UPPER TRIASSIC

Stockton formation

Ŧsu

Upper shale member

Red shale and siltstone, containing beds of fine-grained arkosic sandstone (shown in brown); reported yields from wells in this member range from 10 to 80 gmp; average specific capacity of wells is 0.5 gpm per foot of drawdown.

Ŧsm

Middle arkose member

Fine- and medium-grained arkosic sandstone, containing beds of coarse-grained arkosic sandstone (shown in pink) and red shale and siltstone (shown in blue); reported yields from wells in this member range from 10 to 800 gpm and average 130 gpm; average specific capacity of wells is 5.0 gpm per foot of drawdown.

Ŧsl

Lower arkose member

Medium to coarse, coarse, and very coarse-grained arkosic sandstone and arkosic conglomerate, containing beds of fine- and meduim-grained arkosic sandstone (shown in brown) and red shale and siltstone (shown in blue); reported yields from wells in this member range from 10 to 500 gpm and average 110 gom; average specific capacity of wells is 3.0 gpm per foot of drawdown.

O€p€

Rocks of Ordovician to Precambrian age; these rocks have not been studied in this area.

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1	8/31/01	REDRAWN AND UPDATED.	LDL		

DRAWN BY A.S.M.	DATE 11/10/97	Tetra Tech NUS, Inc.	GENERAL GEOLOGICAL MAP LEGEND OF SYMBOLS SITE 5 – FIRE TRAINING AREA NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA
CHECKED BY	DATE		
REVISED BY	DATE		
SCALE NONE			

CONTRACT NO. 5466
OWNER NO. 2207
APPROVED BY DATE
DRAWING NO. FIGURE 1-3 (PAGE 2) REV. 1

5466gd01_FIG1-3(Page2).dwg

have very low permeabilities. In addition, fractures and joints are typically not as well developed in these finer grained beds. Consequently, the shale and siltstone units often act as confining layers to groundwater flow.

Numerous private (residential) and municipal type production wells supply water for domestic and commercial uses in the NASJRB Willow Grove vicinity. Figure 1-4 shows the approximate locations of public and private wells in the vicinity of the southern end of NASJRB Willow Grove.

1.4.6 Ecology

A detailed evaluation of the NASJRB Willow Grove biological features was conducted during the site investigation phase of the environmental activities for the base (EA, May 1990). Most of the following discussion is excerpted from that report.

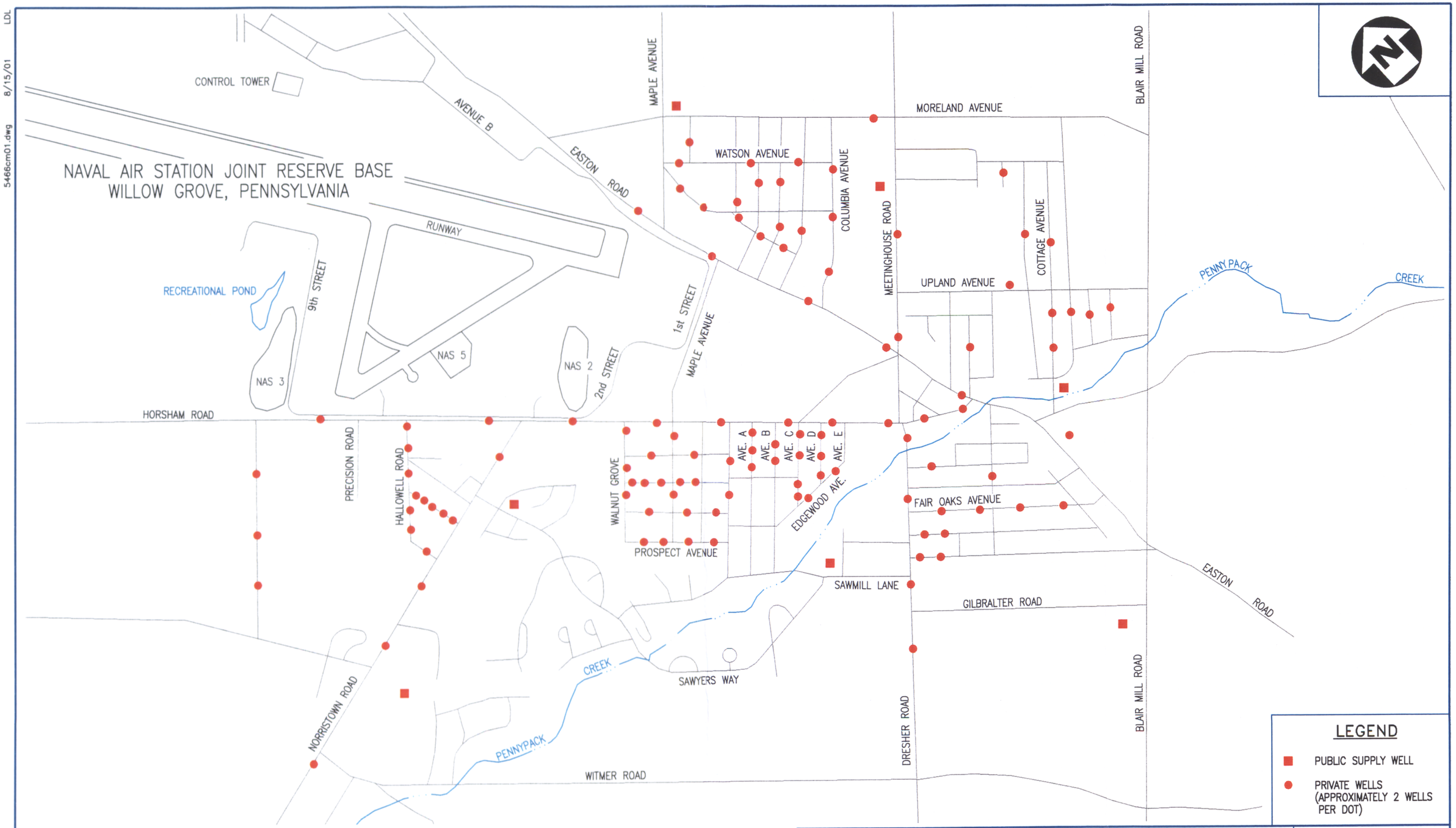
1.4.6.1 Ecosystems

The natural environment at NASJRB Willow Grove has been altered by development ever since the facility was first commissioned in 1942 as an airport. Buildings and paved roadways are concentrated mainly in the eastern portion of the facility. Due to the development on the base, the land has not retained a natural vegetation cover. The vegetative communities that remain are limited and generally include lawn areas maintained by activity personnel, old field, immature forest, and wetland.

Except for old field scrub/shrub, maintained grassy field is probably the most common vegetative cover at the base. Most of this habitat is located west of the runways. The herbaceous species and woody shrubs there provide habitat for many wildlife species. Typical herbaceous plants include cinquefoils (*Potentilla* spp.), ragweed (*Ambrosia artemisiifolia*), field daisy (*Chrysanthemum leucanthemum*), wild strawberry (*Fragaria vesca*), and numerous grasses. Shrubs observed include multiflora rose (*Rosa multiflora*), poison ivy (*Rhus radicans*), chokecherry (*Prunus virginiana*), and blackberry (*Rubus* spp.).

Wooded areas occur mainly along the western boundary of the activity and serve as a buffer between the Activity and residences along Route 643 and the neighboring golf course/commercial complex. Common forest species observed include red maple (*Acer rubrum*), sassafras (*Sassafras albidum*), sycamore (*Platanus occidentalis*), and oak (*Quercus* spp.). The mixed hardwoods provide nesting, protective, and feeding habitat for many wildlife species.

Wetland habitat is rare within the base area. According to the National Wetlands Inventory map of this area (United States Department of Interior, undated), five wetlands exist on the base. An excavated pond,



DRAWN BY LDL	DATE 8/24/01	Tetra Tech NUS, Inc.	APPROXIMATE LOCATION OF PUBLIC AND PRIVATE WELLS SITE 5 – FIRE TRAINING AREA NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA
CHECKED BY	DATE		
REVISED BY	DATE		
SCALE AS NOTED			

CONTRACT NO. 5466	
OWNER NO. 2207	
APPROVED BY	DATE
DRAWING NO. FIGURE 1–4	REV.

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classified as a palustrine, open water, intermittently exposed wetland is located near the property boundary in the extreme northern portion of the base. The recreation pond at the picnic area is classified as a palustrine open water, intermittently exposed, impounded wetland. A small palustrine, scrub/shrub emergent wetland is located downstream of the recreational pond. The recreational pond and the nearby emergent wetland are located adjacent to the Ninth Street Landfill site. Two small ponds near the southeastern corner of the base are classified as palustrine, open water, intermittently exposed, excavated wetlands. Two small (man-made) ponds (approximately 80 feet long by 20 feet wide) are present at the central area of Site 5. These small ponds are not mapped as wetlands but have become established with marsh grasses and sedges. A larger (several acres) area of marsh habitat consisting mainly of sedges and bulrush occupies topographically low areas just north of the runway end zone. Many of these wetland grasses were planted by Air Station tenant personnel to attract waterfowl and have not been formally mapped as wetlands. This area is not located near any former waste disposal activities.

Wildlife species occurring at NASJRB Willow Grove are those that commonly occur near urbanized areas. Species observed, or reported to occur, include eastern cottontail (Sylvilagus floridanus), muskrat (Ondatra zibethica), raccoon (Procyon lotor), woodchuck (Marmota monax), eastern gray squirrel (Sciurus carolinensis), and white-tailed deer (Odocoileus virginianus). Pheasants (Phasianus colchicum) have been observed in the old field habitat. Canada geese (Branta canadensis) apparently nest within the Activity's boundaries. Mallards (Anas platyrhynchos) have been observed in the wetlands area downstream from the pond at the picnic area. Other observed bird species include robin (Turdus migratorius), starling (Sturnus vulgaris), mourning dove (Zenaidura macroura), wood thrush (Hylocichla mustelina), cardinal (Cardinalis cardinalis), mockingbird (Mimus polyglottos), sparrows, and numerous others.

Aquatic communities on the base occupy the two man-made impoundments at the recreational pond (near the Ninth Street Landfill) and the Building 114 pond. The aquatic community includes catfish, largemouth bass (Micropterus salmoides), and sunfish. Both ponds are reportedly available to base personnel for recreational fishing. The recreational pond has reportedly received contaminated runoff from spills related to aircraft accidents and firefighting. Fish kills have been reported in this pond. The two small wet areas at Site 5 are inhabited by frogs and insects if the weather is rainy.

1.4.6.2 Endangered and Threatened Species

The Endangered Species Act of 1973, as amended, provides for the protection of endangered and threatened species. Government agencies are required to submit to the United States Fish and Wildlife Service any proposed actions that may jeopardize the continued existence of any species listed under the act as threatened or endangered. The peregrine falcon (Falco peregrinus), which is classified as endangered by the United States Fish and Wildlife Service, has been observed in the area, but it is

considered to be a rare seasonal (March to November) transient. No other federally listed plants or animals are known to occur on the base. There are no known threatened or endangered plants or animals, as recognized by the Commonwealth of Pennsylvania under Chapter 147, Title 58, within the boundaries of the base.

1.5 QUALITY ASSURANCE/QUALITY CONTROL RESULTS

The objective of this process is to evaluate data quality of field quality control blanks, field duplicate precision, laboratory quality control analyses and precision, accuracy, representatives, comparability, and completeness (PARCC). Field sample results usability was determined by the process described below. As a result of this process, all field sample results have been rated as to data quality. The data usability qualifier (e.g., R - rejected or J - estimated) is included as a suffix to the numerical laboratory result in all data summary tables and the qualifier is explained in a footnote on the table.

1.5.1 Field Quality Control Blanks

Field quality control blanks are generally used to measure success of the program to avoid extraneous contamination during sample collection, storage, and transport. Field blanks served to trace possible routes of contamination, including bottleware, sampling equipment, rinsate water, solvent vapors, and items (e.g., gloves) that may contact samples or sample containers. Field blanks were collected at the frequencies specified in the work plan, following EPA Region III guidance.

Field Blanks

Field blanks were obtained to estimate incidental or accidental contamination from field sampling techniques and to determine if cross-contamination of samples had occurred. Field blanks were taken separately from each source of equipment decontamination water (potable water and bottled deionized water) and analyzed for the same suite of parameters as the environmental samples in accordance with NFESC guidelines.

Trip Blanks

Trip blanks were used to determine if contamination was introduced during sample storage and transport. Trip blanks remained with the sample containers in the field at all times, were returned unopened at the conclusion of each day's field activities, and were included in each cooler shipment of volatile organic compound (VOC) samples sent to the laboratory. Trip blanks were analyzed for TCL VOCs only.

Rinsate Blanks

Equipment rinsate blanks were utilized to determine if contamination had been introduced through contact with the sampling equipment. Equipment rinsate blanks were prepared by running analyte-free water through sample collection equipment (bailer, split-spoon, hand auger bucket, etc.) after decontamination. Rinsate blanks were generated for each type of non-dedicated sampling equipment at the frequencies specified in the work plan. Equipment rinsate blanks were analyzed for the same suite of parameters as the associated environmental samples.

1.5.2 Discussion of Field Quality Control Blank Impact

Table 1-1 summarizes the frequency and concentration of contaminants detected in each type of field quality control blank collected during the 1997 RI. In nearly all cases, blank contamination occurred at very low frequencies and was restricted to concentration ranges near the detection or quantitation limits. During data validation, the concentrations of compounds detected in laboratory and field quality control blanks were compared to concentrations found in the corresponding environmental samples to determine potential impacts on the analytical data. Analytical results from environmental samples were qualified as potential artifacts attributable to blank contamination if the compound was not found at a concentration of at least five times (10 times for certain common laboratory contaminants) the concentration in the associated blank.

Metals and trihalomethanes detected in the potable water source (local tap water) field blank included aluminum, calcium, iron, magnesium, sodium, zinc, bromoform, bromodichloromethane, and dibromochloromethane, among other compounds. The detected metals mentioned are common "hard water" contaminants and the trihalomethanes are common by-products from disinfection water treatment.

Calcium and zinc are elements found naturally in soils and sediments and in the potable water used in the first step of equipment decontamination. Therefore, it cannot be determined whether detection of these elements are associated with the first-step cleaning solution (potable water) or with residual soil materials left after completion of decontamination.

Methylene chloride was detected in several trip blanks and rinsate blanks at concentrations below or near the contract-required quantitation limit (CRQL). This compound is a common laboratory contaminant and was detected more frequently in laboratory blanks than in field quality control blanks. This caused many of the positive field quality control blank results for methylene chloride to be qualified as not detected due to laboratory blank contamination. The positive results in Table 1-1 represent only those compounds remaining after data validation. Methylene chloride was not used in the field; therefore, laboratory

TABLE 1-1

Summary of Field Quality Control Blank Results
NASJRB Willow Grove, Pennsylvania

Analytes	Rinsate Blanks		Field Blanks		Trip Blanks	
	Frequency of Detection	Maximum Concentration (ug/L)	Frequency of Detection	Maximum Concentration (ug/L)	Frequency of Detection	Maximum Concentration (ug/L)
Volatiles						
2-BUTANONE	1 / 25	13	0 / 6		0 / 26	
BROMODICHLOROMETHANE	0 / 25		1 / 6	1	0 / 26	
BROMOFORM	0 / 25		2 / 6	8	0 / 26	
CHLOROFORM	0 / 25		0 / 6		1 / 26	2
DIBROMOCHLOROMETHANE	0 / 25		2 / 6	5	0 / 26	
METHYLENE CHLORIDE	4 / 10	20	1 / 2	16	3 / 9	14
Semivolatiles						
BIS(2-ETHYLHEXYL)PHTHALATE	3 / 23	4	1 / 8	13		N/A
DI-N-BUTYLPHTHALATE	4 / 21	2	1 / 8	1		N/A
DIETHYLPHTHALATE	6 / 23	10	1 / 8	6		N/A
PHENOL	1 / 23	1	0 / 8			N/A
Pesticides/PCBs						
None Detected						N/A
Dioxins/Furans						
1,2,3,4,6,7,8-HPCDD	0 / 3		1 / 2	0.0000807		N/A
1,2,3,4,6,7,8-HPCDF	0 / 3		1 / 2	0.0000416		N/A
1,2,3,6,7,8-HXCDD	0 / 3		1 / 2	0.000006		N/A
1,2,3,7,8,9-HXCDD	0 / 3		1 / 2	0.0000065		N/A
OCDD	0 / 3		1 / 1	0.00111		N/A
OCDF	0 / 3		1 / 1	0.000102		N/A
TCDD TOXICITY EQUIVALENTS		0.00000035	2 / 2	0.00000438		N/A
TOTAL HPCDD	0 / 3		1 / 2	0.0000807		N/A
TOTAL HPCDF	0 / 3		1 / 2	0.000103		N/A
TOTAL HXCDD	0 / 3		1 / 2	0.0000279		N/A
TOTAL HXCDF			1 / 2	0.0000442		N/A
Metals						
ALUMINUM	0 / 19		1 / 5	407		N/A
ARSENIC	0 / 22		2 / 7	2.9		N/A
BARIUM	0 / 22		2 / 7	225		N/A
CADMIUM	1 / 22	6.5	0 / 7			N/A
CALCIUM	6 / 22		2 / 7	77200		
COPPER	0 / 22	739	1 / 7	12.9		N/A
IRON	0 / 22		3 / 7	2900		N/A
LEAD	11 / 22	8.2	4 / 7	9.2		N/A
MAGNESIUM	0 / 22		2 / 7	23600		N/A
MANGANESE	0 / 22		2 / 7	27.1		N/A
POTASSIUM	0 / 22		1 / 7	1910		N/A
SODIUM	0 / 22		2 / 7	15900		N/A
ZINC	7 / 22	20	2 / 6	89.4		N/A
Miscellaneous Parameters						
DIESEL RANGE ORGANICS			0 / 1			N/A
GASOLINE RANGE ORGANICS			0 / 1			N/A

Frequency of detection refers to number of times compound was detected among all samples versus total number of samples. Number of samples may vary based on the number of usable results.

sources are likely to be responsible for the sporadic detection of low levels of this compound in field quality control blanks.

1.5.3 Field Duplicate Precision

Field duplicate pairs were analyzed in order to assess the overall precision of the sampling and analysis process. Field duplicate pairs consisted of two field samples of identical media sampled at the same field location using the same sampling process. Duplicate pairs were stored and transported together to the laboratory for analyses. The relative percent differences (RPDs) for the duplicate pairs were calculated and reported by the laboratory and evaluated by the data validator in order to quantitate any imprecision. In general, the majority of the field duplicate results exhibited acceptable precision and there were no consistent trends to indicate improper sampling technique.

1.5.4 Laboratory Quality Control Analyses

Laboratory quality control samples were analyzed as required by each specific analytical protocol and NFESC requirements. Quality control data from organic analyses included laboratory blank results, surrogate, matrix spike, and matrix spike duplicate recoveries, internal standard recoveries, initial calibration relative standard deviations and minimum response factors, continuing calibration percent differences and response factors, laboratory control spikes, mass spectral tuning ratios, clean-up column recoveries, pesticide performance evaluation recoveries, pesticide analyte degradation percentages, and compound identification criteria (mass ratios, retention time windows, and two-column percent differences). In general, the frequency of analytical problems in each of these areas was very low and indicated overall acceptable method performance for each type of analysis.

Organic analysis laboratory blanks revealed limited contamination, with low concentrations (near or below the CRQL) of common laboratory contaminants such as methylene chloride, acetone, 2-butanone, and selected phthalate esters. Sample-matrix-related interferences caused high percent differences for a few pesticide results, resulting in data qualified as estimated based upon validation protocols. A limited number of volatile and semivolatile results were qualified as estimated based upon calibration relative standard deviations or percent differences. Several semivolatile soil sample results were qualified as estimated due to slightly exceeded holding times [greater than the 7-day allowance per regional data validation guidelines but within Contract Laboratory Program (CLP) method-specified contractual holding times]. In a few cases, sample matrix effects may have caused low or high internal standard, matrix spike, or surrogate recoveries, which lead to the qualification of results as estimated or biased low. Where required, such samples were reanalyzed according the analytical protocol.

Quality control data from inorganic analyses included laboratory blank results, matrix spike recoveries, laboratory duplicate RPDs, serial dilution percent differences, initial calibration, continuing calibration, and CRDL standard percent accuracies, laboratory control sample recoveries, and interference check standard accuracies.

The frequency of analytical problems in each of these areas was low and indicated overall acceptable method performance for each type of analysis. Inorganic analysis laboratory blanks revealed low frequencies of contamination generally restricted to concentrations below the CRDL, which affect data qualification but do not require sample reanalysis based on EPA protocols. Several matrix spike or post-digestion spike recoveries were below or above QC limits and resulted in the qualification of data as biased low or biased high, respectively. These problems are typically attributed to sample matrix interference effects caused by other substances in the sample. A few results were qualified as estimated or biased because of laboratory duplicate imprecision or CRDL standard recoveries above or below control limits. Very few problems occurred in other areas.

1.5.5 Parameters

The quality of the data set is measured by certain characteristics of the data, namely the precision, accuracy, representativeness, comparability, and completeness (PARCC) parameters. Precision and accuracy are expressed quantitatively, and the others are expressed qualitatively.

Precision

Precision characterizes the amount of variability and bias inherent in a data set. Precision describes the reproducibility of measurements of the same parameter for a sample under the same or similar conditions. Precision is expressed as a range (the difference between two measurements of the same parameter) or as an RPD (the range relative to the mean, expressed as a percent). Precision is measured quantitatively. Range and RPD values are calculated as follows:

$$\text{Range} = OR - DR$$

$$RPD = (OR - DR) / [\,(OR + DR) / 2\,] \times 100\%$$

where: OR = original sample result
DR = duplicate sample result

RPD values are calculated for matrix spike duplicates, laboratory duplicates, and field duplicates and are compared to the control limits as a QA check. Data validation field duplicate results associated with this RI are discussed in Section 1.5.3.

Accuracy

Accuracy is the comparison between experimental and known or calculated values expressed as a percent recovery (%R). Percent recoveries are derived from analysis of standards spiked into deionized water (standard recovery) or into actual samples (matrix spike or surrogate spike. recovery). Recovery is calculated as follows:

For a surrogate spike or laboratory control spike or standard

$$\%R = E / T \times 100\%$$

where: E = experimental result
T = true value (theoretical result)

For a sample matrix spike

$$\%R = (SSR - SR) / SA \times 100\%$$

where: SSR = sample spike result
SR = sample result (unspiked)
SA = spike concentration added
and
SA = (spike aliquot)(spike concentration)/(sample aliquot + spike aliquot)

Accuracy for aqueous and solid samples was evaluated by use of surrogate and matrix spikes at the CLP-required frequencies. CLP acceptance criteria and corrective actions were applied. Out-of-criteria results were reviewed during EPA data validation to determine the need for qualification or rejection.

Representativeness

All data obtained should be representative of actual conditions at the sampling location. The work plan was designed so that the samples taken present an accurate representation of actual site conditions. The rationale discussed in the work plan were designed to ensure this. All sampling activities conformed to the protocols specified in the work plan. The use of CLP analytical protocols and data deliverables

ensured that analytical procedures were consistently performed to generate results that are considered representative.

The use of low-flow dedicated sampling pumps in conjunction with monitoring of turbidity and other parameters ensured that monitoring well data were as representative of the formation as possible. Despite efforts such as installation of dedicated low-flow bladder pumps and adherence to the low-flow sampling procedure, in a few instances, low turbidity samples could not be collected. Where use of the low-flow purge method did not result in stabilized turbidity readings, filtered samples were also obtained from the same location. In addition, sample filtration was required for all older monitoring wells that did not possess dedicated low-flow sampling pumps. Filtered and unfiltered metals results were then compared to achieve a more accurate perspective of contaminant fate and transport.

Comparability

Comparability is achieved by using standardized sampling and analysis methods and data reporting procedures. The use of standard analytical procedures and sample collection techniques throughout all sampling rounds maximized the comparability of all Willow Grove data. Additionally, consideration was given to field environmental conditions that could influence analytical results.

Completeness

Completeness is a measure of the amount of valid data obtained from the measurement program, compared to the total amount collected. For relatively clean, homogeneous matrices, 100 percent completeness is expected. However, as matrix complexity and heterogeneity increase, completeness may decrease. Where analysis is precluded or where data quality objectives (DQOs) are compromised, effects on the overall investigation must be considered. Whether any particular sample is critical to the investigation is evaluated in terms of the sample location, the parameter in question, the intended data use, and the risk associated with the error.

Critical data points were not evaluated until all the analytical results were evaluated. If in the evaluation of results it becomes apparent that the data for a specific medium are of insufficient quality (for example, completeness less than 95 percent), either with respect to the number of samples or an individual analysis, resampling of the deficient data point(s) may be necessary. The site- and medium-specific completeness percentages are summarized in Table 1-2.

TABLE 1-2

SUMMARY OF REJECTED DATA
NASJRB WILLOW GROVE, PENNSYLVANIA

SITE NUMBER	Monitoring Wells			Subsurface Soil			Surface Soil			Surface Water			Sediment		
	No. of Rejected Results	Total No. of Results	Percent Rejected Data	No. of Rejected Results	Total No. of Results	Percent Rejected Data	No. of Rejected Results	Total No. of Results	Percent Rejected Data	No. of Rejected Results	Total No. of Results	Percent Rejected Data	No. of Rejected Results	Total No. of Results	Percent Rejected Data
01	16	2910	0.55	71	8030	0.88	0	393	0	0	425	0	0	900	0
02	1	1575	0.06	51	6012	0.85	0	2398	0	2	2683	0.08	0	3135	0
03	8	5080	0.16	0	1200	0	28	4110	0.68	0	1047	0	0	1350	0
04	0	3865	0	6	4048	0.15	11	1426	0.77	0	447	0	0	450	0
12	0	760	0	1	894	0.11	0	447	0	-	-	-	-	-	-
Background Areas	-	-	-	-	-	-	10	1508	0.66	0	1341	0	3	1341	0.22

The overall percentages of rejected data points in Table 1-2 were generally low and within acceptable ranges. In the 1997 RI, most of the rejected data were attributed to ICP spectral interference (antimony), low Contract Required Detection Limit (CRDL) standard recoveries (selenium), or very low surrogate recoveries in one pesticide analysis.

Sample matrix effects may be the cause of the very low pesticide recoveries, which affect the ability of the analysis to successfully detect pesticides in one soil sample. Low CRDL standard recoveries occurred for selenium and triggered the rejection of 14 non-detected soil results in one sample delivery group. The analysis may not have been capable of detecting selenium in these cases.

False positive results may have occurred with 60 sample results for antimony, based on its detection in several associated QC runs in which antimony should have been non-detected [Interference Check Standard (ICS) Mix A]. This problem indicates that the Inductively Coupled Plasma (ICP) spectrometer was not properly correcting for signal bias with antimony caused by the spectral overlap from higher concentrations of common minerals and that samples containing moderate levels of minerals may present results for antimony that appear to be positive but are actually artifacts.

The selenium CRDL recoveries and ICS results for analytes that are supposed to be absent from Mix A are advisory QC criteria that do not require mandatory action according to CLP protocol; however, both problems are related to laboratory performance and not sample matrix effects.

1.5.6 September 2000 Groundwater Sampling

The September 2000 groundwater sampling results resemble the previous results in every way. There were no unexpected compounds encountered and the concentrations generally fall in the range of concentrations encountered in the same wells in previous sampling events. The same stringent laboratory protocols were used as for previous analytical events. The laboratory used maintains the same EPA and Navy certifications required for previous studies. Since these analytical results confirm previous results and are being used to refine nature and extent, no additional data validation beyond that performed under contract by the analytical laboratory was deemed necessary. Likewise, since there is no discrepancy with previous data, the human health and ecological risk assessments performed and presented in the Phase II RI report have not been updated to include this latest similar data. Table 4-17, found at the end of Section 4, summarizes analytical results from the September 2000 groundwater sampling.

2.0 FIELD INVESTIGATION

The Phase II field investigation consisted of initial activities completed in 1997 and follow-on activities at Site 5 completed in 1998 and 2000. The initial field investigation activities were performed between March 3 and July 15, 1997. A second round of groundwater-level measurements was performed on August 7, 1997. The follow-on investigation activities were performed between May 1998 and October 2000. The initial Phase II RI field activities and the May 1998 follow-on activities were conducted in accordance with the final Phase II RI Work Plan submitted by Tetra Tech NUS in May 1997. The September 2000 follow-on activities were conducted in accordance with the Remedial Investigation Work Plan Addendum for Site Investigation at Site 5 submitted by Tetra Tech NUS in May 2000. Subcontractors provided several site investigation services, including drilling and monitoring well installation, site surveying activities and laboratory analysis. The United States Geological Survey (U.S.G.S.) provided borehole geophysical logging services, rock core sample analysis, and aquifer test data review and interpretation through its Interagency Agreement with the Navy. The details of the field investigation tasks performed are discussed in Section 4.

2.1 SUMMARY OF ACTIVITIES

The initial field activities performed in 1997 to support the Phase II investigation included the following:

- Drilling and installation of 30 monitoring wells. Seven wells each were installed at Site 1 and Site 3, five wells were installed at Site 2, and 11 wells were installed at Site 5 (Section 2.1.7.1).

- Geophysical logging of all newly drilled boreholes and one existing borehole.

- Measurement of static water levels in the new wells and existing wells at each site (Section 2.1.8.4) and a long-term water-level study at Site 1 (Section 2.1.7.3).

- Collection of groundwater samples for laboratory analysis from 67 wells, including 28 of the newly installed monitoring wells (Section 2.1.7.2). Samples from Sites 2, 3, and 5 were analyzed for Target Compound List (TCL) VOCs, TCL semivolatile organic compounds (SVOCs), polychorinated biphenyl (PCB)/pesticides, Target Analyte List (TAL) inorganics, and cyanide. Samples from Site 1 were analyzed for TCL VOCs only. Samples were submitted to Applied Research and Development Laboratory (ARDL) in Mount Vermon, Illinois.

- Sampling and analysis of surface soils from each RI site (88 locations total) and 12 NASJRB background locations away from the investigation sites (Section 2.1.1). Samples were submitted to ARDL for various TCL and TAL analyses depending on site data requirements and specific locations. Samples from each site were submitted to Triangle Laboratories, Incorporated of Durham, North Carolina for dioxin analysis. Selected surface soil samples from Site 1 and Site 5 were analyzed in the field for PCBs using a field kit immunoassay procedure.

- Sampling and analysis of subsurface soils at 43 locations from Sites 1, 3, and 5 (Section 2.1.2). Samples were submitted to Triangle Laboratories for dioxin and to ARDL for various TCL and TAL analysis. Selected subsurface soil samples from Site 1 and Site 5 were analyzed in the field for PCBs using a field kit immunoassay procedure.

- Excavation of nine test pits at Site 2 (Section 2.1.2.2). Forty subsurface samples of landfill material and/or soil were collected and submitted to ARDL for TCL VOCs, SVOCs, PCB/pesticides, TAL inorganics, and cyanide analysis. Two of these samples were analyzed for dioxin.

- Sampling of surface water at two locations each at Sites 2, 3, and 5 to obtain water quality data (Section 2.1.4). Nine surface water samples were collected at off-base locations to provide baseline background water quality data. Samples were submitted to ARDL for TCL VOCs, SVOCs, PCB/pesticides, TAL inorganics, and cyanide analysis

- Sampling of sediments were at the same locations as surface water for Sites 2, 3, 5, and off-base background. An additional Site 3 sediment sample was collected upgradient of a Phase I RI sediment location. These samples and one sediment sample from Site 1 were submitted to ARDL for TCL VOCs, SVOCs, PCB/pesticides, TAL inorganics, cyanide, total organic carbon (TOC), and grain size analysis. Five sediment samples were collected at Site 1 from five of the locations sampled in the Phase I RI and submitted to ARDL for TCL SVOCs, TOC, and grain size analysis.

- Sampling of seep areas at Site 2 (aqueous and solid phases) and submission to ARDL for analysis (Section 2.1.6). Seep water and sediments were analyzed for TCL VOCs, SVOCs, PCB/pesticides, TAL inorganics, and cyanide. Sediments were also analyzed for TOC and grain size.

- Repair on three artesian wells at Site 3 to stop groundwater from continually flowing.

- Surveying of the horizontal locations and the vertical elevations of newly installed monitoring wells and at locations of surface soil, subsurface soil, sediment, and seep samples and test pit locations (Section 2.1.8).

- Sampling and disposal of investigation-derived waste (IDW) (Section 2.1.9).

The follow-on activities performed in 1998 through 2000 to support the Phase II investigation at Site 5 included the following:

- Drilling and installation of three permanent monitor wells (well cluster 11) in May 1998 (Section 2.1.7.2).

- Drilling, and installation of three additional permanent monitoring wells (05MW12I, 05MW05I, 05MWO4I) in September 2000 (Section 2.1.7.2).

- Geophysical logging of all newly drilled boreholes.

- Well sampling in September 2000 (Section 2.1.7.4). Collection of groundwater samples for laboratory analysis from 26 wells at Site 5 (Section 2.1.7.4). Samples were analyzed for Target Compound List (TCL) VOCs and monitored natural attenuation (MNA) parameters.

- Measurement of static water levels in all Site 5 monitoring wells (Section 2.1.7.7).

- Evaluation of the effect of geologic structure (dip and bedding planes) on the groundwater flow patterns at Site 5 (Sections 2.1.7.2 and 2.1.7.8).

- Aquifer testing to determine impacts on groundwater at Site 5 from operation of the Horsham Township municipal supply well # 26 (Section 2.1.7.9).

- Rock core investigation to assess weathered bedrock as a source of continuing groundwater contamination (Section 2.1.7.10).

- Review and evaluation of low-flow sampling procedures performed during the initial field investigation activities (Section 2.1.7.11).

- Review of EPIC historical aerial photographs and follow-up site verification visit for Site 5 (Section 2.1.8).

2.1.1 Surface Soil Investigation

Surface soil samples were obtained from 88 locations (18 sampling locations at Site 5) during the Phase II RI in 1997. No surface soil samples were obtained during the follow-on field activities in 2000. The specific soil sampling and analytical program conducted for each site is discussed in the respective site-specific section. A summary of the surface soil samples collected during the Phase II RI is presented in Table 2-1. A Tt NUS Environmental geologist sampled by digging 0 to 6 inches bgs with a stainless-steel trowel and placing soil directly into a laboratory-provided sample jar.

Thirteen background surface soil samples were collected at 12 on-base locations. A minimum of three samples were collected from each of the four major soil series mapped within the base, as specified in the Phase II RI Work Plan. The background soil samples were collected away from known or suspected waste-handling or waste disposal sites. The approximate locations of the soil samples are presented in Section 2.3. Each background sample was analyzed for TCL SVOCs, PCB/pesticides, TAL inorganics, and cyanide (see Table 2-1).

2.1.2 Subsurface Soil Investigation

2.1.2.1 Soil Borings

Subsurface soil samples were collected at Site 1, Site 3, and Site 5 during the 1997 field activities. No subsurface soil samples were collected during the follow-on activities. Soil borings were drilled by hollow-stem auger at 22 locations (14 soil borings at Site 5) using truck-mounted drilling equipment and at 21 locations (all at Site 1) using hand-auger boring techniques. The subsurface soil sampling program is summarized in Table 2-2.

Soil borings were drilled by Advanced Drilling, Incorporated, of Washington, New Jersey. The proposed locations for drilling were cleared for potential underground obstructions by the Navy and local utility companies before beginning each boring. A GEFCO Stratastar-15 drill rig with 4-1/4-inch-inner diameter (ID) augers was used to drill the borings. Each boring was sampled continuously with a split-spoon sampler in accordance with American Society for the Testing of Materials (ASTM) D 1586-84 from the ground surface to the top of bedrock or split-spoon refusal. The augers were advanced after each sample was taken, and a center plug was used during advancement of the augers. Two of the boreholes (03SB01 and 05SB30) were drilled and sampled using a Stratastar-25 drill rig with 2-1/4-inch ID augers.

TABLE 2-1

Surface Soil Sampling Summary
NASJRB, Willow Grove, Pennsylvania

Site	Number of Surface Soil Sample Locations	Number of Environmental Surface Soil Samples[1]	Analytical Parameters
1	28	26	PCBs (Field kit immunoassay)
		4	TCL semivolatiles
		3	Dioxin
		1	TCL PCBs
2	18	20	TAL metals, TCL semivolatiles, TCL pesticides/PCBs, and Cyanide.
		3	Dioxin
3	12	13	TAL metals, TCL semivolatiles, TCL pesticides/PCBs, and Cyanide.
		2	Dioxin
5	18	15	TAL metals, TCL semivolatiles, and Cyanide.
		13	PCBs (Field Kit Immunoassay).
		4	TCL PCBs
		2	Dioxin
Background	12	13	TAL metals, TCL semivolatiles, TCL pesticides/PCBs, and Cyanide.

[1] Includes field duplicates

TABLE 2-2
Subsurface Soil Sampling Summary
NASJRB, Willow Grove, Pennsylvania

Site	Number of Subsurface Soil Sample Locations	Number of Environmental Subsurface Soil Samples[1]	Analytical Parameters
1	28	50	PCBs (Field kit immunoassay)
		14	TCL semivolatiles
		6	TCL PCBs
		3	Dioxin
3	1	3	TCL VOC
5	14	17	TCL semivolatiles and TAL Metals.
		13	TCL VOC
		16	Cyanide
		11	PCBs (Field kit immunoassay)
		4	TCL PCBs

[1] Includes field duplicates

All drilling activities and soil sampling activities were supervised, logged, and recorded by a TT NUS Environmental field geologist. A lithologic description of each sample was recorded on each boring log in accordance with TT NUS Environmental standard operating procedure (SOP) GH-1.5 (Appendix D of the Phase II RI Work Plan). The boring logs are included in Appendix B. Each boring log contains the following information:

- Sample numbers and types
- Sample depths
- Description of soil material
- Standard Penetration Test data (if applicable)
- Sample recovery and sample interval
- Soil color and moisture

In addition, depths of changes in lithology, depth to water, photoionization detector (PID) readings, and the total depth of each borehole are included on each boring log, where applicable.

Hand auger borings were completed to a maximum depth of 6 feet below ground at 21 locations at Site 1 to obtain subsurface soil samples. After surface samples were collected, a stainless-steel hand bucket auger with an extension bar was used to advance the boring and obtain samples from depth intervals of 6 inches to 2 feet, 2 to 4 feet, and 4 to 6 feet. The sample was removed from the auger bucket with a stainless-steel trowel and transferred directly into the laboratory-supplied sample jar.

Selection criteria for soil samples to be submitted to the laboratory for analysis are presented in the detailed discussion for each site. Soil samples were collected in accordance with TT NUS Environmental SOP GH-1.3 (Appendix D of the Phase II RI Work Plan). Sample identification and chain-of-custody requirements were followed as presented in Section 6 and Section 7 of the Quality Assurance Program Plan (QAPP) (Appendix B of the Phase II RI Work Plan). All pertinent field data were recorded in the field logbook and the appropriate sample log sheet. A sample log sheet was filled out for each soil sample selected for laboratory analysis. Sample log sheets are contained in Appendix C. The number of subsurface soil samples collected and the laboratory analytical program for each site are summarized in Table 2-2.

2.1.2.2 Test Pit Investigation

Nine test pits were excavated at the Antenna Field Landfill (Site 2) in order to directly observe and evaluate the subsurface conditions at this location. Test pits were excavated by Advanced Drilling, Incorporated with a backhoe. Each pit was approximately 3 to 4 feet wide and 10 feet long. The depth of each pit was planned to extend to the maximum depth of wastes and/or fill encountered, to the water table, or to the maximum

reach of the backhoe, whichever was encountered first. The depths of the test pits ranged from 10 to 14 feet. Two of the test pits (02TP01 and 02TP02) were excavated on April 2, 1997. Ground conditions on that day were very wet, and the backhoe became repeatedly stuck at the landfill. The remaining test pits were excavated on May 14 and May 15, 1997 with relatively dry conditions at the site.

Four samples of landfill material were collected and submitted for laboratory analysis from each of the nine trench locations. Four duplicate samples were collected. Samples for analyses were selected based on visual evidence of potential contamination and/or elevated PID readings. In general, no unusual visual evidence or elevated PID readings were encountered. Therefore, grab samples were collected from near the center of each open pit at approximately 2- to 3-foot depth intervals. Detailed notes and logs describing the subsurface conditions encountered, PID readings, and sample locations were maintained for each pit. Test pit logs are contained in Appendix D, and sample log forms are included in Appendix C. Subsurface samples of landfill material and/or soil were submitted to ARDL for TCL VOCs, SVOCs, PCB/pesticides, TAL inorganics, and cyanide analysis. Two of these samples were analyzed for dioxin. A summary of the test pit samples is presented in Table 2-3.

Material excavated during the test-pitting program was placed back in the test pit in accordance with the Phase II RI Work Plan.

2.1.3 PCB Field Screening

One hundred soil samples (both surface and subsurface soil) were analyzed in the field for PCBs during the Phase II activities in 1997. PCB screening was performed during the soil removal action follow-on activities at Site 1. TT NUS Environmental personnel tested selected soil samples from the Privet Road Compound (Site 1) in the field for PCBs to delineate the extent of a previously identified "hot spot." Soil samples at the Fire Training Area (Site 5) were field tested for PCBs to identify and delineate potential PCB impact to soil at that site.

An immunoassay test was used to screen for the presence of PCBs. In this test, the estimated concentration of PCBs is determined by measuring the absorbance of samples and standards using a differential photometer and then comparing the sample results against a calibration curve. Typically, results are used to report concentration as either greater or less than a predetermined action level (e.g., 10 ppm). Detailed methods and procedures for the immunoassay test are discussed in Appendix L.

Duplicate soil samples were submitted to ARDL for PCB analysis as confirmation samples for the immunoassay field-tested samples. Duplicate samples were collected at a rate of one per 10 field-tested samples. Surface and subsurface soil samples collected for PCB field screening and confirmation laboratory

TABLE 2-3

Subsurface Soil (Test Pit) Sampling Summary
NASJRB, Willow Grove, Pennsylvania

Site	Number of Test Pit Trench Locations	Number of Environmental Soil Samples[1]	Analytical Parameters
2	9	40	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and Cyanide.
		2	Dioxin

[1] Includes field duplicates

analysis are summarized in Tables 2-1 and 2-2. Results of the Site 5 field testing are presented in Section 4.

2.1.4 Surface Water Sampling Investigation

Eight surface water samples (six locations) were collected at three sites (Site 2, Site 3, Site 5) and nine samples were collected at eight designated off-base background locations during the 1997 RI activities. Two surface water locations were sampled at Site 5. No surface water samples were obtained during the follow-on activities. The Site 5 specific sampling programs are included in the detailed discussions in Section 4. Surface water was sampled at two locations each of Sites 2, 3, and 5 to obtain initial water quality data. Surface water samples were collected at off-base locations to provide baseline background data. Samples were submitted to ARDL for TCL VOCs, SVOCs, PCB/pesticides, TAL inorganics, and cyanide analysis.

Field measurements were taken for the surface water samples prior to sample collection. The field measurements included pH, temperature, and conductivity and visual estimates of the color and turbidity. All field data were recorded in the field logbook and on the appropriate sample log sheet. Sample log sheets for the surface water sampling program are included in Appendix C. A summary of the surface water samples collected at each site during the Phase II RI is presented in Table 2-4.

2.1.5 Sediment Sampling Investigation

Fourteen sediment samples were collected at 13 locations at Sites 1, 2, 3, and 5, and nine sediment samples were collected from the designated eight off-base background locations during the 1997 RI activities. No sediment samples were obtained during the follow-on activities. Sediments were sampled concurrently from the same locations as surface water for Sites 2, 3, 5, and off-base background. One Site 3 and one Site 1 sediment sample were collected without corresponding surface water samples. All samples were submitted to ARDL for TCL VOCs, SVOCs, PCB/pesticides, TAL inorganics, cyanide, total organic carbon (TOC), and grain size analysis. In addition, five sediment samples at Site 1 were collected from the same locations sampled for the Phase I RI and submitted to ARDL for TCL SVOCs, TOC, and grain size analysis to fill analytical data gaps identified during the scoping process for the current investigation.

Sediment sample log sheets are included in Appendix C. A summary of the sediment samples collected during the Phase II RI is presented in Table 2-5.

2.1.6 Seep Sampling Investigation

Seep sampling was proposed in the Phase I RI investigation for the Antenna Field Landfill Site (Site 2) but samples could not be collected due to drought conditions. Seep samples were collected during the initial

TABLE 2-4
Surface Water Sampling Summary
NASJRB, Willow Grove, Pennsylvania

Site	Number of Surface Water Sample Locations	Number of Environmental Surface Water Samples[1]	Analytical Parameters
2	2	2	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and Cyanide.
3	2	3	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and Cyanide.
5	2	3	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and Cyanide.
Offsite	8	9	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and Cyanide.

[1] Includes field duplicates

TABLE 2-5
Sediment Sampling Summary
NASJRB, Willow Grove, Pennsylvania

Site	Number of Sediment Sample Locations	Number of Environmental Sediment Samples[1]	Analytical Parameters
1	6	5	TCL semivolatiles, TOC, and grain size.
		1	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and Cyanide, TOC, and grain size
2	2	2	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, Cyanide, TOC, and grain size.
3	3	3	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, Cyanide, TOC, and grain size.
5	2	3	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, Cyanide, TOC, and grain size.
Offsite	8	9	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, Cyanide, TOC, and grain size.

[1] Includes field duplicates

Phase II RI investigation to fill this data gap. Seep samples were not collected during the follow-on activities. Four groundwater seep samples (02SP01 through 02SP04) were collected. Sediments were also collected from the fine-grained depositional area that receives surface runoff from the seep at these locations. All aqueous seep samples were analyzed for TCL VOC, TCL semivolatile compounds, PCB/pesticides, and TAL metals. Sediment seep samples were analyzed for TCL VOC, TCL semivolatile compounds, PCB/pesticides, TAL metals, TOC, and grain size.

Field measurements of pH, temperature, and conductivity were taken for each aqueous seep sample, along with visual estimations of the color and turbidity. All field data were recorded in the field log book and the appropriate sample log sheet. Seep water and sediment sample log sheets are included in Appendix C. A summary of the seep sampling is presented in Table 2-6.

2.1.7 Groundwater Investigation

2.1.7.1 Monitoring Well Installation – Initial Field Activities

Monitoring wells were installed at each site to obtain the additional groundwater quality and hydraulic head data needed to fill the data gaps identified during the scoping of this investigation and discussed in the Phase II Work Plan.

A total of 30 monitoring wells were installed within 22 boreholes. The specific locations, numbers, and depths of the wells at each site are presented in the detailed discussion for each. A summary of the Phase II RI monitoring well construction details is provided in Table 2-7.

The target depth for each proposed well was determined by the data needs identified during the scoping process and was based on the local hydrogeology as determined from the previous investigation. For shallow wells, the target depth was from the top of bedrock to a subsurface depth of 75 feet. For the intermediate wells, the target depth was from a subsurface depth of 75 to 150 feet. These target drilling depths were used only as general guidelines. The actual depth of the boreholes varied and was based on the subsurface conditions encountered during the drilling process.

The proposed drilling locations were cleared for potential underground obstructions by the Navy and local utilities before beginning the borings. The boreholes were drilled with a Stratistar-25 air-rotary drilling rig operated by Advanced Drilling, Incorporated. For each bedrock borehole, 10-inch-diameter boreholes were drilled from the ground surface to a depth of at least 5 feet into competent bedrock. Six-inch-diameter steel surface casing was installed and grouted into the bedrock with cement-bentonite grout to hydrogeologically isolate the overburden from the bedrock. This casing also serves as the outer protective casing for the completed well above ground. The grout was allowed to set undisturbed for a

TABLE 2-6
Seep Sampling Summary
NASJRB, Willow Grove, Pennsylvania

Site	Number of Seep Sample Locations	Number of Environmental Seep (aqueous) Samples[1]	Number of Environmental Seep (sediment) Samples[1]	Analytical Parameters
2	4	4		TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and Cyanide.
			4	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, Cyanide, TOC, and grain size.

[1] Includes field duplicates

TABLE 2-7
Initial Phase II RI Monitoring Well Construction Summary
NASJRB, Willow Grove, Pennsylvania

Fire Training Area Site 05			
Borehole Depth	WELL I.D.	screen interval (ft)	screen length
150	05MW01 I	125 - 135	10
170	05MW03 I	118 - 128	10
75	05MW08 S	26 - 36	10
	05MW08 SI	55 - 65	10
150	05MW08 I	89 - 99	10
75	05MW09 S	27 - 32	5
	05MW09 SI	59 - 74	15
150	05MW09 I	96 - 106	10
95	05MW10 S	22 - 32	10
	05MW10 SI	79 - 94	15
130	05MW10 I	116 - 126	10
Ninth Street Landfill Site 03			
Borehole Depth	WELL I.D.	screen interval (ft)	screen length
144	03MW02 SI	55 - 65	10
	03MW02 I	134 - 144	10
150	03MW05 I	82 - 92	10
85	03MW06 S	26 - 36	10
	03MW06 SI	75 - 85	10
150	03MW06 I	140 -150	10
75	03MW07 S	34 - 44	10
Antenna Field Landfill Site 02			
Borehole Depth	WELL I.D.	screen interval (ft)	screen length
105	02MW01 I	70 -80	10
150	02MW03 SI	40 - 55	15
	02MW03 I	140 - 150	10
75	02MW04 S	34 - 44	10
150	02MW04 I	105 - 115	10
Privet Road Compound Site 01			
Borehole Depth	WELL I.D.	screen interval (ft)	screen length
33	01MW01 SO	08 - 18	10
	01MW01 S	23 - 33	10
100	01MW01 I	75 - 85	10
100	01MW03 I	69 - 79	10
34	01MW08 SO	7 - 17	10
	01MW08 S	24 - 34	10
100	01MW08 I	76 - 86	10

minimum of 24 hours. Subsequently, a nominal 6-inch-diameter borehole was drilled in the bedrock until significant water-bearing zones were encountered within the target interval for the respective borehole. A TT NUS Environmental field geologist logged subsurface lithology as determined by the drill cuttings and recorded all drilling information, such as water entry zones, on the boring logs. The borehole and the cuttings were screened with a PID, and readings were recorded in the site logbook and documented in the boring logs. Boring logs are included in Appendix B.

Most of the new boreholes were geophysical logged by the U.S.G.S. to identify subsurface lithology, fractured intervals, water entry or exit zones, and vertical flow direction and quantity. Caliper, gamma ray, single-point resistivity, fluid temperature, fluid resistivity, and thermal-pulse flowmeter logs were run in each borehole. A down-hole video camera/recording system was employed at select locations to obtain a visual record of the inner borehole and potential water entry zones. Two shallow boreholes (01MW01S and 01MW08S) were not geophysical logged. Copies of the geophysical log results are contained in Appendix F.

The vertical interval to be screened in each borehole was determined by evaluating the geophysical logs and the well boring logs. In general, the wells were constructed to monitor the most significant (highest yielding) water-bearing zone within the target interval for that particular borehole. Other factors considered included stratigraphic and vertical separation of the various water-bearing zones already screened in existing wells (if any) at that well cluster.

At some locations, a nested pair of two monitoring wells was installed within one borehole. Typically, this was done in shallow bedrock boreholes in order to monitor both the minimally productive zones usually found at the water table and a higher yielding, deeper fracture within the target interval for the shallow wells.

Monitoring Well Construction

Monitoring wells were constructed with 2-inch-diameter, flush-joint and threaded polyvinyl chloride (PVC) well casing and 2-inch-diameter, Schedule 40, 0.020-inch slotted well screen fitted with a bottom cap. The space between the bottom of the borehole and the bottom of the screen (if any) was backfilled with bentonite and/or cement-bentonite grout to the bottom of the desired monitoring interval and with No. 2 quartz sand from that depth to the bottom of the screen. The annular space between the well screen and the borehole was packed with No. 2 quartz sand to at least 1 foot above the top of the desired monitoring interval. A minimum 2-foot-thick bentonite pellet seal was installed above the sand pack and allowed to hydrate prior to grout emplacement. The remaining annulus was then backfilled with a cement-bentonite grout mixture to within 1 foot of the ground surface or, when two wells were constructed in one borehole, to a depth 2 to 5 feet below the bottom of the shallow well. The depths of all backfill materials were constantly monitored by a TT

NUS Environmental geologist during the well installation process to ensure that bridging did not occur and that the correct construction depths were achieved. Monitoring wells were completed with a 2-foot-square concrete pad at ground level around the stickup pipe, keyed 1 foot into the annular space. A standpipe was installed at two Site 1 locations to house well cluster 1MW01S, 01MW01SO and well cluster 01MW08S, 01MW08SO because these wells had no protective surface casing set into bedrock. Steel/concrete bollards were placed at selected monitoring well sites where the risk of damage from vehicular traffic or maintenance activities exists. A monitoring well construction log was completed for each well. Well construction logs are contained in Appendix B.

Well Development

Most monitoring wells were developed with a submersible pump. The groundwater temperature, pH, conductivity, and turbidity were monitored during development. The wells were developed until these parameters were measured within 10 percent of one another from three consecutive samples and the groundwater became clear. The amount of water removed during well development and the field parameters for each well were recorded in the project field notebooks.

One well at Site 3 (03MW06S) was developed by hand bailing with a disposable Teflon bailer for 2-1/2 hours because of low well yield. A total of 60 gallons were removed and the final water had a very light brown color.

Hand bailing was attempted at Site 1 Well 01MW08SO but yielded only 12 ounces of water with no perceptible recharge. This overburden well was installed upgradient of Site 1 within the same borehole as the shallow bedrock well at this location to monitor the groundwater quality in the overburden prior to any potential impacts from the site. The overburden was dry at the time of monitoring well installation during a very dry summer. It is possible that water samples may be available from this well in the future.

2.1.7.2 Monitoring Well Installation – Field Activities 1998 through 2000

Additional monitoring wells were installed at Site 5 to investigate groundwater quality on Navy property to respond to informal comments on the Phase II RI Report. The wells were installed in accordance with the general requirements included in the original Work Plan and the specific requirements indicated in the Addendum Remedial Investigation Work Plan for Site Investigation at Site 5.

Six monitoring wells were installed, including three wells at a new location (05MW11), one new well location (well 05MW12I), and one well each at cluster locations 4 (05MW04I) and 5 (05MW05I). The

specific locations, numbers, and depths of the wells are presented in the detailed discussion (Section 4). A summary of the follow-on Phase II RI monitoring well construction details is provided in Table 2-8.

The wells at 05MW11 are located near the Navy's property boundary, between the source area at Site 5 and the Horsham Township Water District production well No. 26. These wells are installed at shallow (25 feet), intermediate (50 feet) and deep (149 feet) intervals, to assess the quality of groundwater quality that could potentially migrate from Site 5 toward the public water supply well.

Well 05MW12I was primarily installed to investigate the effects of geologic structure (bedrock dip) on the groundwater flow patterns at Site 5. Wells 05MW04I and 05MW05I were installed to fill additional hydraulic and groundwater quality data gaps. The rationale for the installation of each of these wells is discussed in more detail in Subsection 4.4.1.

Bore hole advancement, monitoring well construction, and well development were performed using methods similar to those described for the initial field activities. Geophysical logs were also generated for the follow-on boring locations. Boring logs, well construction diagrams, and well development records are included in Appendix B.

2.1.7.3 Groundwater Sampling – Phase II RI Activities

Groundwater samples were obtained from all accessible permanent monitoring wells at the four study sites, including the newly installed wells (Phase II RI) and pre-existing wells. Groundwater samples were also obtained from the two Navy supply wells and four monitoring wells at the Air Reserve Station located adjacent to the Private Road Compound (Site 1). Monitoring wells were sampled a minimum of 14 days after development. The groundwater sampling programs specific to each site are presented in the detailed discussions for each site. Four monitoring wells could not be sampled due to field conditions. Wells 01MW08SO (Site 1) and 02MW01I (Site 2) were dry wells. The pump could not be lowered into wells 02MW03S (Site 2) and 03MW01SI (Site 3). Well 02MW03S has apparently collapsed and was filled with sediment to a depth of approximately 3 feet bgs. Well 03MW01SI was damaged, with the casing disjointed approximately 3 feet bgs.

The groundwater sampling program was conducted in accordance with the low-flow sampling procedure (Appendix M) based on EPA Region III (amended) Groundwater Sampling Procedure Low-Flow Purge and Sampling guidance. Monitoring wells were purged prior to sampling using a low-flow submersible pump and disposable polyethylene tubing. Care was taken to place the pump at the prescribed depth within the well screen and to purge the wells at a rate less than the well yield. Purge rates generally did not exceed 1 liter per minute (L/min) and were typically set to the minimum capability of the pump (0.2 L/min to 0.5 L/min)

TABLE 2-8

Follow-on Phase II RI Monitoring Well Construction Summary
NASJRB, Willow Grove, Pennsylvania

Fire Training Area Site 05			
Borehole Depth	WELL I.D.	screen interval (ft)	screen length
150	05MW11I	139 – 149	10
70	05MW11SI	40 - 50	10
	05MW11S	20 - 25	5
151	05MW12I	103.5 – 113.5	10
261	05MW05I	189.5 – 209.5	10
150	05MW04I	74.5 – 84.5	10

shortly after flow was established. Groundwater was directed into a flow-through cell with a multi-probe water quality meter. Each well was purged until the monitored parameters (pH, temperature, conductivity, turbidity, and dissolved oxygen) of three consecutive readings were within 10 percent.

The groundwater samples from the monitoring wells were obtained directly at the discharge point of dedicated, disposable polyethylene tubing. The tubing was detached from the flow-through monitoring cell during sample collection in order to obtain the groundwater directly from the pump and dedicated tubing. The two Navy production wells at Site 1 (01MWNW1 and 01MWNW2) were sampled during normal pumping conditions by collecting water through existing in-line ball valves at each pumphouse.

Groundwater samples from Sites 2, 3, and 5 were analyzed for TCL VOC, TCL SVOCs, TCL pesticides/PCBs, TAL metals, and cyanide. Groundwater samples from the Privet Road Compound (Site 1) were analyzed for TCL VOCs only. Table 2-9 summarizes the groundwater sampling program. All pertinent field data were recorded in the field logbook and on the appropriate sample log sheet. The groundwater sample log sheets are included in Appendix C.

2.1.7.4 Groundwater Sampling – 1998 through 2000 Field Activities

Groundwater samples were obtained from all existing and newly installed permanent monitoring wells at Site 5. Newly installed monitoring wells were sampled a minimum of 14 days after development. More details on the groundwater sampling programs specific to Site 5 are presented in Section 4.

The groundwater sampling program was conducted in accordance with a modified sampling procedure (Appendix M) based on the EPA Region III (amended) Groundwater Sampling Procedure Purge and Sampling guidance. The same procedure is used at the former NAWC Warminster, Pennsylvania, which is located only three miles from NASJRB Willow Grove, in a similar hydrogeological setting.

A total of 30 groundwater samples (26 monitoring wells, 3 duplicates, and 1 re-analysis) were analyzed for TCL VOC and MNA parameters. The MNA parameters included liquid (alkalinity, chloride, ferrous iron, nitrate, nitrite, sulfide, total organic carbon) and gas (carbon dioxide, ethane, ethene, hydrogen, methane, nitrogen, and oxygen) fractions. The VOC samples were analyzed by Severn Trent Services and the MNA parameters were analyzed by Vapor Tech Services. All pertinent field data were recorded in the field logbook and on the appropriate sample log sheet. The groundwater sample log sheets are included in Appendix C.

TABLE 2-9

Initial Field Activities - Ground Water Sampling Summary
NASJRB, Willow Grove, Pennsylvania

Site	Number of Groundwater Sample Locations (Wells)	Number of Environmental Groundwater Samples[1]	Analytical Parameters
1	23	26	TCL VOC
2	6	7	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and Cyanide.
3	17	19	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and Cyanide.
5	21	23	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and Cyanide.

[1] Includes field duplicates

2.1.7.5 Long-Term Water-Level Study – Phase II RI Field Activities

A long-term water-level study was conducted at the Privet Road Compound from March 4 to April 21, 1997. The results of previous investigations and existing data indicated that the groundwater flow conditions at this site were quite complex due to the presence of both unconfined and confined aquifers and the differing effects from the pumping of the Navy supply wells on each aquifer.

Pressure transducers were installed to monitor the water levels in 13 selected wells. Self-contained units (with stand-alone transducer and data logger) and satellite transducers wired into a common data logger were used to collect the water-level readings, which were obtained at 10-minute intervals from each well. A strip chart recorder was installed in Building 6 (Boiler House) to monitor the on-off cycle of the Navy supply wells (NW-1 & NW-2) to relate the water-level data recorded in the Privet Road monitoring wells to the production well pumping cycles. Section 4.5.1 details the field activities for the water-level study and Section 4.3 presents the hydrogeology for the Privet Road Compound site.

2.1.7.6 Static Water Level Measurements – Phase II RI Field Activities

Two rounds of groundwater-level measurements were collected at the four RI sites (on July 2, 1997 and August 7, 1997) to provide hydraulic head data for piezometric elevations and groundwater contour maps. Static water levels were measured in all available wells using an electronic water-level indicator (m-scope) and were recorded to the nearest 0.01 foot. Well 02MW02S at the Antenna Field Landfill (Site 02) was not measured on July 2, 1997 because the well could not be located. Groundwater levels at four monitoring wells (01MWWW1, 01MWWW1B, 01MWWW2, and 01 MWWW3) at the Air Reserve Station adjacent to and northwest of the Privet Road Site (part of the Site 1 investigation) were not collected on July 2, 1997.

2.1.7.7 Static Water Level Measurements – 1998 Through 2000 Field Activities

A base-wide round of water level measurements was performed in October 1998 to assist the USGS to construct of a regional groundwater elevation contour map.

Groundwater-level measurements were recorded at Site 5 on September 11, 2000 to provide hydraulic head data for piezometric elevations and groundwater contour maps. Static water levels were measured in all available wells using an electronic water-level indicator (Herron Water Level Indicator) and were recorded to the nearest 0.01-foot.

2.1.7.8 Evaluation of Geological Structure – 1998 Through 2000 Field Activities

The presence of chlorinated solvents in well 05MW03I, located north and upgradient from the Site 5 source area, prompted theories of another unidentified contaminant source, or that contaminant migration was impacted by geologic structure. In particular, regulators asked if the dip of the sedimentary bedrock units caused either the dissolved-phase groundwater plume or a separate-phase DNAPL to migrate from the source area toward well 05MW03I.

In response to the regulatory concern, well 05MW12I was installed to evaluate the effects of geologic structure (bedrock dip) on the groundwater flow patterns and the potential for plume migration in a different direction than the groundwater flow gradient at Site 5. The work was performed in accordance with the Addendum Remedial Investigation Work Plan for Site Inspection at Site 5. The borehole for well 05MW12I was located downdip (northwest) of the source area. The location and depth of the borehole was based on the site-specific strike and dip directions that were determined through the correlation of the subsurface geophysical logs from Site 5 boreholes.

Site-specific geological structure data, hydrogeologic data, and groundwater quality data were evaluated concurrently to ascertain the most likely contaminant source location(s) and migration potential. Hydraulic head values were compared across potential semi-confining layers. Contaminant concentrations in wells screened below potential confining layers were reviewed, and the potential presence of a DNAPL layer was considered based on contaminant concentrations encountered.

2.1.7.9 Water Level Monitoring Tests – 1998 Through 2000 Field Activities

Between January 14, 2000 and February 7, 2000, a water level investigation was performed to identify potential influence on groundwater flow at Site 5 (and elsewhere) from the operation of the Horsham Township production well number 26 (Well No. 26). Well No. 26 is located off Navy property, approximately 1800 feet south of the Site 5 source area.

The general approach and specific design of the water level measurement test, and the subsequent data review and interpretation, were the responsibility of USGS with on-base field assistance from Tetra Tech NUS. Water level measurements were obtained before and after the shut down/start up of production well 26. Water levels were recorded at on-base and off-base well locations using electronic data loggers, and through direct measurement with water level probes. On-base data were collected by the TtNUS field geologists. Off-base work was performed by the USGS.

2.1.7.10 Rock Core Investigation – 1998 Through 2000 Field Activities

The USGS questioned whether either a DNAPL or a highly concentrated residual phase trapped within the bedrock's primary porosity (pore spaces) could act as a continuing contaminant source. Previous studies from USGS have shown that DNAPL may diffuse into the primary pore space of some sedimentary rocks. The USGS developed an approach and field sampling and analysis design to evaluate the potential for this phenomenon at Site 5. The work was performed in accordance with the Addendum Remedial Investigation Work Plan for Site Inspection at Site 5.

Bedrock core samples were obtained from a borehole drilled within the contaminant source area. The USGS provided a protocol, equipment, and personnel to handle and preserve the samples in the field. TtNUS provided a drilling subcontractor to advance the borehole, and a field geologist to record the lithologic log. The work was completed on September 8, 2000. The rock core samples were analyzed at the USGS National Laboratory.

2.1.7.11 Review and Evaluation of Low-Flow Sampling Procedures

The regulatory community expressed concerns that the low-flow sampling methods used during the Phase II initial field activities may not have been executed in accordance with approved protocols. The Navy was requested to review all Phase II initial field activity groundwater sample acquisition records. The Navy was also requested to compare historical results with the Phase II RI sample results for those samples that were found to have been acquired outside of conformance with accepted low-flow protocol. The ultimate objective was to identify potential impacts on the site conceptual model (and the associated human health risk evaluation) at the site. The Navy and TtNUS completed the review and evaluation in June 1999. The results of this evaluation can be found in Appendix N - Summary of Action Items Evaluation.

2.1.8 Review of EPIC Historical Aerial Photographs

In April 1999, the EPA provided information to the Navy summarizing a review of EPIC historical aerial photographs that indicated various unidentifiable anomalies at or near each of the IRP Sites. The EPA considered these anomalies potential environmental concerns, and requested the Navy to conduct further investigation to assess the potential concerns. The Navy obtained the EPIC aerial photos and completed further review.

The Navy conducted an independent review of the aerial photos and systematically attempted to ascertain the identity of each anomaly, and if an environmental concern existed. The location of each anomaly was determined in relation to current site conditions. Sample location mapping developed for the RI were

reviewed to determine if and to what extent the anomalies were investigated. On-site personnel were interviewed, and a site visit at each location was performed on October 24, 2000.

2.1.9 Site Survey

The newly installed monitoring wells were surveyed for horizontal location and elevation by the Pennsylvania-licensed surveyors GEO-Technical Services, Incorporated, of Harrisburg, Pennsylvania. Class B surveying was performed, allowing for a horizontal closure of 1:10,000 and a high vertical accuracy (at least 0.01-foot). Elevations measured for each well included the ground surface at the well and a designated reference point on the uncapped monitoring well top of inner casing (TOC). Horizontal coordinates are reported to Pennsylvania South Zone-NAD 83 and elevations are reported with respect to NAVD 88. Select existing wells were surveyed to tie in previous survey data and as a check on the new survey data. Vertical elevation data from the previous investigation phases were reported to NGVD 29 and have been converted to NAVD 88 for this report.

Soil borings, surface soil sampling locations, surface water, and sediment, and seep sampling locations were surveyed for horizontal location and elevation. In addition, other significant site features such as building corners or site boundaries were surveyed for horizontal locations as needed to provide adequate site references for improving the quality and accuracy of the site-specific drawings.

2.1.10 Handling of Investigation-Derived Waste

2.1.10.1 Drill Cuttings

All drill cuttings generated during the soil boring and well installation program were field screened with a PID. Drill cuttings from monitoring well boreholes that did not generate elevated organic vapor readings were spread on the ground around the completed well. The soil boring boreholes were backfilled with drill cuttings generated by the drilling or with a cement grout, depending on the presence or absence of organic vapors. Where no elevated organic vapor readings were detected, the borehole was backfilled with soil cuttings. If elevated readings were detected, then the cuttings were isolated and containerized in Department of Transportation (DOT)-approved (Specification 17-C) 55-gallon drums, and the borehole was backfilled with cement grout. Drill cuttings from the Fire Training Area (Site 5) soil borings 05SB17, 05SB19, 05SB21, 05SB22, 05SB24, and 05SB28 produced elevated PID readings and were therefore containerized. The drums were sealed, labeled, and stored at a designated waste holding location pending further testing and ultimate proper disposal of the cuttings. Drill cuttings from well boring FTAW-1D were also containerized and handled in the same manner. Drill cuttings from all other boring locations did not produce any significant

PID readings, so the cuttings were spread around the immediate area of the borehole. Appendix I contains waste disposal records.

2.1.10.2 Development Water

Development water from most of the newly installed monitoring wells was directed away from the wellhead and discharged to the ground surface and allowed to infiltrate the soil. Elevated (above background) PID readings were noted during the drilling at well boring 01MW01S. Therefore, the development water from wells 01MW01S and 01MW01SO was containerized and stored on site pending test results of groundwater from those wells. Appendix I contains waste disposal records.

2.1.10.3 Purge Water

Purge water was directed away from the wellhead and discharged to the ground surface and allowed to infiltrate the soil. Very small quantities of purge water were generated during groundwater sampling due to the low-flow sampling procedure. The quantities of purge water removed from each well are listed on the groundwater sample log sheets which are located in Appendix C.

2.1.10.4 Decontamination Fluids and Drilling Fluids

Steam wash and rinse liquids from the drill rig, tools, and the backhoe bucket were collected at site-specific collection pads. In most cases, the water in the decontamination pads evaporated or was discharged in a manner consistent with the handling of the solids produced during that activity (e.g., drilling auger rinses were allowed to infiltrate the site soil where the corresponding cuttings had been returned to the hole or were spread on the site surface). Decontamination rinse solutions from Site 5, where cuttings from soil borings displayed elevated PID readings, were containerized, held, and sampled. Appendix I contains waste disposal records.

Water produced during the air-rotary drilling was temporarily contained at the head of the borehole in a plastic-lined, bermed holding pad. This water was discharged away from the wellhead and to the local ground surface and allowed to reinfiltrate if PID readings from the borehole were not elevated and there was no possibility of the drilling water flowing to a natural surface water body. At several locations, the drilling water was contained where there were nearby storm drain ditches or a nearby surface water impoundment. In these cases, drilling fluids were pumped from the temporary holding pad to a 4,000-gallon-capacity tank-trailer. The tank trailer was emptied, as needed, to two holding tanks (6,000 gallons each) until the water was sampled, analyzed, and approved for discharge to the NASJRB water treatment facility. Drilling

locations where water was contained and transferred for disposal include the Privet Road Compound (01MW01I, 01MW03I, and 01MW08I) and the Antenna Field Landfill.

2.1.10.5 Personal Protective Equipment (PPE)

PPE was double bagged and disposed off site. PPE and plastic sheeting from the cuttings at Site 5 were containerized and temporarily held pending testing of the cuttings. Appendix I contains waste disposal records.

2.1.11 General Sampling Operations

2.1.11.1 Sample Designation

Each collected sample was assigned a unique sample tracking number. The sample tracking number consisted of a three-segment or four-segment alpha (A)-numeric (N) code that identifies the sample medium and location, sample depth (for subsurface soils), and QA designation if required. Any other pertinent information regarding sample identification was recorded in the field logbooks. Additionally, monitoring wells installed during the previous SI and RI were renamed to fit the Phase II RI designations with a code that expresses the site number, monitoring well (initials), location number, and assigned depth designation; for example, 05MW08SI represents Site 5, monitoring well, location 8, shallow-intermediate.

The alpha-numeric coding used in the sample system is explained in the diagram and the subsequent definitions:

NN	AA	NN	NNNN
Site	Medium	Location	Sample depth

Character Type:

A = Alphabetical

N = Numerical

Site Designation:

01 = Site 1 - Privet Road Compound

02 = Site 2 - Antenna Field Landfill

03 = Site 3 - Ninth Street Landfill

05 = Site 5 - Fire Training Area

BG = background Sampling Location

Medium:

MW = Groundwater sample from a monitoring well

SB = Soil boring sample

SS = Surface soil sample

SW = Surface water sample

SD = Sediment sample

SP = Seep sample (additional designation L-liquid, S-sediment at end of tracking number)

Sample Location:

Subsurface soil	=	soil boring number
Surface soil	=	sample location number from map
Groundwater sample	=	well number
Surface water/sediment	=	sample location number from map
Seeps	=	sample location number from map
Background Sample	=	background sample location number

Sample Depth:

- For soil samples, the two-digit start depth followed by the two-digit final depth (i.e., 0204 is beginning at 2 feet and ending at 4 feet).
- Not used for groundwater, surface water, sediment, or seep samples.

QA Sample Designation

DUP	=	Duplicate
RB	=	Equipment Rinsate Blank
FB	=	Field Blank
TP	=	Trip Blank

Field Duplicate Labels

Field duplicates were designated as DUP-01, DUP-02, etc. so they were submitted to the laboratory "blind." The chain-of-custody form and other documentation submitted to the laboratory were filled out in such a way that the laboratory could not match the duplicates to the original sample. The time on the duplicate samples was noted as 00:00. The correct sample location, time, etc. were documented in the field logbook. Alternately, duplicate samples were assigned a fictitious sample location, depth, and time

to appear as another environmental sample. The correct sample association for the duplicate was documented in the field notebook.

Quality Control Sample Labels

Quality control samples were taken periodically. These samples were used to document the effectiveness of decontamination, to determine the quality of water used for decontamination, and to identify possible cross-contamination occurring during transit. These blank samples, including trip blanks, field blanks, and equipment rinsate blanks, used the QC sample identification scheme, listed below.

Sample Number

A sequential numeric designation was assigned to each type of blank on a daily basis.

Sample Date

The format MMDDYY (M=Month, D=Day, Y=Year) was used to indicate the day the sample was generated.

Example of the Quality Control Labels

The first field blank sample collected on December 4, 1996 would have had the sample identification label FB-01-120496.

Matrix spike and matrix spike duplicate (MS/MSD) samples were designated on the field documentation forms and sample labels.

2.1.12 Sample Handling

Sample Packaging and Shipping

- Samples were packaged and shipped in accordance with TT NUS Environmental SOP SA-6.2. The field operations leader (FOL), or designate, was responsible for completing the following forms:

- Sample labels

- Chain-of-custody forms
- Appropriate labels applied to shipping coolers
- Chain-of-custody seals
- Federal Express air bills

Sample Custody

Custody of the samples was maintained and documented in accordance with procedures described in TT NUS Environmental SOP SA-6.1. Chain-of-custody began with the collection of the samples in the field.

Equipment Decontamination

Equipment involved in field sampling operations, including drilling rigs, backhoe, down-hole tools, augers, and all sampling equipment, was decontaminated before sampling, between individual samples, and after drilling or sampling activities.

The down-hole drilling equipment and sampling tools were cleaned using a high-pressure steam generator (steam jenny) before beginning work, between sample locations (such as test pits, soil borings, soil gas points, etc.), at the completion of the drilling program, and any time the drilling rig left a site before completing a boring. The NASJRB provided potable water directly from fire hydrants. Additional operations followed during drilling equipment decontamination are found in TT NUS SOP GH-1.6.

The sampling equipment used for collecting samples was decontaminated before the beginning of field sampling and between samples. The following decontamination steps were followed:

- Potable water rinse
- Alconox or liquinox detergent wash
- Potable water rinse
- Deionized water rinse
- Air dry

Field analytical equipment such as pH, conductivity, and temperature instrument probes were rinsed first with deionized water, then with the sample liquid.

2.2 COMPARISON TO ARARs and TBCs

All data were evaluated by comparison by medium to applicable or relevant and appropriate requirements (ARARs) or criteria to be considered (TBCs). Exceedences of ARARs and TBCs are detailed in the site-specific nature and extent of contamination narratives. The following ARARs and TBCs are applicable in this evaluation:

- Surface and subsurface soils:

  - Risk based concentration (RBC) for residential soil ingestion
  - RBC for industrial soil ingestion
  - Pennsylvania Department of Environmental Protection (PADEP) soil residential direct contact medium specific concentration (MSC)
  - PADEP soil non-residential MSC

- Surface water:

  - Ambient Water Quality Criterion (AWQC) freshwater aquatic life
  - AWQC ingestion of water and fish
  - PADEP Water Quality Criteria (WQC); continuous concentrations
  - PADEP WQC; human health criteria

- Sediment

  - Sediment ecological toxicity threshold values

- Groundwater

  - Maximum Contaminant Level (MCL)
  - Drinking water health advisory
  - PADEP groundwater MSC
  - RBC for tap water consumption

This section presents available regulatory standards or guidelines for the COPCs discussed in subsequent sections on a site-specific basis. Currently, the only enforceable regulatory standards for exposure to groundwater are EPA MCLs. However, MCLs have not been specified for many of the COPCs. Therefore, other regulatory guidelines may be used for comparative purposes to determine

health risks and environmental impacts. Federal relevant regulatory guidelines referenced include MCLGs, AWQCs, and EPA Drinking Water Health Advisories (DWHAs). Pennsylvania relevant regulatory standards referenced include ACT 2 Human Health Standards for soils (residential and non-residential ingestion of soil and soil to groundwater pathway) and groundwater (groundwater aquifer ingestion), and Title 25 Chapter 16 Water Quality Toxics Management Strategy (fish and aquatic life continuous criteria concentration and human health criteria). Federal and state ARARs and TBCs are presented in Table 2-10. These criteria are discussed briefly below.

Maximum Contaminant Levels (MCLs)

MCLs are enforceable standards promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MCLs are based on laboratory or epidemiological studies and apply to drinking water supplies consumed by a minimum of 25 persons. They are designed for prevention of human health effects associated with lifetime exposure (70 years) of an average adult (weighing 70 kilograms) consuming 2 liters of water per day, but they also reflect technical limits on removing the contaminant from water. These enforceable standards are also based upon the toxicant expected to be absorbed by the gastrointestinal tract.

Maximum Contaminant Level Goals (MCLGs)

MCLGs are generally specified as zero for carcinogenic substances (although exceptions, such as beryllium, do exist) and do not consider the technical or economic feasibility of achieving these goals. MCLGs are nonenforceable guidelines based entirely on health effects. MCLs have been set as close to the MCLGs as technologically and economically feasible.

Drinking Water Health Advisories (DWHAs)

DWHAs are guidelines developed by the EPA Office of Drinking Water for non-regulated contaminants in drinking water. These guidelines are designed to consider both acute and chronic toxic effects in children (with an assumed body weight of 10 kilograms) who consume 1 liter of water per day and in adults (assumed body weight of 70 kilograms) who consume 2 liters of water per day. Health Advisories are generally available for acute (1-day), subchronic (10-day), and chronic (longer-term or lifetime) exposure scenarios. These guidelines are designed to consider only threshold effects and, as such, are not used to set acceptable levels for known or probable human carcinogens.

TABLE 2-10

ARARS AND TO-BE-CONSIDERED CRITERIA
NASJRB, WILLOW GROVE, PENNSYLVANIA

Substance	FEDERAL DRINKING WATER STANDARDS AND GUIDELINES [a]			FEDERAL HEALTH ADVISORIES [a]					FEDERAL AWQC			PADEP ACT 2 HUMAN HEALTH STANDARDS [4]				TITLE 25 CHAPTER 16 WATER QUALITY STANDARDS FOR TOXIC SUBSTANCES [a]	
	Maximum Contaminant Level (MCL) (ug/L)	Maximum Contaminant Level Goal (MCLG) (ug/L)	Secondary Maximum Contaminant Levels (SMCL) (ug/L)	Lifetime Adult (ug/L)	Longer-Term Adult (ug/L)	One-Day Child (ug/L)	Ten-Day Child (ug/L)	Longer-Term Child (ug/L)	Freshwater Chronic Aquatic Life [c] (ug/L)	Ingestion of Water and Fish [b] (ug/L)	Ingestion of Fish Only [b] (ug/L)	PADEP Groundwater MSC <=2,500 TDS (ug/L)	Soils Ingestion Residential (ug/Kg)	Soils Ingestion Non-Residential (ug/Kg)	Soil to Groundwater Pathway (ug/Kg)	Fish and Aquatic Life Criteria Continuous Concentrations (ug/L)	Human Health Criteria (ug/L)
Metals																	
aluminum	-	-	2.00E+02	-	-	-	-	-	-	-	-	-	-	-	-	-	-
antimony	6.00E+00	6.00E+00	-	3.00E+00	1.50E+01	1.00E+01	1.00E+01	1.00E+01	-	1.40E+01	4.30E+03	6.00E+00	3.00E+01	4.00E+02	6.00E-01	2.19E+02	1.00E+01
arsenic	5.00E+01	-	-	-	-	-	-	-	1.89E+02	1.80E-02	1.40E-01	5.00E+01	3.00E+00	4.00E+00	5.00E+00	1.90E+02 [12]	5.00E+01
barium	2.00E+03	2.00E+03	-	2.00E+03	-	-	-	-	-	-	-	2.00E+03	5.00E+03	7.00E+04	2.00E+02	4.10E+03	1.00E+03
beryllium	4.00E+00	4.00E+00	-	-	2.00E+04	3.00E+04	3.00E+04	4.00E+03	-	-	-	4.00E+00	1.00E+00	1.30E+00	4.00E-01	0.01 x 96hr LC50	-
cadmium	5.00E+00	5.00E+00	-	5.00E+00	2.00E+01	4.00E+01	4.00E+01	5.00E+00	1.10E+00 [6]	-	-	5.00E+00	2.00E+01	5.00E+02	5.00E-01	1.00E+00 [6,12]	1.00E+01
chromium, total	1.00E+02 [1]	1.00E+02 [1]	-	1.00E+02 [1]	8.00E+02 [1]	1.00E+03 [1]	1.00E+03 [1]	2.00E+02 [1]	2.09E+02 [6]	-	-	1.00E+02	-	-	-	1.00E+01 [12]	-
cobalt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.90E+01	-
copper	1.30E+03 [2]	1.30E+03	1.00E+03	-	-	-	-	-	1.10E+01 [6]	-	-	1.00E+03	7.00E+02	3.70E+04	1.00E+02	1.10E+01 [6,12]	1.00E+03
cyanide	2.00E+02	2.00E+02	-	2.00E+02	8.00E-02	2.00E+02	2.00E+02	2.00E+02	5.20E+00	7.00E+02	2.20E+05	2.00E+02	1.00E+03	2.00E+04	2.00E+01	5.00E+00	7.00E+02
iron	-	-	3.00E+02	-	-	-	-	-	-	-	-	-	-	-	-	-	-
lead	1.50E+01 [3]	0.00E+00	-	-	-	-	-	-	3.20E+00 [6]	-	-	5.00E+00	5.00E+02	1.00E+03	-	2.50E+00 [6,12]	5.00E+01
manganese	-	-	5.00E+01	-	-	-	-	-	-	-	-	-	-	-	-	-	-
mercury	2.00E+00	2.00E+00	-	2.00E+00	2.00E+00	-	-	-	1.20E-02 [b]	1.40E-01	1.50E-01	2.00E+00	2.00E+01	3.00E+02	-	1.20E-02	1.44E-01
nickel	1.00E+02	1.00E+02	-	1.00E+02	1.70E+03	1.00E+03	1.00E+03	5.00E+02	1.60E+02 [6]	6.10E+02	4.60E+03	1.00E+02	2.00E+02	2.00E+04	-	1.60E+02 [6,12]	6.00E+02
selenium	5.00E+01	5.00E+01	-	-	-	-	-	-	5.00E+00	-	-	5.00E+01	6.00E+01	5.00E+03	5.00E+00	4.60E+00 [6,12]	-
silver	-	-	1.00E+02	1.00E+02	2.00E+02	2.00E+02	2.00E+02	2.00E+02	1.90E+00 [12]	-	-	1.00E+02	-	-	-	2.00E-01	2.00E+02
thallium	2.00E+00	5.00E-01	-	5.00E-01	2.00E+01	7.00E+00	7.00E+00	7.00E+00	- [7]	1.70E+00	6.30E+00	2.00E+00	6.00E+00	8.00E+01	2.00E-01	1.30E+01	-
vanadium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.03E+02	2.00E+00
zinc	-	-	5.00E+03	2.00E+03	1.00E+04	6.00E+03	6.00E+03	3.00E+03	1.01E+02 [6]	-	-	-	-	-	-	1.00E+02 [6,12]	5.00E+03
Pesticides/PCBs																	
4,4'-DDD	-	-	-	-	-	-	-	-	-	8.30E-04	8.40E-04	-	2.00E+04	2.40E+04	5.00E+05	1.00E-03	-
4,4'-DDE	-	-	-	-	-	-	-	-	-	5.90E-04	5.90E-04	-	1.00E+04	1.70E+04	5.00E+05	1.00E-03	N.D
4,4'-DDT	-	-	-	-	-	-	-	-	1.00E-03	5.90E-04	5.90E-04	-	1.00E+04	1.70E+04	5.00E+05	1.00E-03	N.D
aldrin	-	-	-	-	3.00E-01	3.00E-01	3.00E-01	3.00E-01	-	1.30E-04	1.40E-04	2.00E-03	2.60E+02	3.40E+02	5.00E+05	1.00E-01	1.00E-04
alpha-chlordane	2.00E+00 [4]	0.00E+00 [4]	-	-	-	6.00E+01 [4]	6.00E+01 [4]	-	4.30E-03 [4]	5.70E-04 [4]	5.90E-04 [4]	2.00E+00 [4]	3.00E+03	4.00E+03	5.00E+05	4.30E-03 [4]	5.00E-04 [4]
Aroclor-1254 [8]	5.00E-01	0.00E+00	-	-	-	-	-	-	1.40E-02 [8]	4.40E-05	4.50E-05	5.00E-01	5.00E+03	-	-	1.40E-02	4.00E-05
Aroclor-1260 [8]	5.00E-01	0.00E+00	-	-	-	-	-	-	1.40E-02 [8]	4.40E-05	4.50E-05	5.00E-01	5.00E+03	-	-	1.40E-02	4.00E-05
beta-BHC	-	-	-	-	-	-	-	-	-	1.40E-02	4.60E-02	-	2.00E+03	3.00E+03	4.00E+04	-	2.00E-02
dieldrin	-	-	-	-	2.00E+00	5.00E-01	5.00E-01	5.00E-01	-	-	-	2.00E-03	3.00E+02	4.00E+02	9.00E+04	1.90E-03	1.00E-04
endosulfan I	-	-	-	-	-	-	-	-	5.60E-02	9.30E-01	2.00E+00	-	5.00E+05	6.00E+06	7.00E+04	2.30E-03	9.00E-01
endrin	2.00E+00	2.00E+00	-	2.00E+00	1.00E+01	2.00E+01	2.00E+01	3.00E+00	2.30E-03	7.60E-01	8.10E-01	2.00E+00	2.00E+04	3.00E+05	5.00E+05	5.60E-02	8.00E-01
gamma-chlordane	2.00E+00 [4]	0.00E+00 [4]	-	-	-	6.00E+01 [4]	6.00E+01 [4]	-	4.30E-03 [4]	5.70E-04 [4]	5.90E-04 [4]	2.00E+00 [4]	3.00E+03	4.00E+03	5.00E+05	4.30E-03 [4]	5.00E-04 [4]
heptachlor	4.00E-01	0.00E+00	-	-	5.00E+00	1.00E+01	1.00E+01	5.00E+00	3.80E-03	2.10E-04	2.10E-04	4.00E-01	1.00E+03	1.30E+03	4.00E+05	3.80E-03	6.00E-04
heptachlor epoxide	2.00E-01	0.00E+00	-	-	1.00E-01	1.00E+01	-	1.00E-01	3.80E-03	1.00E-04	1.10E-04	2.00E-01	5.00E+02	6.00E+02	5.00E+05	1.00E-01	N.D
Dioxins/Furans																	
2,3,7,8-TCDD	3.00E-05	0.00E+00	-	-	4.00E-05	1.00E-03	1.00E-04	1.00E-05	-	-	-	3.00E-05	3.00E-02	4.00E-02	-	-	1.00E-08
Semivolatiles																	
1,2,4-trichlorobenzene	7.00E+01	7.00E+01	-	4.00E+01	5.00E+02	1.00E+02	1.00E+02	1.00E+02	-	-	-	7.00E+01	8.00E+05	1.00E+07	2.00E+04	2.60E+01	7.00E+02
1,2-dichlorobenzene	6.00E+02	6.00E+02	-	3.00E+03	3.00E+04	9.00E+03	9.00E+03	9.00E+03	-	2.70E+03	1.70E+04	6.00E+02	7.00E+06	9.00E+07	6.00E+04	1.64E+02	4.00E+02 [9]
1,4-dichlorobenzene	7.50E+01	7.50E+01	-	7.50E+01	4.00E+04	1.00E+04	1.00E+04	1.00E+04	- [9]	4.00E+02	2.60E+03	7.50E+01	1.00E+05	2.00E+05	8.00E+03	1.46E+02	4.00E+02 [9]
2,4-dinitrotoluene	-	-	-	-	1.00E+03	5.00E+02	5.00E+02	3.00E+02	-	1.10E-01	2.10E+00	5.00E-02	1.56E+05	2.00E+06	1.00E+03	3.18E+02	5.00E-02
2,6-dinitrotoluene	-	-	-	-	1.00E+03	4.00E+02	4.00E+02	4.00E+02	-	-	-	5.00E-02	7.60E+04	1.00E+06	1.00E+03	1.98E+02	5.00E-02
2-chlorophenol	-	-	-	4.00E+01	2.00E+03	5.00E+02	5.00E+02	5.00E+02	-	-	-	4.00E+01	4.00E+05	5.00E+06	4.00E+03	-	-
2-methylnaphthalene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	-	-	-	-	-
2-methylphenol	-	-	-	1.00E+02	7.00E+03	2.00E+03	2.00E+03	2.00E+03	-	-	-	-	-	-	-	-	-
4-nitrophenol	-	-	-	6.00E+01	3.00E+03	8.00E+02	8.00E+02	8.00E+02	-	-	-	6.00E+01	5.00E+06	6.00E+07	6.00E+03	-	-
acenaphthene	-	-	-	-	-	-	-	-	5.20E+02	1.20E+03	2.70E+03	-	5.00E+06	6.00E+07	3.00E+04	1.70E+01	2.00E+01
acenaphthylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
anthracene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	2.30E+07	3.00E+08	7.00E+04	-	1.00E+04
benzo(a)anthracene	-	-	-	-	-	-	-	-	-	2.80E-03	3.11E-02	-	6.00E+03	8.00E+03	5.00E+05	1.00E-01	3.00E-03
benzo(a)pyrene	2.00E+00	0.00E+00	-	-	-	-	-	-	-	2.80E-03	3.11E-02	2.00E-01	6.00E+02	8.00E+02	5.00E+05	-	3.00E-03

TABLE 2-10

ARARS AND TO-BE-CONSIDERED CRITERIA
NASJRB, WILLOW GROVE, PENNSYLVANIA

Substance	FEDERAL DRINKING WATER STANDARDS AND GUIDELINES [a]			FEDERAL HEALTH ADVISORIES [a]					FEDERAL AWQC			PADEP ACT 2 HUMAN HEALTH STANDARDS [d]				TITLE 25 CHAPTER 16 WATER QUALITY STANDARDS FOR TOXIC SUBSTANCES [e]	
	Maximum Contaminant Level (MCL) (ug/L)	Maximum Contaminant Level Goal (MCLG) (ug/L)	Secondary Maximum Contaminant Levels (SMCL) (ug/L)	Lifetime Adult (ug/L)	Longer-Term Adult (ug/L)	One-Day Child (ug/L)	Ten-Day Child (ug/L)	Longer-Term Child (ug/L)	Freshwater Chronic Aquatic Life [c] (ug/L)	Ingestion of Water and Fish [b] (ug/L)	Ingestion of Fish Only [b] (ug/L)	PADEP Groundwater MSC <=2,500 TDS (ug/L)	Soils Ingestion Residential (ug/Kg)	Soils Ingestion Non-Residential (ug/Kg)	Soil to Groundwater Pathway (ug/Kg)	Fish and Aquatic Life Criteria Continuous Concentrations (ug/L)	Human Health Criteria (ug/L)
benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	2.80E-03	3.11E-02	-	6.00E+03	8.00E+03	5.00E+05	-	3.00E-03
benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	-	-	5.00E+05	-	-
benzo(k)fluoranthene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-02	3.11E-02	-	6.00E+04	8.00E+04	5.00E+05	-	3.00E-03
benzoic acid	-	-	-	-	-	-	-	-	-	-	-	-	3.00E+08	1.00E+09	6.00E+02	-	-
bis(2-ethylhexyl)phthalate	-	0.00E+00	-	-	-	-	-	-	3.00E+00	1.80E+00	5.90E+00	6.00E+00	3.00E+05	4.00E+05	4.00E+05	5.40E+01	-
butylbenzylphthalate	-	-	-	-	-	-	-	-	3.00E+00	3.00E+03	5.20E+03	-	1.60E+07	2.00E+08	1.00E+05	3.50E+01	3.00E+02
carbazole	-	-	-	-	-	-	-	-	3.00E+02	-	-	-	-	-	-	-	-
chrysene	-	-	-	-	-	-	-	-	-	2.80E-03	3.11E-02	-	6.00E+05	8.00E+05	5.00E+05	-	3.00E-03
di-n-butylphthalate	-	-	-	-	-	-	-	-	3.00E+00	2.70E+03	1.20E+04	-	-	-	-	2.10E+01	3.00E+03
di-n-octylphthalate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	6.00E+02	8.00E+02	5.00E+05	-	3.00E-03
dibenzofuran	-	-	-	-	-	-	-	-	3.00E+02	-	-	-	-	-	3.00E+04	-	-
diethylphthalate	-	-	-	5.00E+03	-	-	-	-	3.00E+00	2.30E+04	1.20E+05	5.00E+03	6.00E+07	8.00E+08	5.00E+05	8.00E+02	2.00E+04
fluoranthene	-	-	-	-	-	-	-	-	3.98E+03	4.20E+01	5.40E+01	-	3.00E+06	4.00E+07	4.00E+05	4.00E+01	3.00E+02
fluorene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	3.00E+06	4.00E+07	4.00E+04	-	1.00E+03
indeno(1,2,3-cd)pyrene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	6.00E+03	8.00E+03	5.00E+05	-	3.00E-03
N-nitrosodiphenylamine	-	-	-	2.00E+02	1.00E+03	1.00E+03	1.00E+03	3.00E+02	-	5.00E+00	1.60E+01	-	-	-	1.00E+03	5.90E+01	5.00E+00
naphthalene	-	-	-	2.00E+01	1.00E+03	5.00E+02	5.00E+02	4.00E+02	6.20E+02	-	-	2.00E+01	3.00E+06	4.00E+07	8.00E+03	4.30E+01	1.00E+01
phenanthrene	-	-	-	-	-	-	-	-	-	2.80E-03	3.11E-02	-	-	-	8.00E+04	1.00E+00	-
phenol	-	-	-	4.00E+03	2.00E+04	6.00E+03	6.00E+03	6.00E+03	-	2.10E+04	4.60E+06	4.00E+03	4.00E+07	6.00E+08	4.00E+04	2.00E+01	3.00E+02
pyrene	-	-	-	-	-	-	-	-	-	2.80E-03	3.11E-02	-	2.00E+06	3.00E+07	3.00E+05	-	1.00E+03
Volatiles																	
1,1,1-trichloroethane	2.00E+02	2.00E+02	-	2.00E+02	1.00E+05	1.00E+05	4.00E+04	4.00E+04	3.12E+04	3.10E+03	1.70E+05	2.00E+02	7.00E+06	9.00E+07	2.00E+04	6.05E+02	1.00E+03
1,1,2-trichloroethane	3.00E+00	3.00E+00	-	3.00E+00	1.00E+03	6.00E+02	4.00E+02	4.00E+02	- [7]	6.00E-01	4.20E+01	5.00E+00	3.00E+05	4.00E+06	8.00E+02	6.78E+02	6.00E-01
1,1-dichloroethane	-	-	-	-	-	-	-	-	-	-	-	-	7.00E+06	1.00E+08	5.00E+02	-	-
1,1-dichloroethene	7.00E+00	7.00E+00	-	7.00E+00	4.00E+03	2.00E+03	1.00E+03	1.00E+03	1.16E+04	5.70E-02	3.20E+00	-	7.00E+05	9.00E+06	1.00E+03	1.492E+03	6.00E-02
1,2-dichloroethane	5.00E+00	0.00E+00	-	-	2.60E+03	7.00E+02	7.00E+02	7.00E+02	- [7]	3.80E-01	9.90E+01	5.00E+00	5.00E+04	6.00E+04	5.00E+02	3.088E+03	4.00E-01
1,2-dichloroethane (total)	7.00E+01 [5]	7.00E+01 [5]	-	7.00E+01 [5]	6.00E+03 [5]	4.00E+03 [5]	2.00E+03 [5]	2.00E+03 [5]	1.16E+04	-	-	7.00E+01	8.00E+05	1.00E+07	7.00E+03	1.35E+03	7.00E+02
2-butanone	-	-	-	-	-	-	-	-	-	-	-	-	4.00E+07	6.00E+08	5.00E+01	3.22E+04	2.00E+03
2-hexanone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-methyl-2-pentanone	-	-	-	-	-	-	-	-	-	-	-	-	6.00E+06	8.00E+07	2.00E+02	-	-
acetone	-	-	-	-	-	-	-	-	-	-	-	-	8.00E+06	1.00E+08	3.00E+01	8.60E+04	4.00E+03
benzene	5.00E+00	0.00E+00	-	-	-	2.00E+02	2.00E+02	-	5.30E+03	1.20E+00	7.10E+01	5.00E+00	1.00E+05	2.00E+05	8.00E+02	1.28E+02	1.00E+00
bromodichloromethane	1.00E+02 [11]	0.00E+00 [11]	-	-	1.30E+04	6.00E+03	6.00E+03	4.00E+03	-	2.70E-01	2.20E+01	1.00E+02 [11]	7.00E+04	9.00E+04	1.00E+04	-	3.00E-01
bromoform	1.00E+02 [11]	0.00E+00 [11]	-	-	6.00E+03	5.00E+03	2.00E+03	2.00E+03	-	4.30E+00	3.60E+02	1.00E+02 [11]	5.00E+05	7.00E+05	1.00E+04	3.65E+02	4.00E+00
carbon disulfide	-	-	-	-	-	-	-	-	-	-	-	-	7.00E+06	1.00E+08	8.00E+02	-	-
carbon tetrachloride	5.00E+00	0.00E+00	-	-	3.00E+02	4.00E+03	2.00E+02	7.00E+01	-	-	-	5.00E+00	3.40E+04	4.40E+04	2.10E+03	5.56E+02	3.00E-01
chlorobenzene	-	-	-	-	-	-	-	-	-	6.80E+02	2.10E+04	-	1.00E+06	2.00E+07	1.00E+05	2.36E+02	2.00E+01
chloroform	1.00E+02 [11]	0.00E+00 [11]	-	-	4.00E+02	4.00E+03	4.00E+03	1.00E+02	1.24E+03 [7]	5.70E+00	4.70E+02	1.00E+02 [11]	7.00E+05	9.00E+05	1.00E+04	3.89E+02	6.00E+00
chloromethane	-	-	-	3.00E+00	1.00E+03	9.00E+03	4.00E+02	4.00E+02	-	-	-	1.00E+02	-	-	-	-	-
dibromochloromethane	1.00E+02 [11]	6.00E+01 [11]	-	6.00E+01	8.00E+03	6.00E+03	6.00E+03	2.00E+03	-	4.10E-01	3.40E+01	1.00E+02 [11]	-	-	-	-	4.00E-01
ethylbenzene	7.00E+02	7.00E+02	-	7.00E+02	3.00E+03	3.00E+04	3.00E+03	1.00E+03	3.20E+04	3.10E+03	2.90E+04	7.00E+02	7.00E+06	1.00E+08	7.00E+04	5.80E+02	3.00E+03
methyl tert-butyl ether	-	-	-	2.00E+01	1.20E+04	2.40E+04	2.40E+04	3.00E+03	-	-	-	2.00E+01	4.00E+05	5.00E+06	2.00E+03	-	-
methylene chloride	5.00E+00	0.00E+00	-	2.00E+01	-	1.00E+04	2.00E+03	-	-	4.70E+00	1.60E+03	5.00E+00	6.00E+05	8.00E+05	5.00E+02	2.368E+03	5.00E+00
tetrachloroethene	5.00E+00	0.00E+00	-	-	5.00E+03	2.00E+03	2.00E+03	1.00E+03	8.40E+02 [7]	8.00E-01	8.85E+00	5.00E+00	7.00E+05	1.00E+07	2.00E+03	1.39E+02	7.00E-01
toluene	1.00E+03	1.00E+03	-	1.00E+03	7.00E+03	2.00E+04	2.00E+03	2.00E+03	1.75E+04	1.00E+04	3.00E+05	1.00E+03	1.60E+07	2.00E+08	1.00E+05	3.30E+02	7.00E+03
trichloroethene	5.00E+00	0.00E+00	-	-	-	-	-	-	2.19E+04 [7]	2.70E+00	8.10E+01	5.00E+00	4.00E+05	5.00E+05	2.00E+03	4.50E+02	3.00E+00

TABLE 2-10

ARARS AND TO-BE-CONSIDERED CRITERIA
NASJRB, WILLOW GROVE, PENNSYLVANIA

Substance	FEDERAL DRINKING WATER STANDARDS AND GUIDELINES [a]			FEDERAL HEALTH ADVISORIES [a]					FEDERAL AWQC			PADEP ACT 2 HUMAN HEALTH STANDARDS [d]				TITLE 25 CHAPTER 16 WATER QUALITY STANDARDS FOR TOXIC SUBSTANCES [e]	
	Maximum Contaminant Level (MCL) (ug/L)	Maximum Contaminant Level Goal (MCLG) (ug/L)	Secondary Maximum Contaminant Levels (SMCL) (ug/L	Lifetime Adult (ug/L)	Longer-Term Adult (ug/L)	One-Day Child (ug/L)	Ten-Day Child (ug/L)	Longer-Term Child (ug/L)	Freshwater Chronic Aquatic Life [c] (ug/L)	Ingestion of Water and Fish [b] (ug/L)	Ingestion of Fish Only [b] (ug/L)	PADEP Groundwater MSC <=2,500 TDS (ug/L)	Soils Ingestion Residential (ug/Kg)	Soils Ingestion Non-Residential (ug/Kg)	Soil to Groundwater Pathway (ug/Kg)	Fish and Aquatic Life Criteria Continuous Concentrations (ug/L)	Human Health Criteria (ug/L)
xylene (total)	1.00E+04	1.00E+04	-	1.00E+04	1.00E+05	4.00E+04	4.00E+04	4.00E+04	-	-	-	1.00E+04	-	-	5.00E+03	2.11E+02	3.00E+02

[1] Criteria are for total chromium
[2] Action Level is 1,300 ug/L
[3] Action Level is 15 ug/L
[4] Criteria are for chlordane
[5] Where applicable, value(s) represent the more stringent of criteria for cis- and trans- isomers
[6] Hardness dependent criteria (100 mg/L used)
[7] Insufficient data to develop criteria. Value given is for Lowest Observable Effect Level (LOEL)
[8] Value given is for PCBs
[9] Value given is for dichlorobenzene
[10] pH dependent criteria (pH 7.8 used)
[11] Criteria are for total trihalomethanes
[12] Value is for dissolved metal
[a] EPA. Drinking Water Regulations and Health Advisories. October 1996. EPA 822-B-96-002
[b] EPA. Quality Criteria for Water 1986. Updated 1991 and December 22, 1992
[c] EPA. Quality Criteria for Water 1986. Update 2, May 1, 1987 and Updates December 22, 1992 and May 4, 1995
[d] Land Recycling and Environmental Remediation Standards Act. May 19, 1995. (ACT 2)
[e] Title 25 Chapter 16 Water Quality Toxics Management Strategy. May 18, 1996.

Note: MCLs that are promulgated by EPA are automatically incorporated into the Pennsylvania Safe Drinking Water Act.

Ambient Water Quality Criteria (AWQCs)

AWQCs were developed under the Clean Water Act and are not enforceable federal regulatory guidelines but are of primary utility in assessing the potential for toxic effects in aquatic organisms as well as human receptors. AWQCs consider acute and chronic human health effects from ingestion of both water (2 liters per day) and aquatic organisms (6.5 grams per day). The AWQC may also be adjusted to consider ingestion of water alone (2 liters per day). The AWQC for protection of human health for carcinogenic substances is based on EPA's specified incremental cancer risk range of one additional case of cancer in an exposed population of 100,000 to 10,000,000 persons and is generally based on older toxicological data.

Pennsylvania Regulatory Standards and Guidelines

Pennsylvania Safe Drinking Water Regulations (PA Code, Title 25, Chapter 109) set forth drinking water quality standards at least as stringent as the Federal Drinking Water Standards. MCLs that are promulgated by EPA are automatically incorporated in the Pennsylvania SDWA. If an MCL does not exist for a contaminant, the Pennsylvania SDWA requires the maximum allowable concentration to be determined in the following order: the concentration that EPA has proposed to set or is considered setting as a primary MCL for the contaminant; the concentration associated with a lifetime cancer risk of 10-6 for carcinogenic contaminants or the lifetime drinking water health advisory concentration for noncarcinogenic contaminants, provided that this concentration is equal to or greater than the practical quantitation level and the level achievable through the use of available treatment technology; or the lowest concentration achievable considering the practical quantitation level and available treatment technology.

Pennsylvania Land Recycling and Environmental Standards Act (ACT 2) is the primary law establishing the land recycling program and provides the foundation for standards, procedures, clean-up liability limits, and funding for environmental studies and cleanups. Persons who propose or are required to respond to the release of a regulated substance at a site and who wish to be eligible for clean-up liability protection must select and attain one or more of the environmental standards in ACT 2. The three types of clean-up standards are background, statewide health, and site-specific standards. Background is the concentration of a regulated substance that is present at a site but is not related to the release of regulated substances at the site. Statewide health standards consist of all numerical residential and non-residential standards adopted by PADEP and the federal government. Groundwater in aquifers intended for drinking or agricultural purposes is required to comply with the MCL or Health Advisory Level established for drinking water, except where naturally occurring groundwater has concentrations of total dissolved solids greater than 2,500 mg/L. Site-specific standards are developed using specific risk factors. For site remediation

managed under Act 2, a Notice of Intent to Remediate and public notice are required for cleanups planned to achieve background, statewide health, and site-specific standards. In addition, for cleanups to site-specific standards, there is a public comment period and public involvement.

During data evaluation for the draft RI report, interim Act 2 standards issued by PADEP (revision dated November 1996) were applied for comparison purposes. When available, final promulgated standards will supersede the interim PADEP guidelines.

Pennsylvania Water Quality Standards (PA Code, Title 25, Chapter 93) are based upon water uses that are to be protected and considered by PADEP in its regulation of discharges to surface water. The standards may be applicable for actions involving the discharge of pollutants to surface water.

Pennsylvania Water Quality Toxic Management Strategy-Statement of Policy (PA Code, Title 25, Chapter 16) specifies guidelines and procedures for the development of criteria for toxic substances and lists those limits which have been developed to date. The water quality criteria in Chapter 16 are the numeric limits for stream conditions that need to be maintained or attained to prevent or eliminate pollution and are designed to protect the water uses listed in Chapter 93.

Values of the available regulatory standards and guidelines are presented in Table 2-10. This table presents values for the COPCs that are human, probable human, or possible human carcinogens, for chemicals having only noncarcinogenic effects, and for chemicals having both carcinogenic and noncarcinogenic effects.

2.3 ESTABLISHMENT OF BACKGROUND CONCENTRATIONS

COPC selection is based on a series of statistical tests and comparison to background samples. Background samples were collected in and around NASJRB Willow Grove from media similar in characteristics to on-site samples but from areas outside the known or suspected areas of influence of the sites. Site sampling data are compared to background to determine if contaminants are elevated at a site.

During the Phase II sampling, background samples were obtained from surface soils (BGSS01 through BGSS12) and surface water and associated sediments (BGSW01/BGSD01 through BGSW08/BGSD08). Background sample locations may be found in Figure 2-1. Background surface soil samples were also used for comparison to subsurface soil samples. The significance of and occurrence and distribution of background results, are discussed in the site-specific sections. Results of background sample analysis for surface soils, surface water, and sediment may be found in Tables 2-11, 2-12 and 2-13, respectively.

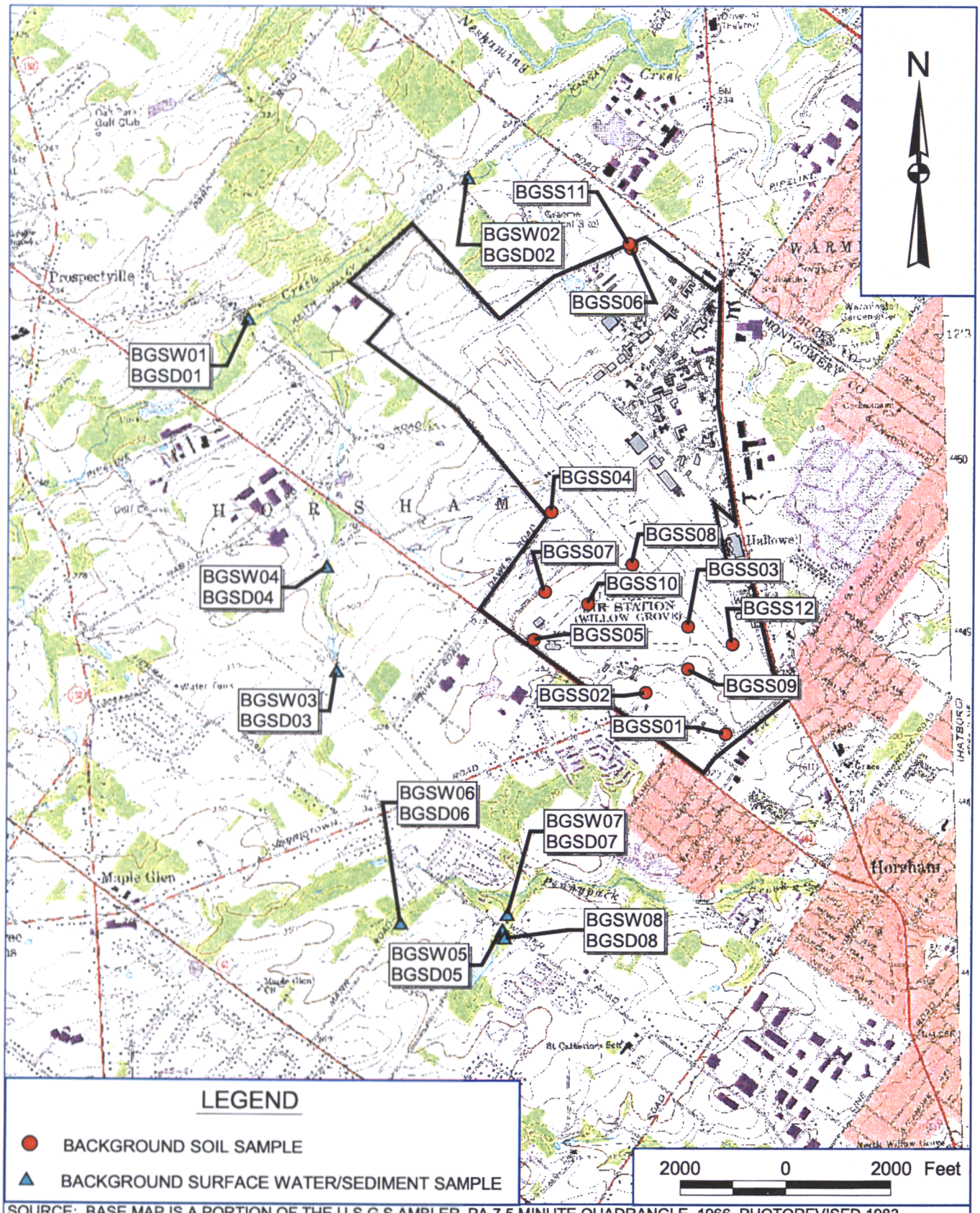
Tables 2-14 through 2-16 present summaries of background sample analytical statistics for each media sampled (groundwater background was not attempted).

Background Comparison Tests

To determine if results of samples from each site were elevated relative to background sample results, an array of statistical tests were performed. The name of each test, the statistical question answered by the test, the assumptions required to run the test, and the criterion used by each test to judge whether site data are greater than background are delineated in the headings and footnotes to each background comparison table presented in the site specific sections. These statistical procedures include three quantitative tests that look for overall differences between the entire populations of site and background data values; four quantitative tests that essentially look for hot spots; and two qualitative tests that examine only the frequency of detection (proportion of detected versus non-detected values in site versus background) but not the magnitude of values.

Each statistical test was run using a decision-making probability level (P-level) of 0.05, which means that, in situations where the test conclusion states that site-related results are greater than background, the chance of the test yielding a false conclusion caused by random variations in the data set is five percent or less. The overall conclusion (whether site results are greater than background) was assumed to be "yes" if any one of the quantitative tests concluded that site data are elevated above background. If no conclusion could be reached for any of the quantitative tests (e.g., if the assumptions necessary to run each of the various tests were not valid), then the overall decision was based on the conclusions of the qualitative tests alone. Further information regarding each statistical test is presented below:

- The means of the two data sets were compared if both site and background matched the same type of distribution (normal or lognormal). If the site and background data exhibited equal standard deviations (based upon Bartlett's test for equal variances), then the student's t-test was applied; otherwise, Satterthwaite's t-test was performed to see if the site mean is greater than the background mean. The t-test is valid only if at least 85 percent of site data and 85 percent of background data are positive detects, there are at least three sampling points in each data set, and the pooled standard deviation is not zero.



SOURCE: BASE MAP IS A PORTION OF THE U.S.G.S AMBLER, PA 7.5 MINUTE QUADRANGLE, 1966. PHOTOREVISED 1983.

DRAWN BY LDL	DATE 8/28/01	Tetra Tech NUS, Inc.	CONTRACT NUMBER 5466 / OWNER No. 2207
CHECKED BY RJT	DATE	BACKGROUND SAMPLE LOCATIONS	APROVED BY / DATE
COST/SCHEDULE-AREA		NASJRB WILLOW GROVE	APROVED BY / DATE
SCALE AS NOTED		WILLOW GROVE, PENNSYLVANIA	DRAWING No. FIGURE 2-1 / REV

TABLE 2-11

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS01		BGSS01-DUP		BGSS02		BGSS03		BGSS04		BGSS05		BGSS06		BGSS07		BGSS08	
LOCATION:	BGSS01		BGSS01		BGSS02		BGSS03		BGSS04		BGSS05		BGSS06		BGSS07		BGSS08	
DATA SOURCE:	Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil	
SAMPLE DATE:	04/07/97		04/07/97		04/07/97		04/07/97		04/07/97		04/07/97		04/07/97		04/07/97		04/07/97	
INORGANICS	**mg/kg**		**mg/kg**		**mg/kg**		**mg/kg**		**mg/kg**		**mg/kg**		**mg/kg**		**mg/kg**		**mg/kg**	
aluminum	10500		8570		9090		12300		12800		9240		15000		11900		10500	
antimony	5.6	UJ	5.2	UJ	8.4	R	5.8	UJ	7.5	R	7.6	R	9.6	R	8.2	R	5.6	R
arsenic	6.1	J	7		3.7	K	10.6		4.4	K	5.6		5.6	J	7.5		8	
barium	95.7		89.9		77.8		108		111		79.5		111		97.9		96.4	
beryllium	0.89		0.86		0.75		1.2		1.2		0.79		1.2		0.84		0.98	
cadmium	1.4	U	1.3	U	1.3	U	1.4	U	1.3	U	1.4	U	1.3	U	1.3	U	1.3	U
calcium	766		690		1530		914		685		939		1500		763		1010	
chromium, total	16.3		14		20.8		15.7		15.9		13.2		17.9		14.5		13.5	
cobalt	8.1		8.2		9.3		6.8		7.8		8.3		8.3		8.5		7.1	
copper	11.3		10.2		11.9		11.7		8		9.8		10.7		10.7		10.1	
cyanide	0.69	U	0.65	U	0.64	U	0.7	U	0.66	U	0.67	U	0.64	U	0.66	U	0.64	U
iron	13200		11500		15700		13200		14100		13900		17600		16900		12800	
lead	37.2		29.8		22.9		29.9		64.7		25.2		19.5		18.1		56.7	
magnesium	1430		1210		1670		1450		1370		1480		1940		1500		1410	
manganese	621		644		514		527		1190		538		684		538		667	
mercury	0.14	U	0.13	U	0.13	U	0.14	U	0.13	U	0.14	U	0.13	U	0.13	U	0.13	U
nickel	9		9.2		9.8		10.3		11.2		9.3		10.4		10.4		9.5	
potassium	418	U	392	U	627		433	U	402	U	771		750		436		618	
selenium	0.28	UL	1.3	UL	1.3	UL	1.4	UL	0.27	UL	1.4	UL	1.3	UL	1.3	UL	1.3	UL
silver	1.4	U	1.3	U	1.3	U	1.4	U	1.3	U	1.4	U	1.3	U	1.3	U	1.3	U
sodium	112	U	104	U	103	U	115	U	107	U	109	U	103	U	105	U	106	U
thallium	0.28	U	0.26	U	0.26	U	0.3		0.27	U	0.27	U	0.28		0.34		0.27	U
vanadium	25.4		22.1		28.2		24.4		24.9		23.8		28.2		25.3		23	
zinc	53.1		42.9		49.4		54.2		597		38.7		47.2		31.7		53	

NOTES:

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TABLE 2-11

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS01		BGSS01-DUP		BGSS02		BGSS03		BGSS04		BGSS05		BGSS06		BGSS07		BGSS08	
LOCATION:	BGSS01		BGSS01		BGSS02		BGSS03		BGSS04		BGSS05		BGSS06		BGSS07		BGSS08	
DATA SOURCE:	Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil	
SAMPLE DATE:	04/07/97		04/07/97		04/07/97		04/07/97		04/07/97		04/07/97		04/07/97		04/07/97		04/07/97	
SEMIVOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	
1,2,4-trichlorobenzene	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
1,2-dichlorobenzene	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
1,3-dichlorobenzene	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
1,4-dichlorobenzene	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
2,2'-oxybis(1-chloropropane)	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
2,4,5-trichlorophenol	1200	U	1100	U	1100	U	1200	U	1100	U	1100	U	1100	UJ	1100	UJ	1100	U
2,4,6-trichlorophenol	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
2,4-dichlorophenol	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
2,4-dimethylphenol	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
2,4-dinitrophenol	1200	U	1100	U	1100	U	1200	U	1100	U	1100	U	1100	UJ	1100	UJ	1100	U
2,4-dinitrotoluene	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
2,6-dinitrotoluene	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
2-chloronaphthalene	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
2-chlorophenol	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
2-methylnaphthalene	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
2-methylphenol	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
2-nitroaniline	1200	U	1100	U	1100	U	1200	U	1100	U	1100	U	1100	UJ	1100	UJ	1100	U
2-nitrophenol	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
3,3'-dichlorobenzidine	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
3-nitroaniline	1200	U	1100	U	1100	U	1200	U	1100	U	1100	U	1100	UJ	1100	UJ	1100	U
4,6-dinitro-2-methylphenol	1200	U	1100	U	1100	U	1200	U	1100	U	1100	U	1100	UJ	1100	UJ	1100	U
4-bromophenyl-phenylether	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
4-chloro-3-methylphenol	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
4-chloroaniline	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U

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TABLE 2-11

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS01		BGSS01-DUP		BGSS02		BGSS03		BGSS04		BGSS05		BGSS06		BGSS07		BGSS08	
LOCATION:	BGSS01		BGSS01		BGSS02		BGSS03		BGSS04		BGSS05		BGSS06		BGSS07		BGSS08	
DATA SOURCE:	Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil	
SAMPLE DATE:	04/07/97		04/07/97		04/07/97		04/07/97		04/07/97		04/07/97		04/07/97		04/07/97		04/07/97	
SEMIVOLATILES	ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg	
4-chlorophenyl-phenylether	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
4-methylphenol	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
4-nitroaniline	1200	U	1100	U	1100	U	1200	U	1100	U	1100	U	1100	UJ	1100	UJ	1100	U
4-nitrophenol	1200	U	1100	U	1100	U	1200	U	1100	U	1100	U	1100	UJ	1100	UJ	1100	U
N-nitroso-di-n-propylamine	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
N-nitrosodiphenylamine (1)	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
acenaphthene	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	61	J
acenaphthylene	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	57	J
anthracene	460	U	430	U	420	U	46	J	440	U	68	J	420	UJ	65	J	110	J
benzo(a)anthracene	460	U	430	U	96	J	220	J	100	J	310	J	33	J	270	J	480	
benzo(a)pyrene	460	U	430	U	110	J	350	J	110	J	400	J	420	UJ	270	J	720	
benzo(b)fluoranthene	460	U	430	U	160	J	540		160	J	550		420	UJ	340	J	990	
benzo(g,h,i)perylene	460	U	430	U	52	J	180	J	440	U	180	J	420	UJ	110	J	300	J
benzo(k)fluoranthene	460	U	430	U	420	U	310	J	98	J	310	J	420	UJ	270	J	660	
bis(2-chloroethoxy)methane	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
bis(2-chloroethyl)ether	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
bis(2-ethylhexyl)phthalate	67	B	130	B	100	B	480	B	60	B	130	B	160	B	150	B	240	B
butylbenzylphthalate	460	U	430	U	280	J	480	U	180	J	83	J	420	UJ	430	UJ	440	U
carbazole	460	U	430	U	420	U	140	J	440	U	80	J	420	UJ	430	UJ	270	J
chrysene	460	U	430	U	130	J	470	J	130	J	460		43	J	320	J	790	
di-n-butylphthalate	820	B	790	B	400	B	840	B	1100	B	1100	B	420	UJ	430	UJ	81	B
di-n-octylphthalate	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
dibenz(a,h)anthracene	460	U	430	U	420	U	52	J	440	U	52	J	420	UJ	430	UJ	83	J
dibenzofuran	460	U	430	U	420	U	51	J	440	U	450	U	420	UJ	430	UJ	120	J
diethylphthalate	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U

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TABLE 2-11

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NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS01	BGSS01-DUP	BGSS02	BGSS03	BGSS04	BGSS05	BGSS06	BGSS07	BGSS08
LOCATION:	BGSS01	BGSS01	BGSS02	BGSS03	BGSS04	BGSS05	BGSS06	BGSS07	BGSS08
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil
SAMPLE DATE:	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
dimethylphthalate	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
fluoranthene	62 J	51 J	270 J	1200	270 J	1000	49 J	670 J	2000
fluorene	460 U	430 U	420 U	59 J	440 U	450 U	420 UJ	430 UJ	160 J
hexachlorobenzene	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
hexachlorobutadiene	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
hexachlorocyclopentadiene	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
hexachloroethane	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
indeno(1,2,3-cd)pyrene	460 U	430 U	62 J	240 J	49 J	220 J	420 UJ	140 J	400 J
isophorone	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
naphthalene	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
nitrobenzene	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
pentachlorophenol	1200 U	1100 U	1100 U	1200 U	1100 U	1100 U	1100 UJ	1100 UJ	1100 U
phenanthrene	460 U	430 U	120 J	990	110 J	650	420 UJ	490 J	1500
phenol	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
pyrene	51 J	46 J	220 J	870	250 J	810	56 J	610 J	1600
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
4,4'-DDD	4.6 U	4.3 U	4.2 U	4.8 U	4.4 U	4.5 U	4.2 U	4.3 U	4.4 U
4,4'-DDE	4.6 U	4.3 U	4.2 U	4.8 U	4.4 U	4.5 U	4.2 U	4.3 U	4.4 U
4,4'-DDT	4.6 U	4.3 U	4.2 U	4.8 U	4.4 U	4.5 U	4.2 U	4.3 U	6.2 J
Aroclor-1016	46 U	43 U	42 U	48 U	44 U	45 U	42 U	43 U	44 U
Aroclor-1221	93 U	88 U	86 U	97 U	89 U	91 U	86 U	88 U	89 U
Aroclor-1232	46 U	43 U	42 U	48 U	44 U	45 U	42 U	43 U	44 U
Aroclor-1242	46 U	43 U	42 U	48 U	44 U	45 U	42 U	43 U	44 U
Aroclor-1248	46 U	43 U	42 U	48 U	44 U	45 U	42 U	43 U	44 U
Aroclor-1254	46 U	43 U	42 U	48 U	44 U	45 U	42 U	43 U	44 U

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- UR -- Non-detected result is considered unusable due to exceedance of technical quality control criteria.
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TABLE 2-11

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS01	BGSS01-DUP	BGSS02	BGSS03	BGSS04	BGSS05	BGSS06	BGSS07	BGSS08
LOCATION:	BGSS01	BGSS01	BGSS02	BGSS03	BGSS04	BGSS05	BGSS06	BGSS07	BGSS08
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil
SAMPLE DATE:	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
Aroclor-1260	46 U	43 U	42 U	48 U	44 U	45 U	42 U	43 U	44 U
aldrin	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	2.3 U
alpha-BHC	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	2.3 U
alpha-chlordane	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	2.3 U
beta-BHC	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	2.3 U
delta-BHC	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	2.3 U
dieldrin	13	14	4.2 U	760	13 J	220	14	86	420
endosulfan I	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	2.3 U
endosulfan II	4.6 U	4.3 U	4.2 U	4.8 U	4.4 U	4.5 U	4.2 U	4.3 U	4.4 U
endosulfan sulfate	4.6 U	4.3 U	4.2 U	4.8 U	4.4 U	4.5 U	4.2 U	4.3 U	4.4 U
endrin	4.6 U	4.3 U	4.2 U	4.8 U	4.4 U	4.5 U	4.2 U	4.3 U	4.4 U
endrin aldehyde	4.6 U	4.3 U	4.2 U	4.8 U	4.4 U	4.5 U	4.2 U	4.3 U	4.4 U
endrin ketone	4.6 U	4.3 U	4.2 U	4.8 U	4.4 U	4.5 U	4.2 U	4.3 U	4.4 U
gamma-BHC (Lindane)	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	2.3 U
gamma-chlordane	2.4 U	2.2 U	2.2 U	10 J	2.3 U	2.3 U	2.2 U	2.2 U	34
heptachlor	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	2.3 U
heptachlor epoxide	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	33
methoxychlor	24 U	22 U	22 U	25 U	23 U	23 U	22 U	22 U	23 U
toxaphene	240 U	220 U	220 U	250 U	230 U	230 U	220 U	220 U	230 U

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TABLE 2-11

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS09		BGSS10		BGSS11		BGSS12		---	---	---	---	---
LOCATION:	BGSS09		BGSS10		BGSS11		BGSS12		---	---	---	---	---
DATA SOURCE:	Surface Soil		Surface Soil		Surface Soil		Surface Soil						
SAMPLE DATE:	04/07/97		04/07/97		04/07/97		04/07/97						
INORGANICS	**mg/kg**		**mg/kg**		**mg/kg**		**mg/kg**						
aluminum	12000		10700		11900		10300						
antimony	8.7	R	6.4	R	8.1	R	8.8	R					
arsenic	6.1	J	7.4		8		6.3						
barium	89.7		90		111		83.7						
beryllium	0.79		1		1.3		0.92						
cadmium	1.2	U	1.3	U	1.3	U	1.3	U					
calcium	614		762		1160		1600						
chromium, total	12.4		13.8		15.3		16						
cobalt	8.2		6.9		8.5		7						
copper	13.4		9.3		9.3		12.7						
cyanide	3.8		0.7		0.64	U	0.66	U					
iron	15700		13300		16700		15500						
lead	16.3		29	K	20.5		31.4						
magnesium	1530		1300		1480		1550						
manganese	429		667		844		477						
mercury	0.12	U	0.13	U	0.13	U	0.13	U					
nickel	10.4		7.4		9.6		10.1						
potassium	460		531		388	U	396	U					
selenium	1.2	UL	1.3	UL	1.3	UL	1.3	UL					
silver	1.2	U	1.3	U	1.3	U	1.3	U					
sodium	120		106	U	103	U	112						
thallium	0.25		0.3		0.29		0.28						
vanadium	20.9		23.7		26.2		26.5						
zinc	21.7		44.6		49.4		45.8						

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TABLE 2-11

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS09		BGSS10		BGSS11		BGSS12		---	---	---	---	---
LOCATION:	BGSS09		BGSS10		BGSS11		BGSS12		---	---	---	---	---
DATA SOURCE:	Surface Soil		Surface Soil		Surface Soil		Surface Soil						
SAMPLE DATE:	04/07/97		04/07/97		04/07/97		04/07/97						
SEMIVOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**						
1,2,4-trichlorobenzene	390	U	440	U	430	U	440	U					
1,2-dichlorobenzene	390	U	440	U	430	U	440	U					
1,3-dichlorobenzene	390	U	440	U	430	U	440	U					
1,4-dichlorobenzene	390	U	440	U	430	U	440	U					
2,2'-oxybis(1-chloropropane)	390	U	440	U	430	U	440	U					
2,4,5-trichlorophenol	990	U	1100	U	1100	U	1100	U					
2,4,6-trichlorophenol	390	U	440	U	430	U	440	U					
2,4-dichlorophenol	390	U	440	U	430	U	440	U					
2,4-dimethylphenol	390	U	440	U	430	U	440	U					
2,4-dinitrophenol	990	U	1100	U	1100	U	1100	U					
2,4-dinitrotoluene	390	U	440	U	430	U	440	U					
2,6-dinitrotoluene	390	U	440	U	430	U	440	U					
2-chloronaphthalene	390	U	440	U	430	U	440	U					
2-chlorophenol	390	U	440	U	430	U	440	U					
2-methylnaphthalene	390	U	440	U	430	U	440	U					
2-methylphenol	390	U	440	U	430	U	440	U					
2-nitroaniline	990	U	1100	U	1100	U	1100	U					
2-nitrophenol	390	U	440	U	430	U	440	U					
3,3'-dichlorobenzidine	390	U	440	U	430	U	440	U					
3-nitroaniline	990	U	1100	U	1100	U	1100	U					
4,6-dinitro-2-methylphenol	990	U	1100	U	1100	U	1100	U					
4-bromophenyl-phenylether	390	U	440	U	430	U	440	U					
4-chloro-3-methylphenol	390	U	440	U	430	U	440	U					
4-chloroaniline	390	U	440	U	430	U	440	U					

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TABLE 2-11

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS09		BGSS10		BGSS11		BGSS12		---	---	---	---	---
LOCATION:	BGSS09		BGSS10		BGSS11		BGSS12		---	---	---	---	---
DATA SOURCE:	Surface Soil		Surface Soil		Surface Soil		Surface Soil						
SAMPLE DATE:	04/07/97		04/07/97		04/07/97		04/07/97						
SEMIVOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**						
4-chlorophenyl-phenylether	390	U	440	U	430	U	440	U					
4-methylphenol	390	U	440	U	430	U	440	U					
4-nitroaniline	990	U	1100	U	1100	U	1100	U					
4-nitrophenol	990	U	1100	U	1100	U	1100	U					
N-nitroso-di-n-propylamine	390	U	440	U	430	U	440	U					
N-nitrosodiphenylamine (1)	390	U	440	U	430	U	440	U					
acenaphthene	390	U	64	J	430	U	55	J					
acenaphthylene	390	U	54	J	430	U	62	J					
anthracene	390	U	130	J	430	U	160	J					
benzo(a)anthracene	390	U	590		430	U	940						
benzo(a)pyrene	390	U	830		430	U	1100						
benzo(b)fluoranthene	390	U	1000		430	U	1500						
benzo(g,h,i)perylene	390	U	320	J	430	U	490						
benzo(k)fluoranthene	390	U	820		430	U	920						
bis(2-chloroethoxy)methane	390	U	440	U	430	U	440	U					
bis(2-chloroethyl)ether	390	U	440	U	430	U	440	U					
bis(2-ethylhexyl)phthalate	92	B	110	B	110	B	130	B					
butylbenzylphthalate	390	U	440	U	430	U	440	U					
carbazole	390	U	310	J	430	U	260	J					
chrysene	390	U	860		430	U	1200						
di-n-butylphthalate	460	B	1000	B	740	B	660	B					
di-n-octylphthalate	390	U	440	U	430	U	440	U					
dibenz(a,h)anthracene	390	U	96	J	430	U	160	J					
dibenzofuran	390	U	120	J	430	U	61	J					
diethylphthalate	390	U	440	U	430	U	440	U					

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TABLE 2-11

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS09		BGSS10		BGSS11		BGSS12		---	---	---	---	---
LOCATION:	BGSS09		BGSS10		BGSS11		BGSS12		---	---	---	---	---
DATA SOURCE:	Surface Soil		Surface Soil		Surface Soil		Surface Soil						
SAMPLE DATE:	04/07/97		04/07/97		04/07/97		04/07/97						
SEMIVOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**						
dimethylphthalate	390	U	440	U	430	U	440	U					
fluoranthene	390	U	2300		430	U	2600						
fluorene	390	U	160	J	430	U	120	J					
hexachlorobenzene	390	U	440	U	430	U	440	U					
hexachlorobutadiene	390	U	440	U	430	U	440	U					
hexachlorocyclopentadiene	390	U	440	U	430	U	440	U					
hexachloroethane	390	U	440	U	430	U	440	U					
indeno(1,2,3-cd)pyrene	390	U	420	J	430	U	640						
isophorone	390	U	440	U	430	U	440	U					
naphthalene	390	U	440	U	430	U	440	U					
nitrobenzene	390	U	440	U	430	U	440	U					
pentachlorophenol	990	U	1100	U	1100	U	1100	U					
phenanthrene	390	U	1600		430	U	1700						
phenol	390	U	440	U	430	U	440	U					
pyrene	390	U	1700		430	U	2100						
PESTICIDES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**						
4,4'-DDD	3.9	U	4.3	U	4.3	U	4.3	U					
4,4'-DDE	3.9	U	4.3	U	4.3	U	4.3	U					
4,4'-DDT	3.9	U	8.3	J	4.3	U	4.3	U					
Aroclor-1016	39	U	43	U	43	U	43	U					
Aroclor-1221	80	U	88	U	87	U	88	U					
Aroclor-1232	39	U	43	U	43	U	43	U					
Aroclor-1242	39	U	43	U	43	U	43	U					
Aroclor-1248	39	U	43	U	43	U	43	U					
Aroclor-1254	39	U	43	U	43	U	43	U					

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TABLE 2-11

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS09		BGSS10		BGSS11		BGSS12		---	---	---	---	---
LOCATION:	BGSS09		BGSS10		BGSS11		BGSS12		---	---	---	---	---
DATA SOURCE:	Surface Soil		Surface Soil		Surface Soil		Surface Soil						
SAMPLE DATE:	04/07/97		04/07/97		04/07/97		04/07/97						
PESTICIDES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**						
Aroclor-1260	39	U	43	U	43	U	43	U					
aldrin	2	U	2.2	U	2.2	U	2.2	U					
alpha-BHC	2	U	2.2	U	2.2	U	2.2	U					
alpha-chlordane	2	U	2.2	U	2.2	U	2.2	U					
beta-BHC	2	U	2.2	U	2.2	U	2.2	U					
delta-BHC	2	U	2.2	U	2.2	U	2.2	U					
dieldrin	3.9	U	550		4.3	U	63	J					
endosulfan I	2	U	2.2	U	2.2	U	2.2	U					
endosulfan II	3.9	U	4.3	U	4.3	U	4.3	U					
endosulfan sulfate	3.9	U	4.3	U	4.3	U	4.3	U					
endrin	3.9	U	4.3	U	4.3	U	4.3	U					
endrin aldehyde	3.9	U	4.3	U	4.3	U	4.3	U					
endrin ketone	3.9	U	4.3	U	4.3	U	4.3	U					
gamma-BHC (Lindane)	2	U	2.2	U	2.2	U	2.2	U					
gamma-chlordane	2	U	48	J	2.2	U	3.2						
heptachlor	2	U	2.2	U	2.2	U	2.2	U					
heptachlor epoxide	2	U	47		2.2	U	3.4	J					
methoxychlor	20	U	22	U	22	U	22	U					
toxaphene	200	U	220	U	220	U	220	U					

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TABLE 2-12

ANALYTICAL RESULTS FOR SURFACE WATER - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSW01		BGSW02		BGSW03		BGSW03-DUP		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
LOCATION:	BGSW01		BGSW02		BGSW03		BGSW03		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
DATA SOURCE:	Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water	
SAMPLE DATE:	03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97	
INORGANICS	**ug/L**		**ug/L**		**ug/L**		**ug/L**		**ug/L**		**ug/L**		**ug/L**		**ug/L**		**ug/L**	
aluminum	226	B	247	B	284	B	561		267	B	236	B	163	B	177	B	301	B
antimony	20	U	20	U	20	U	20	U	20	U	20	U	20	U	20	U	20	U
arsenic	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
barium	93		95.9		93.6		97.2		105		112		87.3		110		109	
beryllium	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
cadmium	5	UL	5	UL	5	UL	5	UL	5	UL	5	UL	5	UL	5	UL	5	UL
calcium	34900		34400		26800		27700		28000		15800		22400		18500		15800	
chromium, total	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U
cobalt	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U
copper	10	U	10	U	10	U	16.6		10	U	10	U	10	U	10	U	10	U
cyanide	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U
iron	222		351		519		751		366		273		85.3		311		326	
lead	1	U	1	U	1	U	1.1		1	U	1	U	1	U	1	U	1	U
magnesium	12100		11800		9740		10100		9750		6290		8260		6940		6250	
manganese	75.7		92		98.5		122		65.8		56.7		26.7		45.1		64.2	
mercury	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U
nickel	20	U	20	U	20	U	31.4		20	U	20	U	20	U	20	U	20	U
potassium	2860		2570		1930		1950		2110		1870		1750		1500	U	1500	U
selenium	1	UL	1	UL	5	U	1	U	1	UL	5	U	5	U	5	U	5	U
silver	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U
sodium	34000		36200		22500		17400		23300		10700		13200		12700		10800	
thallium	1	UL	1	UL	1	UL	1	UL	1	UL	1	UL	1	UL	1	UL	1	UL
vanadium	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U
zinc	5	U	7.8		6.8		18.9		9.1		5	U	5	U	5	U	5	U

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TABLE 2-12

ANALYTICAL RESULTS FOR SURFACE WATER - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSW01		BGSW02		BGSW03		BGSW03-DUP		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
LOCATION:	BGSW01		BGSW02		BGSW03		BGSW03		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
DATA SOURCE:	Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water	
SAMPLE DATE:	03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97	
SEMIVOLATILES	ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L	
1,2,4-trichlorobenzene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
1,2-dichlorobenzene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
1,3-dichlorobenzene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
1,4-dichlorobenzene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2,2'-oxybis(1-chloropropane)	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2,4,5-trichlorophenol	25	U	25	U	25	U	25	U	25	U	25	U	25	U	250	U	25	U
2,4,6-trichlorophenol	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2,4-dichlorophenol	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2,4-dimethylphenol	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2,4-dinitrophenol	25	U	25	U	25	U	25	U	25	U	25	U	25	U	250	U	25	U
2,4-dinitrotoluene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2,6-dinitrotoluene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2-chloronaphthalene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2-chlorophenol	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2-methylnaphthalene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2-methylphenol	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2-nitroaniline	25	U	25	U	25	U	25	U	25	U	25	U	25	U	250	U	25	U
2-nitrophenol	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
3,3'-dichlorobenzidine	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
3-nitroaniline	25	U	25	U	25	U	25	U	25	U	25	U	25	U	250	U	25	U
4,6-dinitro-2-methylphenol	25	U	25	U	25	U	25	U	25	U	25	U	25	U	250	U	25	U
4-bromophenyl-phenylether	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
4-chloro-3-methylphenol	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
4-chloroaniline	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U

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TABLE 2-12

ANALYTICAL RESULTS FOR SURFACE WATER - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSW01	BGSW02	BGSW03	BGSW03-DUP	BGSW04	BGSW05	BGSW06	BGSW07	BGSW08
LOCATION:	BGSW01	BGSW02	BGSW03	BGSW03	BGSW04	BGSW05	BGSW06	BGSW07	BGSW08
DATA SOURCE:	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
SAMPLE DATE:	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97
SEMIVOLATILES	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
4-chlorophenyl-phenylether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
4-methylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
4-nitroaniline	25 U	25 U	25 U	25 U	25 U	25 U	25 U	250 U	25 U
4-nitrophenol	25 U	25 U	25 U	25 U	25 U	25 U	25 U	250 U	25 U
N-nitroso-di-n-propylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
N-nitrosodiphenylamine (1)	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
acenaphthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
acenaphthylene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
benzo(a)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
benzo(a)pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
benzo(b)fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
benzo(g,h,i)perylene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
benzo(k)fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
bis(2-chloroethoxy)methane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
bis(2-chloroethyl)ether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
bis(2-ethylhexyl)phthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
butylbenzylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
carbazole	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
chrysene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
di-n-butylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
di-n-octylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
dibenz(a,h)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
dibenzofuran	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
diethylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U

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ANALYTICAL RESULTS FOR SURFACE WATER - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSW01	BGSW02	BGSW03	BGSW03-DUP	BGSW04	BGSW05	BGSW06	BGSW07	BGSW08
LOCATION:	BGSW01	BGSW02	BGSW03	BGSW03	BGSW04	BGSW05	BGSW06	BGSW07	BGSW08
DATA SOURCE:	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
SAMPLE DATE:	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97
SEMIVOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
dimethylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
fluorene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
hexachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
hexachlorobutadiene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
hexachlorocyclopentadiene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
hexachloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
indeno(1,2,3-cd)pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
isophorone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
naphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
nitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
pentachlorophenol	25 U	25 U	25 U	25 U	25 U	25 U	25 U	250 U	25 U
phenanthrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
phenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2,2-tetrachloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2-trichloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1-dichloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1-dichloroethene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-dichloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-dichloroethene (total)	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-dichloropropane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-butanone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

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TABLE 2-12

ANALYTICAL RESULTS FOR SURFACE WATER - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSW01		BGSW02		BGSW03		BGSW03-DUP		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
LOCATION:	BGSW01		BGSW02		BGSW03		BGSW03		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
DATA SOURCE:	Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water	
SAMPLE DATE:	03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97	
VOLATILES	ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L	
2-hexanone	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
4-methyl-2-pentanone	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
acetone	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
benzene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
bromodichloromethane	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
bromoform	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
bromomethane	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
carbon disulfide	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
carbon tetrachloride	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
chlorobenzene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
chloroethane	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
chloroform	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
chloromethane	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
cis-1,3-dichloropropene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
dibromochloromethane	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
ethylbenzene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
methylene chloride	10	U	10	U	20	B	13	B	16	B	11	B	23	B	7	B	15	B
styrene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
tetrachloroethene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
toluene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
trans-1,3-dichloropropene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
trichloroethene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
vinyl chloride	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
xylene (total)	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U

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NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSW01		BGSW02		BGSW03		BGSW03-DUP		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
LOCATION:	BGSW01		BGSW02		BGSW03		BGSW03		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
DATA SOURCE:	Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water	
SAMPLE DATE:	03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97	
PESTICIDES	ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L	
4,4'-DDD	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
4,4'-DDE	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
4,4'-DDT	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Aroclor-1016	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
Aroclor-1221	2	U	2	U	2	U	2	U	2	U	2	U	2	U	2	U	2	U
Aroclor-1232	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
Aroclor-1242	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
Aroclor-1248	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
Aroclor-1254	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
Aroclor-1260	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
aldrin	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
alpha-BHC	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
alpha-chlordane	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
beta-BHC	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
delta-BHC	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
dieldrin	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
endosulfan I	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
endosulfan II	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
endosulfan sulfate	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
endrin	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
endrin aldehyde	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
endrin ketone	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
gamma-BHC (Lindane)	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
gamma-chlordane	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U

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TABLE 2-12

ANALYTICAL RESULTS FOR SURFACE WATER - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSW01		BGSW02		BGSW03		BGSW03-DUP		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
LOCATION:	BGSW01		BGSW02		BGSW03		BGSW03		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
DATA SOURCE:	Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water	
SAMPLE DATE:	03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97	
PESTICIDES	**ug/L**		**ug/L**		**ug/L**		**ug/L**		**ug/L**		**ug/L**		**ug/L**		**ug/L**		**ug/L**	
heptachlor	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
heptachlor epoxide	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
methoxychlor	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U
toxaphene	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U

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TABLE 2-13

ANALYTICAL RESULTS FOR SEDIMENT - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSD01		BGSD02		BGSD03		BGSD03-DUP		BGSD04		BGSD05		BGSD06		BGSD07		BGSD08	
LOCATION:	BGSD01		BGSD02		BGSD03		BGSD03		BGSD04		BGSD05		BGSD06		BGSD07		BGSD08	
DATA SOURCE:	Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment	
SAMPLE DATE:	03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97	
INORGANICS	**mg/kg**		**mg/kg**		**mg/kg**		**mg/kg**		**mg/kg**		**mg/kg**		**mg/kg**		**mg/kg**		**mg/kg**	
aluminum	8950		7330		5750		10900		6000		3610		8510		4690		5580	
antimony	12.6	R	5.5	UJ	7.8	UJ	7.8	UJ	6.2	UJ	4.6	UJ	11.1	R	5.1	UJ	5.5	R
arsenic	7.2		3.7		5		5.6		4.1		3.2		4		4.9		4	
barium	105		54.6		142		179		106		76.2		81.2		82.4		120	
beryllium	1.2		0.52		1.1		1.3		0.81		0.6		1.1		0.61		0.98	
cadmium	1.2	UL	1.4	UL	2	UL	1.9	UL	1.6	UL	1.1	UL	1.2	UL	1.3	UL	1.4	UL
calcium	14800		744		1850		2070		1060		878		18200		1080		1130	
chromium, total	34.5		9.7		10.9		16.5		13.5		6.8		29.3		8.7		9.2	
cobalt	12.4		5.8		5.5		7.7		6.8		4.5		9.8		4.9		6.9	
copper	27.8		11.3		11.9		13.7		10.9		5.8		22.1		7.4		8.8	
cyanide	0.61	U	0.68	U	0.97	U	0.96	U	0.77	U	0.56	U	0.58	U	0.62	U	0.67	U
iron	35400		10500		11400		15000		13700		9540		25400		9660		14300	
lead	18.7		20.4		26.8		28.4		19.6		6.4		8.6		10.6		10.4	
magnesium	9100		1000		1130		1670		999		1350		10600		1450		1600	
manganese	759		384		416		551		573		376		529		388		618	
mercury	0.12	U	0.14	U	0.2	U	0.19	U	0.16	U	0.11	U	0.12	U	0.13	U	0.14	U
nickel	22.7		6.8	K	12.5		16.1		9.1		7.8	K	19.1		10.1		9.7	
potassium	2330		514		586	U	825		467	U	775		2330		721		921	
selenium	0.24	UJ	0.27	UJ	0.44	J	0.51	J	0.36	J	0.23	UJ	0.23	UJ	0.25	UJ	0.27	UJ
silver	1.2	U	1.4	U	2	U	1.9	U	1.6	U	1.1	U	1.2	U	1.3	U	1.4	U
sodium	560		109	U	156	U	155	U	125	U	91.7	U	240		101	U	109	U
thallium	0.24	U	0.27	U	0.39	U	0.39	U	0.31	U	0.23	U	0.23	U	0.25	U	0.27	U
vanadium	52.6		12.2		20.3		25.8		18.8		7.9		42.8		11.9		11.9	
zinc	97.6		39.5		43.9		60		51.3		25.4		80.4		28.2		35	

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TABLE 2-13

ANALYTICAL RESULTS FOR SEDIMENT - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSD01		BGSD02		BGSD03		BGSD03-DUP		BGSD04		BGSD05		BGSD06		BGSD07		BGSD08	
LOCATION:	BGSD01		BGSD02		BGSD03		BGSD03		BGSD04		BGSD05		BGSD06		BGSD07		BGSD08	
DATA SOURCE:	Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment	
SAMPLE DATE:	03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97	
SEMIVOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	
1,2,4-trichlorobenzene	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
1,2-dichlorobenzene	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
1,3-dichlorobenzene	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
1,4-dichlorobenzene	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
2,2'-oxybis(1-chloropropane)	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
2,4,5-trichlorophenol	1000	U	1100	U	1600	U	1600	U	1300	U	950	U	960	U	1100	U	1100	U
2,4,6-trichlorophenol	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
2,4-dichlorophenol	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
2,4-dimethylphenol	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
2,4-dinitrophenol	1000	U	1100	U	1600	U	1600	U	1300	U	950	U	960	U	1100	U	1100	U
2,4-dinitrotoluene	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
2,6-dinitrotoluene	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
2-chloronaphthalene	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
2-chlorophenol	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
2-methylnaphthalene	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
2-methylphenol	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
2-nitroaniline	1000	U	1100	U	1600	U	1600	U	1300	U	950	U	960	U	1100	U	1100	U
2-nitrophenol	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
3,3'-dichlorobenzidine	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
3-nitroaniline	1000	U	1100	U	1600	U	1600	U	1300	U	950	U	960	U	1100	U	1100	U
4,6-dinitro-2-methylphenol	1000	U	1100	U	1600	U	1600	U	1300	U	950	U	960	U	1100	U	1100	U
4-bromophenyl-phenylether	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
4-chloro-3-methylphenol	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
4-chloroaniline	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U

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TABLE 2-13

ANALYTICAL RESULTS FOR SEDIMENT - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSD01		BGSD02		BGSD03		BGSD03-DUP		BGSD04		BGSD05		BGSD06		BGSD07		BGSD08	
LOCATION:	BGSD01		BGSD02		BGSD03		BGSD03		BGSD04		BGSD05		BGSD06		BGSD07		BGSD08	
DATA SOURCE:	Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment	
SAMPLE DATE:	03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97	
SEMIVOLATILES	ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg	
4-chlorophenyl-phenylether	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
4-methylphenol	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
4-nitroaniline	1000	U	1100	U	1600	U	1600	U	1300	U	950	U	960	U	1100	U	1100	U
4-nitrophenol	1000	U	1100	U	1600	U	1600	U	1300	U	950	U	960	U	1100	U	1100	U
N-nitroso-di-n-propylamine	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
N-nitrosodiphenylamine (1)	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
acenaphthene	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
acenaphthylene	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
anthracene	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
benzo(a)anthracene	580		450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
benzo(a)pyrene	530	J	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
benzo(b)fluoranthene	670	J	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
benzo(g,h,i)perylene	400	UJ	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
benzo(k)fluoranthene	300	J	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
bis(2-chloroethoxy)methane	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
bis(2-chloroethyl)ether	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
bis(2-ethylhexyl)phthalate	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
butylbenzylphthalate	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
carbazole	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
chrysene	640		450	U	130	J	90	J	110	J	380	U	380	U	420	U	450	U
di-n-butylphthalate	400	UJ	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
di-n-octylphthalate	400	UJ	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
dibenz(a,h)anthracene	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
dibenzofuran	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U
diethylphthalate	400	U	450	U	650	U	640	U	510	U	380	U	380	U	420	U	450	U

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TABLE 2-13

ANALYTICAL RESULTS FOR SEDIMENT - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSD01	BGSD02	BGSD03	BGSD03-DUP	BGSD04	BGSD05	BGSD06	BGSD07	BGSD08
LOCATION:	BGSD01	BGSD02	BGSD03	BGSD03	BGSD04	BGSD05	BGSD06	BGSD07	BGSD08
DATA SOURCE:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
SAMPLE DATE:	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97
SEMIVOLATILES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
dimethylphthalate	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
fluoranthene	510	100 J	210 J	140 J	170 J	380 U	380 U	420 U	450 U
fluorene	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
hexachlorobenzene	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
hexachlorobutadiene	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
hexachlorocyclopentadiene	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
hexachloroethane	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
indeno(1,2,3-cd)pyrene	400 UJ	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
isophorone	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
naphthalene	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
nitrobenzene	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
pentachlorophenol	1000 U	1100 U	1600 U	1600 U	1300 U	950 U	960 U	1100 U	1100 U
phenanthrene	260 J	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
phenol	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
pyrene	1300	100 J	190 J	120 J	150 J	380 U	380 U	420 U	450 U
VOLATILES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
1,1,1-trichloroethane	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
1,1,2,2-tetrachloroethane	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
1,1,2-trichloroethane	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
1,1-dichloroethane	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
1,1-dichloroethene	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
1,2-dichloroethane	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
1,2-dichloroethene (total)	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
1,2-dichloropropane	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
2-butanone	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U

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TABLE 2-13

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NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSD01		BGSD02		BGSD03		BGSD03-DUP		BGSD04		BGSD05		BGSD06		BGSD07		BGSD08	
LOCATION:	BGSD01		BGSD02		BGSD03		BGSD03		BGSD04		BGSD05		BGSD06		BGSD07		BGSD08	
DATA SOURCE:	Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment	
SAMPLE DATE:	03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97	
VOLATILES	ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg	
2-hexanone	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
4-methyl-2-pentanone	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
acetone	38	B	51	B	20	U	19	U	91	B	12	U	12	U	13	U	14	U
benzene	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
bromodichloromethane	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
bromoform	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
bromomethane	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
carbon disulfide	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
carbon tetrachloride	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
chlorobenzene	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
chloroethane	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
chloroform	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
chloromethane	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
cis-1,3-dichloropropene	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
dibromochloromethane	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
ethylbenzene	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
methylene chloride	8	B	9	B	20	U	19	U	11	B	12	U	12	U	13	U	14	U
styrene	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
tetrachloroethene	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
toluene	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
trans-1,3-dichloropropene	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
trichloroethene	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
vinyl chloride	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U
xylene (total)	12	U	14	U	20	U	19	U	16	U	12	U	12	U	13	U	14	U

NOTES:

J -- Value is considered estimated due to exceedance of technical quality control criteria or because result is less than the Contract Required Quantitation Limit (CRQL).
U -- *Value is a non-detected result as reported by the laboratory.*
UJ -- Non-detected result is considered estimated due to exceedance of technical quality control criteria.
UL -- Non-detected result is considered biased low due to exceedance of technical quality control criteria.
UR -- Non-detected result is considered unusable due to exceedance of technical quality control criteria.
L -- Positive result is considered biased low due to exceedance of technical quality control criteria.
K -- Positive result is considered biased high due to exceedance of technical quality control criteria.
B -- Positive result is considered to be an artifact of blank contamination, and should not be considered present.
R -- Positive result is considered unusable due to exceedance of technical quality control criteria.

TABLE 2-13

ANALYTICAL RESULTS FOR SEDIMENT - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSD01		BGSD02		BGSD03		BGSD03-DUP		BGSD04		BGSD05		BGSD06		BGSD07		BGSD08	
LOCATION:	BGSD01		BGSD02		BGSD03		BGSD03		BGSD04		BGSD05		BGSD06		BGSD07		BGSD08	
DATA SOURCE:	Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment	
SAMPLE DATE:	03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97	
PESTICIDES	ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg	
4,4'-DDD	4	U	4.5	U	6.4	U	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
4,4'-DDE	4	U	4.5	U	6.4	U	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
4,4'-DDT	4	U	4.5	U	6.4	U	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
Aroclor-1016	40	U	45	U	65	U	64	U	51	U	38	U	38	U	42	U	45	U
Aroclor-1221	82	U	91	U	130	U	130	U	100	U	77	U	78	U	85	U	91	U
Aroclor-1232	40	U	45	U	65	U	64	U	51	U	38	U	38	U	42	U	45	U
Aroclor-1242	40	U	45	U	65	U	64	U	51	U	38	U	38	U	42	U	45	U
Aroclor-1248	40	U	45	U	65	U	64	U	51	U	38	U	38	U	42	U	45	U
Aroclor-1254	40	U	45	U	65	U	64	U	51	U	38	U	38	U	42	U	45	U
Aroclor-1260	40	U	45	U	65	U	64	U	51	U	38	U	38	U	42	U	45	U
aldrin	2.1	U	2.3	U	3.3	U	3.3	U	2.6	U	1.9	U	2	U	2.1	U	2.3	U
alpha-BHC	2.1	U	2.3	U	3.3	U	3.3	U	2.6	U	1.9	U	2	U	2.1	U	2.3	U
alpha-chlordane	2.1	U	2.3	U	3.3	U	3.3	U	2.6	U	1.9	U	2	U	2.1	U	2.3	U
beta-BHC	2.1	U	2.3	U	3.3	U	3.3	U	2.6	U	1.9	U	2	U	2.1	U	2.3	U
delta-BHC	2.1	U	2.3	U	3.3	U	3.3	U	2.6	U	1.9	U	2	U	2.1	U	2.3	U
dieldrin	4	U	4.5	U	3.1	J	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
endosulfan I	2.1	U	2.3	U	3.3	U	3.3	U	2.6	U	1.9	U	2	U	2.1	U	2.3	U
endosulfan II	4	U	4.5	U	6.4	U	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
endosulfan sulfate	4	U	4.5	U	6.4	U	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
endrin	4	U	4.5	U	6.4	U	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
endrin aldehyde	4	U	4.5	U	6.4	U	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
endrin ketone	4	U	4.5	U	6.4	U	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
gamma-BHC (Lindane)	2.1	U	2.3	U	3.3	U	3.3	U	2.6	U	1.9	U	2	U	2.1	U	2.3	U
gamma-chlordane	2.1	U	2.3	U	3.3	U	3.3	U	2.6	U	1.9	U	2	U	2.1	U	2.3	U

NOTES:

- J -- Value is considered estimated due to exceedance of technical quality control criteria or because result is less than the Contract Required Quantitation Limit (CRQL).
- U -- Value is a non-detected result as reported by the laboratory.
- UJ -- Non-detected result is considered estimated due to exceedance of technical quality control criteria.
- UL -- Non-detected result is considered biased low due to exceedance of technical quality control criteria.
- UR -- Non-detected result is considered unusable due to exceedance of technical quality control criteria.
- L -- Positive result is considered biased low due to exceedance of technical quality control criteria.
- K -- Positive result is considered biased high due to exceedance of technical quality control criteria.
- B -- Positive result is considered to be an artifact of blank contamination, and should not be considered present.
- R -- Positive result is considered unusable due to exceedance of technical quality control criteria.

TABLE 2-13

ANALYTICAL RESULTS FOR SEDIMENT - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSD01	BGSD02	BGSD03	BGSD03-DUP	BGSD04	BGSD05	BGSD06	BGSD07	BGSD08
LOCATION:	BGSD01	BGSD02	BGSD03	BGSD03	BGSD04	BGSD05	BGSD06	BGSD07	BGSD08
DATA SOURCE:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
SAMPLE DATE:	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97
PESTICIDES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
heptachlor	2.1 U	2.3 U	3.3 U	3.3 U	2.6 U	1.9 U	2 U	2.1 U	2.3 U
heptachlor epoxide	2.1 U	2.3 U	3.3 U	3.3 U	2.6 U	1.9 U	2 U	2.1 U	2.3 U
methoxychlor	21 U	23 U	33 U	33 U	27 U	20 U	20 U	22 U	23 U
toxaphene	210 U	230 U	330 U	330 U	270 U	200 U	200 U	220 U	230 U

NOTES:

- J -- Value is considered estimated due to exceedance of technical quality control criteria or because result is less than the Contract Required Quantitation Limit (CRQL).
- U -- Value is a non-detected result as reported by the laboratory.
- UJ -- Non-detected result is considered estimated due to exceedance of technical quality control criteria.
- UL -- Non-detected result is considered biased low due to exceedance of technical quality control criteria.
- UR -- Non-detected result is considered unusable due to exceedance of technical quality control criteria.
- L -- Positive result is considered biased low due to exceedance of technical quality control criteria.
- K -- Positive result is considered biased high due to exceedance of technical quality control criteria.
- B -- Positive result is considered to be an artifact of blank contamination, and should not be considered present.
- R -- Positive result is considered unusable due to exceedance of technical quality control criteria.

TABLE 2-14
Background Statistics - Soil Data
NASJRB Willow Grove, Pennsylvania

Substance	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	95 % Upper Tolerance Limit (UTL) Back. Mean[a]	Std.Dev. Back.[a]	t Value	L,N Q	Back. UTL
aluminum	12/12	9090	15000	11300	BGSS06 04/07/97	9.32	0.149	1.7959	L	14700
antimony	0/2	-			NA					
arsenic	12/12	3.7	10.6	6.65	BGSS03 04/07/97	1.86	0.283	1.7959	L	10.9
barium	12/12	77.8	111	95.7	BGSS04 04/07/97	4.55	0.13	1.7959	L	121
beryllium	12/12	0.75	1.3	0.987	BGSS11 04/07/97	-0.0301	0.192	1.7959	L	1.39
cadmium	0/12	-			NA					
calcium	12/12	614	1600	1020	BGSS12 04/07/97	6.87	0.332	1.7959	L	1800
chromium	12/12	12.4	20.8	15.3	BGSS02 04/07/97	2.72	0.141	1.7959	L	19.8
cobalt	12/12	6.8	9.3	7.9	BGSS02 04/07/97	7.9	0.788	1.7959	N	9.38
copper	12/12	8	13.4	10.7	BGSS09 04/07/97	10.7	1.54	1.7959	N	13.6
cyanide	2/12	0.7	3.8	0.649	BGSS09 04/07/97	0.649				
iron	12/12	12350	17600	14800	BGSS06 04/07/97	9.6	0.119	1.7959	L	18400
lead	12/12	16.3	64.7	30.6	BGSS04 04/07/97	3.33	0.428	1.7959	L	62.2
magnesium	12/12	1300	1940	1500	BGSS06 04/07/97	7.31	0.108	1.7959	L	1830
manganese	12/12	429	1190	642	BGSS04 04/07/97	6.43	0.277	1.7959	L	1040
mercury	0/12	-			NA					
nickel	12/12	7.4	11.2	9.79	BGSS04 04/07/97	9.79	0.954	1.7959	N	11.6
potassium	7/12	436	771	434	BGSS05 04/07/97	434				
selenium	0/12	-			NA					
silver	0/12	-			NA					
sodium	2/12	112	120	63.7	BGSS09 04/07/97	63.7				
thallium	7/12	0.25	0.34	0.226	BGSS07 04/07/97	0.226				
vanadium	12/12	20.9	28.2	24.9	BGSS02 04/07/97	24.9	2.13	1.7959	N	28.9
zinc	12/12	21.7	597	90.1	BGSS04 04/07/97	90.1				
4,4'-DDD	0/12	-			NA					
4,4'-DDE	0/12	-			NA					
4,4'-DDT	2/12	6.2	8.3	3.01	BGSS10 04/07/97	3.01				

TABLE 2-14
Background Statistics - Soil Data
NASJRB Willow Grove, Pennsylvania

Substance	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	95 % Upper Tolerance Limit (UTL) Back. Mean[@]	Std.Dev. Back.[@]	t Value	L,N Q	Back. UTL
Aroclor-1254	0/12	-			NA					
Aroclor-1260	0/12	-			NA					
beta-BHC	0/12	-			NA					
dieldrin	9/12	13	760	179	BGSS03 04/07/97	179				
endosulfan I	0/12	-			NA					
endrin	0/12	-			NA					
heptachlor	0/12	-			NA					
heptachlor epoxide	3/12	3.4	47	7.79	BGSS10 04/07/97	7.79				
1,2,4-trichlorobenzene	0/12	-			NA					
1,2-dichlorobenzene	0/12	-			NA					
1,4-dichlorobenzene	0/12	-			NA					
2-methylnaphthalene	0/12	-			NA					
2-methylphenol	0/12	-			NA					
acenaphthene	3/12	55	64	178	BGSS10 04/07/97	178				
acenaphthylene	3/12	54	62	177	BGSS12 04/07/97	177				
anthracene	6/12	46	160	154	BGSS12 04/07/97	154				
benz(a)anthracene	9/12	33	940	306	BGSS12 04/07/97	306				
benzo(a)pyrene	8/12	110	1100	394	BGSS12 04/07/97	394				
benzo(b)fluoranthene	8/12	160	1500	507	BGSS12 04/07/97	507				
benzo(g,h,i)perylene	7/12	52	490	225	BGSS12 04/07/97	225				
benzo(k)fluoranthene	7/12	98	920	370	BGSS12 04/07/97	370				
butylbenzylphthalate	3/12	83	280	208	BGSS02 04/07/97	208				
carbazole	5/12	80	310	212	BGSS10 04/07/97	212				
chrysene	9/12	43	1200	420	BGSS12 04/07/97	420				
di-n-butylphthalate	0/2	-			NA					
dibenz(a,h)anthracene	5/12	52	160	161	BGSS12 04/07/97	161				
dibenzofuran	4/12	51	120	172	BGSS08 04/07/97	172				

TABLE 2-14

Background Statistics - Soil Data
NASJRB Willow Grove, Pennsylvania

Substance	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	95 % Upper Tolerance Limit (UTL) Back. Mean@	Std.Dev. Back.@	t Value	L,N Q	Back. UTL
fluoranthene	10/12	49	2600	902	BGSS12 04/07/97	902				
fluorene	4/12	59	160	184	BGSS08 04/07/97	184				
indeno(1,2,3-cd)pyrene	8/12	49	640	251	BGSS12 04/07/97	251				
N-nitrosodiphenylamine (1)	0/12	-			NA					
naphthalene	0/12	-			NA					
phenanthrene	8/12	110	1700	667	BGSS12 04/07/97	667				
pyrene	10/12	48.5	2100	723	BGSS12 04/07/97	723				

Notes:
Units are mg/kg for inorganics, ug/kg for organics.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result.
Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.
Number of samples may vary based on the number of usable results.
UTL is the expected value for the upper 95 % quantile of the background population; there is an equal chance of the population's true 95 % quantile being either below or above this estimate.

Abbreviations:

L, N, or Q — UTL is based on 95 % upper limit (using t-value) when data are lognormal (L) or normal (N). Otherwise, an upper 95 % quantile (Q) is used if there are > 18 back. points.

@ — Mean and standard deviations are shown of log-transformed data when distributions are of this type; ie., if an (L) code appears for the UTL test and background distribution matches lognormal.

TABLE 2-15
Background Statistics - Sediment Data
NASJRB Willow Grove, Pennsylvania

Substance	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	95 % Upper Tolerance Limit (UTL) Back. Mean[e]	Std.Dev. Back.[e]	t Value	L,N Q	Back. UTL
aluminum	8/8	3610	8950	6620	BGSD01 03/13/97	6620	1950	1.8946	N	10500
antimony	0/5	-			NA					
arsenic	8/8	3.2	7.2	4.55	BGSD01 03/13/97	1.49	0.252	1.8946	L	7.33
barium	8/8	54.6	160.5	98.2	BGSD03 03/13/97	4.54	0.327	1.8946	L	181
beryllium	8/8	0.52	1.2	0.878	BGSD01 03/13/97	0.878	0.28	1.8946	N	1.44
cadmium	0/8	-			NA					
calcium	8/8	744	18200	4980	BGSD06 03/13/97	4980				
chromium	8/8	6.8	34.5	15.7	BGSD01 03/13/97	2.59	0.585	1.8946	L	43.2
cobalt	8/8	4.5	12.4	7.21	BGSD01 03/13/97	1.92	0.338	1.8946	L	13.5
copper	8/8	5.8	27.8	13.4	BGSD01 03/13/97	2.46	0.528	1.8946	L	34
cyanide	0/8	-			NA					
iron	8/8	9540	35400	16500	BGSD01 03/13/97	9.6	0.473	1.8946	L	38200
lead	8/8	6.4	27.6	15.3	BGSD03 03/13/97	2.62	0.509	1.8946	L	38.1
magnesium	8/8	999	10600	3440	BGSD06 03/13/97	3440				
manganese	8/8	376	759	514	BGSD01 03/13/97	6.21	0.256	1.8946	L	834
mercury	0/8	-			NA					
nickel	8/8	6.8	22.7	12.5	BGSD01 03/13/97	2.44	0.43	1.8946	L	27.1
potassium	7/8	514	2330	1050	BGSD01 03/13/97	6.7	0.771	1.8946	L	3820
selenium	2/8	0.36	0.475	0.198	BGSD03 03/13/97	0.198				
sodium	2/8	240	560	143	BGSD01 03/13/97	143				
thallium	0/8	-			NA					
vanadium	8/8	7.9	52.6	22.6	BGSD01 03/13/97	2.91	0.669	1.8946	L	70.7
zinc	8/8	25.4	97.6	51.2	BGSD01 03/13/97	3.83	0.477	1.8946	L	121
aldrin	0/8	-			NA					
alpha-chlordane	0/8	-			NA					
Aroclor-1260	0/8	-			NA					
dieldrin	1/8	3.1	3.1	2.26	BGSD03 03/13/97	2.26				

TABLE 2-15

Background Statistics - Sediment Data
NASJRB Willow Grove, Pennsylvania

Substance	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	95 % Upper Tolerance Limit (UTL) Back. Mean@	Std.Dev. Back.@	t Value	L,N Q	Back. UTL
endosulfan I	0/8	-			NA					
gamma-chlordane	0/8	-			NA					
2,4-dinitrotoluene	0/8	-			NA					
2,6-dinitrotoluene	0/8	-			NA					
2-methylnaphthalene	0/8	-			NA					
acenaphthene	0/8	-			NA					
acenaphthylene	0/8	-			NA					
anthracene	0/8	-			NA					
benz(a)anthracene	1/8	580	580	275	BGSD01 03/13/97	275				
benzo(a)pyrene	1/8	530	530	268	BGSD01 03/13/97	268				
benzo(b)fluoranthene	1/8	670	670	286	BGSD01 03/13/97	286				
benzo(g,h,i)perylene	0/8	-			NA					
benzo(k)fluoranthene	1/8	300	300	240	BGSD01 03/13/97	240				
bis(2-ethylhexyl)phthalate	0/8	-			NA					
butylbenzylphthalate	0/8	-			NA					
carbazole	0/8	-			NA					
chrysene	3/8	110	640	238	BGSD01 03/13/97	238				
dibenz(a,h)anthracene	0/8	-			NA					
dibenzofuran	0/8	-			NA					
fluoranthene	4/8	100	510	221	BGSD01 03/13/97	221				
fluorene	0/8	-			NA					
indeno(1,2,3-cd)pyrene	0/8	-			NA					
N-nitrosodiphenylamine (1)	0/8	-			NA					
naphthalene	0/8	-			NA					
phenanthrene	1/8	260	260	235	BGSD01 03/13/97	235				
pyrene	4/8	100	1300	315	BGSD01 03/13/97	315				
2-butanone	0/8	-			NA					

TABLE 2-15

Background Statistics - Sediment Data
NASJRB Willow Grove, Pennsylvania

Substance	Freq. of Detection	Range of Positive Detection		Mean of All Data	Sampling Round and Location of Maximum	95 % Upper Tolerance Limit (UTL)				
		Min.	Max.			Back. Mean@	Std.Dev. Back.@	t Value	L,N Q	Back. UTL
acetone	0/5	-			NA					
ethylbenzene	0/8	-			NA					
toluene	0/8	-			NA					

Notes: Units are mg/kg for inorganics, ug/kg for organics.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result.
Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.
Number of samples may vary based on the number of usable results.
UTL is the expected value for the upper 95 % quantile of the background population; there is an equal chance of the population's true 95 % quantile being either below or above this estimate.

Abbreviations:

L, N, or Q — UTL is based on 95 % upper limit (using t-value) when data are lognormal (L) or normal (N). Otherwise, an upper 95 % quantile (Q) is used if there are > 18 back. points.

@ — Mean and standard deviations are shown of log-transformed data when distributions are of this type; ie., if an (L) code appears for the UTL test and background distribution matches lognormal.

TABLE 2-16
Background Statistics - Surface Water Data
NASJRB Willow Grove, Pennsylvania

Substance	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	95 % Upper Tolerance Limit (UTL) Back. Mean[e]	Std.Dev. Back.[e]	t Value	L,N Q	Back. UTL
aluminum	1/1	561	561	561	BGSW03 03/13/97	561				
antimony	0/8	-			NA					
arsenic	0/8	-			NA					
barium	8/8	87.3	112	101	BGSW05 03/13/97	4.61	0.0919	1.8946	L	121
beryllium	0/8	-			NA					
calcium	8/8	15800	34900	24600	BGSW01 03/13/97	24600	7720	1.8946	N	40200
chromium	0/8	-			NA					
cobalt	0/8	-			NA					
copper	1/8	10.8	10.8	5.73	BGSW03 03/13/97	5.73				
cyanide	0/8	-			NA					
iron	8/8	85.3	635	321	BGSW03 03/13/97	321	156	1.8946	N	634
lead	1/8	0.8	0.8	0.538	BGSW03 03/13/97	0.538				
magnesium	8/8	6250	12100	8910	BGSW01 03/13/97	8910	2350	1.8946	N	13600
manganese	8/8	26.7	110.25	67.1	BGSW03 03/13/97	67.1	26.2	1.8946	N	120
nickel	1/8	20.7	20.7	11.3	BGSW03 03/13/97	11.3				
potassium	6/8	1750	2860	1830	BGSW01 03/13/97	1830				
sodium	8/8	10700	36200	20100	BGSW02 03/13/97	9.8	0.496	1.8946	L	48800
vanadium	0/8	-			NA					
zinc	3/8	7.8	12.85	5.28	BGSW03 03/13/97	5.28				
dieldrin	0/8	-			NA					
bis(2-ethylhexyl)phthalate	0/8	-			NA					
di-n-butylphthalate	0/8	-			NA					
4-methyl-2-pentanone	0/8	-			NA					
acetone	0/8	-			NA					

Notes: Units are ug/L.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are

TABLE 2-16

Background Statistics - Surface Water Data
NASJRB Willow Grove, Pennsylvania

Substance	Freq. of Detection	Range of Positive Detection		Mean of All Data	Sampling Round and Location of Maximum	95 % Upper Tolerance Limit (UTL)				
		Min.	Max.			Back. Mean@	Std.Dev. Back.@	t Value	L,N Q	Back. UTL

consolidated into one result.

Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.

Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.

Number of samples may vary based on the number of usable results.

UTL is the expected value for the upper 95 % quantile of the background population; there is an equal chance of the population's true 95 % quantile being either below or above this estimate.

Abbreviations:

L, N, or Q — UTL is based on 95 % upper limit (using t-value) when data are lognormal (L) or normal (N). Otherwise, an upper 95 % quantile (Q) is used if there are > 18 back. points.

@ — Mean and standard deviations are shown of log-transformed data when distributions are of this type; ie., if an (L) code appears for the UTL test and background distribution matches lognormal.

- Nonparametric statistical tests, which do not require underlying assumptions regarding equal data distributions, were also applied in each case. The Mann-Whitney U-test was used to determine whether the site and background data are from populations with identical medians and rank distributions. The Mann-Whitney test involves combining the two data sets, ranking results from smallest to largest, and evaluating whether the two sites have a similar distribution of data within the range of low to high ranks. If more than 40 percent nondetected results are present in either the site or the background data set or when multiple levels of detection limits are present, a different statistically valid test, Gehan's test, was substituted because recent guidance (EPA, 1992c) indicates that the Mann-Whitney test is not valid in the aforementioned situations. (Gehan's test is statistically equivalent to the Mann-Whitney Test if all results are positive.) For either of these tests to work, not all data points can be tied and there must be at least two background data points. The Mann-Whitney U test and the Gehan test statistics were computed using appropriate score adjustments for tied values and a normal approximation when sufficient data points were available; whereas, an exact computation of probabilities was used in the situations where there were very few (for example, less than eight) data points.

- A 95 percent upper tolerance limit (UTL) test was applied to determine whether the maximum concentration detected in an area of interest was a hot spot of a magnitude exceeding 95 percent of the background population. The 95 percent UTL is defined as the calculated upper limit that, on the average, is expected to include 95 percent of the background population. If the background data were determined to match the shape of a normal or lognormal population, then the limit was calculated using the t-distribution and the appropriate normal or log-transformed mean and standard deviation from the background data set. For this test to be valid, the background data set was required to be comprised of at least 85 percent detects and at least three data points.

- A substitute procedure for the 95 percent UTL, called the 95 percent quantile test, was employed to test for hot spots if the background data were not in the shape of a lognormal or a normal population. For the quantile test to be valid, at least 19 background data points were required, no detection limit could be greater than the UTL, and at least 10 percent of the data points must be detects in the background data set.

- The upper ranks test (EPA, 1992c, 1996d) is another hot spot test. This test combines the site and background data into one set and determines whether the major portion of a subset of the largest detected results is comprised chiefly of site data rather than an

equal mixture of site and background. In this procedure, the probability is calculated that k or more samples from the largest r data points in the combined data set are comprised of site data, assuming that the site and background populations are equal. In the event that there is less than a five percent chance that this could happen if the populations are indeed the same, then the test concludes that there is a hot spot comprised of k samples from the area of interest.

- In the event that none of the above quantitative statistical tests yielded a definite "yes" or "no" decision, a test of proportions was used to determine if the percentage of positively detected results was greater in the site data versus the background data. When only a very small portion of results are detected (less than 10 percent), this test is recommended (EPA, 1996d, 1989b). The test is routinely applied using a normal distribution approximation to the probability that site is above background but is not considered valid when fewer than five samples are detected in either site or background. To reach a confident decision regarding VOCs in surface water, a generalized version of the test of proportions, called the Fisher Exact Test, was required (Brownlee, 1965). This test can be applied to all situations because it calculates the exact probability for all combinations of possible outcomes and gives a probability level for the condition where the observed frequency of site detects is greater than background, given the number of samples involved.

- As recommended (EPA, 1996d, 1992b, 1989b), quantitative statistical tests were preceded by data analysis to evaluate the distributional shape for both positive and nondetected data, of which quantile plots or tables are one recommended (and efficient) approach. This data analysis is required because multiple detection limits bias or invalidate the conclusions of common statistical tests. For each chemical in each risk group, a quantile (percentile) range evaluation was required to compare the number and magnitude of site and background nondetects. In particular, some of the above tests do not tolerate any non-detects above a certain magnitude or portion of the total. In the case of the Mann-Whitney test, careful quantitative evaluation was used to determine if the site and background populations exhibited the same distributional spread of non-detected results and whether to instead use the more robust Gehan test. For the Gehan test to be valid, the only requirement was that the method of data censoring could not be significantly different for site versus background, a condition that rendered somewhat unreliable the usability of background tests for the combined routine and low detection limit mercury data comparisons due to different proportions of low detection limit data among the site and background populations.

3.0 RISK ASSESSMENT APPROACHES

3.1 METHODS FOR THE HUMAN HEALTH RISK ASSESSMENT APPROACH

This section provides a description of the human health risk assessment (HHRA) methods used to evaluate the NASJRB Willow Grove data collected at Sites 1 (Privet Road), 2 (Antenna Field Landfill), 3 (Ninth Street Landfill), and 5 (Fire Training Area). The objectives of the risk assessment were to estimate the actual or potential risks to human health resulting from the presence of contamination in surface soil, subsurface soil, sediment, groundwater, and surface water and to provide the basis for determining the need for remedial measures for these media in the feasibility study.

Three major aspects of chemical contamination must be considered when assessing public health risks: contaminants with toxic characteristics must be found in environmental media and must be released by either natural processes or by human action; potential exposure points must exist either at the source or via migration pathways if exposure occurs at a remote location other than the source; and human or environmental receptors must be present at the point of exposure. Risk is a function of both toxicity and exposure; without any one of the three factors listed above, there is no risk.

The risk assessment estimated the potential for human health risk attributable to each NASJRB Willow Grove site. Information regarding the toxicity of the compounds detected in the various media, the distribution of contamination, potential migration pathways, and a site-specific estimate of chemical intake via assumed exposure routes were combined to estimate potential risks for each NASJRB Willow Grove site. The risk assessment processes used at NASJRB Willow Grove were in accordance with current EPA risk assessment guidance (see EPA references at end of document) and were performed according to methods established in the NASJRB Willow Grove Work Plan (1997), which was reviewed and approved by EPA Region III and the Pennsylvania DEP.

The human health risk assessment consists of five sections: Data Evaluation, Toxicity Assessment, Exposure Assessment, Risk Characterization, and Uncertainty Analysis. Each section is briefly discussed below.

Data Evaluation (Section 3.1.1) was primarily concerned with distributional analysis of the data, background comparison tests, identification of chemicals of potential concern (COPCs), and representative concentrations. COPCs selected in this section are representative of the type expected for potential human health exposure. Distributional analysis of the data, contaminant concentrations relative to background levels, contaminant release and environmental transport mechanisms, exposure routes,

and toxicity were all considered in order to develop a list of COPCs used to define the site-associated risks.

The Toxicity Assessment (Section 3.1.2) presents available reference doses, cancer slope factors, EPA weight of evidence, adjustment of the dose-response parameters, relative potencies for PAHs, and relative potencies for dioxins/furans. Quantitative toxicity indices, where available, are presented in this section, including any applicable regulatory standards and criteria.

The Exposure Assessment (Section 3.1.3) identifies potential human health exposure including a characterization of the site setting, selection of potential receptors, selection of exposure routes by medium, a presentation of a site-conceptual model, derivation of exposure estimates for each pathway, and a special explanation of the blood lead modeling. This section identifies potential pathways of COPC migration, selected potential receptors, and the estimated intakes of COPCs for the identified receptors.

Risk Characterization (Section 3.1.4) presents the approaches for determining carcinogenic risks, noncarcinogenic risks, and lead risks. The risk characterization evaluates the potential for adverse health effects from exposure to COPC concentrations in environmental media by integrating information developed during the toxicity and exposure assessments. Reasonable maximum exposure (RME) and central tendency (CT) risks, as defined by EPA guidance, have been calculated. Carcinogenic human health risk is reported as a numerical result based on the exposure which would result in one additional cancer event in a population of 10,000 persons (1E-04) to one additional cancer event in a population of 1,000,000 persons (1E-06). Noncarcinogenic human health risk is reported as a decimal equivalent of a fraction, a hazard quotient (HQ), resulting from the ratio of the concentration of a noncancer causing compound found in a particular site media (e.g., soil or groundwater) divided by the concentration of that compound suspected to cause adverse health affects. HQs greater than 1 indicate that the corresponding noncancer causing compound is found in site media at a concentration greater than the concentration of that compound thought to be associated with adverse health affects. A hazard index (HI) is a sum of HQs, and is used to represent aggregate noncancer human health risk at a site.

The Uncertainty Analysis (Section 3.1.5) is a discussion of the uncertainties associated with the HHRA.

3.1.1 Data Evaluation

This section presents the approaches for distributional analysis of the data, background comparison tests, identification of COPCs, representative concentrations, and special notes concerning chromium concentrations, filtered groundwater samples, use of 1991 groundwater data at Site 1 for inorganics, and PCB analysis at Site 1.

3.1.1.1 Distributional Analysis of the Data

Statistical analyses discussed in this section adhere to the guidance referenced in several EPA and related publications (1989a, 1989b, 1992a, 1992b, and 1996a). Section 4.1.5 discusses the general limitations and uncertainties of statistical procedures, particularly with regards to confidence and decision-making power when limited numbers of samples are involved. Before representative concentrations (Section 4.1.4) could be estimated for each site, the underlying statistical distribution of data was determined for each chemical in each medium. The Shapiro-Wilk W test or the Shapiro-Francia Test (EPA, 1992a) were performed to determine if the data set of chemical concentrations matches the shape of a normal or lognormal distribution. [The latter test is required if there are greater than 50 samples (EPA, 1992a, 1996a).] Normally distributed data exhibit a characteristic "bell-shape" curve that is symmetrical, whereas lognormal data have a skewed shape (more results at the high-concentration tail). For each chemical in each medium at a site, the W test was performed once using the original data and once after data were converted to their logarithms. A five percent level of significance was used to determine if the data deviate from either hypothesized distribution. If the W test indicated a normal distribution, then the estimation of the reasonable maximum exposure point concentration (using the upper 95th percentile, as discussed in the next section) was based upon a normal distribution and standard deviation. If taking the logarithms of the data provided a better match to the data than a normal distribution, a lognormal transformation of data was used before the upper 95th percentile concentrations were computed. In most cases, the distribution of data fit one of the above two categories. If neither distribution matched well, the default assumption of an underlying lognormal distribution was followed (EPA, 1989a).

3.1.1.2 Background Comparison Tests

To determine if results of samples from each site were elevated relative to background sample results, an array of statistical tests were performed. Section 2.3 presents a discussion of the statistical analyses performed on background analytical data.

3.1.1.3 Identification of Chemicals of Potential Concern (COPCs)

COPC selection is based on various aspects of chemical concentration, distribution, and toxicity. Chemicals are selected to represent site contamination and will provide the framework for the quantitative risk assessment.

Inorganic and organic samples were collected from the NASJRB Willow Grove Sites in groundwater, spring water, surface soil, sediment (seeps, creeks, and ponds), surface water (seeps, creeks, and

ponds), and fish media. The positively detected chemicals for each site are compared to background levels and presented in occurrence and distribution and background tables in site-specific Nature and Extent of Contamination sections. COPC selection is based on these tables and the following rules (EPA, 1993):

- Screen COPCs against RBC criteria (EPA, 1993). Developed by Region III EPA, RBCs are chemical-specific benchmark criteria that represent the calculated concentration for a given contaminant that might produce a cancer risk of 1E-06 or a noncarcinogenic HI of 1.0, given exposure to soil or groundwater by residential receptors and assuming the EPA default values for upper range (RME) intake (e.g., 2 liters groundwater consumption per day for a residential adult or 200 mg soil ingestion per day for a residential child). Using the RBC screening approach, a chemical was eliminated from consideration as a COPC at a site if the maximum detected concentration was less than the RBC screening value or if site concentrations were not significantly greater than background (inorganics only). The COPC selection process differed slightly for each sampling medium, as explained below:

Surface Soil Exposure COPC Selection

Inorganics - Compare the maximum concentration detected in surface soil to the residential soil RBC determined at a risk level of 1×10^{-6} or a HQ of 0.1 and compare site concentration to background concentration in order to determine if the area of interest is significantly greater than background. If both criteria are met, the chemical is selected as a COPC.

Organics - Compare the maximum concentration detected in surface soil to the residential soil RBC determined at a risk level of 1×10^{-6} or an HQ of 0.1. All chemicals exceeding RBCs were selected as COPCs.

Residential RBCs were used as comparison criteria because they are expected to be protective of all receptors exposed to surface soil.

Subsurface Soil Exposure COPC Selection

Inorganics - Compare the maximum concentration detected in subsurface soil to the industrial soil RBC determined at a risk level of 1×10^{-6} or an HQ of 0.1 and compare site concentration to background concentration in order to determine if the area of interest is significantly greater than background. If both criteria are met, the chemical is selected as a COPC.

Organics - Compare the maximum concentration detected in subsurface soil to the industrial soil RBC determined at a risk level of 1×10^{-6} or an HQ of 0.1. All chemicals exceeding RBCs were selected as COPCs.

Industrial RBCs were used as comparison criteria because, generally, only industrial receptors are expected to be exposed to subsurface soils during excavation or construction activities.

Sediment Exposure COPC Selection

Inorganics - Compare the maximum concentration detected in sediment to the residential soil RBC determined at a risk level of 1×10^{-5} or an HQ of 1.0 and compare site concentrations to background concentrations in order to determine if the concentrations in the area of interest are significantly greater than background. This comparison is conservative in that it assumes that exposure intakes for sediment are one-tenth as great as the exposure pathway based on the RBC soil ingestion value. If both criteria are met, the chemical is selected as a COPC.

Organics - Compare the maximum concentration detected in sediment to the residential soil RBC determined at a risk level of 1×10^{-5} or an HQ of 1.0. This comparison is conservative in that it assumes that exposure intakes for sediment are one-tenth as great as the exposure pathway based on the RBC soil ingestion value (whereas exposure to surface water in this HHRA is expected to be even significantly lower than one-tenth of the exposure to surface soil). All chemicals exceeding RBCs were selected as COPCs.

Surface Water Exposure COPC Selection

Inorganics - Compare the maximum concentration detected in surface water to the tap water RBC determined at a risk level of 1×10^{-5} or an HQ of 1.0 and compare site concentrations to background concentrations in order to determine if the concentrations at the site are significantly greater than background. This comparison is conservative in that it assumes that exposure intakes for surface water are one-tenth as great as the exposure pathway based on the RBC tap water value, whereas exposure to surface water in this HHRA is expected to be even lower than one-tenth of the exposure to tap water. If both criteria are met, the chemical is selected as a COPC.

Organics - Compare the maximum concentration detected in surface water to the tap water RBC determined at a risk level of 1×10^{-5} or an HQ of 1.0. This comparison is conservative in that it assumes that exposure intakes for surface water are one-tenth as great as the exposure pathway based on the

RBC tap water value, whereas exposure to surface water in this HHRA is expected to be even lower than one-tenth of the exposure to tap water. All chemicals exceeding RBCs were selected as COPCs.

Future Groundwater Exposure COPC Selection

Inorganics (Monitoring Wells) - Compare the maximum concentration detected in monitoring wells to the tap water RBC determined at a risk level of 1×10^{-6} or an HQ of 0.1 and compare site concentrations to background monitoring well concentrations in order to determine if the concentration at a site is significantly greater than background. If both criteria are met, the chemical is selected as a COPC. Additionally, the maximum concentration detected in groundwater will be compared to applicable MCLs and those chemicals exceeding MCLs will be identified and considered candidate COPCs.

Organics (Monitoring Wells) - Compare the maximum concentration detected in groundwater to the tap water RBC determined at a risk level of 1×10^{-6} or an HQ of 0.1. All organic chemicals exceeding RBCs were selected as COPCs. Additionally, the maximum concentration detected in groundwater will be compared to applicable MCLs and those chemicals exceeding MCLs will be identified and considered candidate COPCs.

- The essential nutrients, including calcium, chlorine, iodine, magnesium, phosphorus, potassium, and sodium, were eliminated as COPCs if they were not present at high concentrations at a site (EPA, 1989a).
- Previously eliminated chemicals were evaluated to determine whether any fell within the following two classifications and, therefore, must be retained as COPCs:
  - If the chemical was a break-down product of a COPC, it was included as a COPC for that medium.
  - If a chemical was a member of the same class of chemicals that were selected as COPCs, that chemical was included as a COPC for that medium (e.g., carcinogenic PAHs, dioxins/furans, and PCBs).
- Lead will be evaluated as a COPC based on a derived screening levels for tap water and residential soil. Per EPA Region III directive, a value of 400 mg/kg [Office of Solid Waste and Emergency Response (OSWER) Directive, EPA, 1994a] will be used as the residential soil screening RBC and a value of 15 ug/L (Drinking Water Action Level, EPA, 1996b) will be used as the residential tap water RBC.

3.1.1.4 Representative Concentrations

The risk assessment for NASJRB Willow Grove will be performed using a representative concentration for each COPC in each medium identified at the particular site of interest. Current and historic concentrations of detected chemicals at each site medium will be evaluated. Usability of results is discussed below. The representative concentration was calculated using the latest risk assessment guidance from EPA (EPA, 1989a).

The validated data will be used to calculate representative concentrations. The data will include 1997 RI data and 1991 RI data. For chemicals with at least one positive detection, the corresponding non-detects will be assumed to be one-half the detection limit (sample quantitation limit). Rejected values (R) and blank qualified results (B) will be eliminated from further consideration. Estimated and biased values (J, K, L) will be used as the reported value.

Duplicate samples will be averaged together and considered as one result. For duplicates, where one result is positive and the other result is a non-detect, the problem of calculating an average result arises whenever half the detection limit exceeds the positive result. In these situations, the positive result will be used to represent the non-detect.

The calculation of the representative concentration is a two-step process. First, the distribution of the data must be determined as discussed in the preceding section. Then, based on the distribution of the data, a representative concentration is either calculated or selected.
Several important points are associated with distribution of the data:

- The distribution of a data set is determined using a Shapiro-Wilk test.
- The distributions are classified as either lognormal, normal, or unknown.
- Environmental data are usually determined to be lognormally distributed (default).
- If the data are not determined to be either a lognormal or normal distribution, they are classified as an unknown distribution and a lognormal distribution is assumed.

For data that are considered to be lognormally distributed, the standard deviation of the log-transformed sample set must be determined, as follows:

$$S = \sqrt{\Sigma\left(\frac{(X_i - \mu)^2}{n-1}\right)}$$

where:

S = Standard deviation of the log-transformed data

X_i = Individual sample value (log-transformed)

μ = Arithmetic mean of the log-transformed n samples

n = Number of samples

Calculation of the one-sided upper 95 percent confidence limit (UCL_{LOG}) is shown on the following page.

$$UCL_{LOG} = e^{\left[\mu + 0.5s^2 + \left(\frac{sH}{\sqrt{n-1}}\right)\right]}$$

where:

e = Constant (base of the natural log, equal to 2.718)

μ = Arithmetic mean of the log-transformed data

H = H-statistic (e.g., from table published in Gilbert, 1987)

S = Standard deviation of the log-transformed data

n = Number of samples

If the data are determined to be normally distributed, then the standard deviation of the sample set is used to calculate the one-sided 95 percent UCL, as follows:

First, the standard deviation of the sample set must be determined:

$$S = \sqrt{\sum\left(\frac{(X_i - \mu)^2}{n-1}\right)}$$

where:

S = Standard deviation of the data

X_i = Individual sample value

μ = Arithmetic mean of the n samples

n = Number of samples

The one-sided upper 95 percent confidence limit (UCL_{NOR}) is then calculated as follows:

$$UCL_{NOR} = \mu + \frac{(t * S)}{\sqrt{n}}$$

where:

S	=	Standard deviation of the data
t	=	One-sided t distribution factor
μ	=	Arithmetic mean of the n samples
n	=	Number of samples

For small sample sets or sample sets in which all positive results equal less than one-half the detection limit, the UCL can exceed the maximum detected concentration. In these cases, the maximum concentration will be selected as the representative concentration. The maximum positive value is frequently the default choice when a lognormal distribution (having a higher upper confidence limit from the distributional shape) is used.

3.1.1.5 Special Note Concerning Chromium Concentrations

Chromium data were considered to be the hexavalent chromium (VI) form as opposed to the trivalent form (chromium III) because no speciation data were available. Hexavalent chromium is considered the more toxic form; therefore, assuming that all chromium is hexavalent is a conservative approach.

3.1.1.6 Special Note Concerning Filtered Groundwater Samples

Some monitoring well samples were collected using dedicated low-flow pumps to minimize the occurrence of suspended solids associated with conventional purging and sampling techniques. Filtered samples were collected from older monitoring wells that did not have these pumps.

When samples were collected both as filtered and unfiltered aliquots, EPA technical guidance was applied to pick the most representative data to use for risk assessment. If suspended solids were strongly suggested in the unfiltered analysis, then filtered results were considered more representative of the metals available from transport in the aquifer. Elevated aluminum, iron, and manganese levels in the unfiltered sample relative to the filtered sample were used as evidence that filtered results should be used. Otherwise, unfiltered results were used if there was not a clear indication of elevated metals in association with suspended solids.

3.1.1.7 Special Note Concerning Analysis of PCBs at Site 1

Two types of PCBs data were collected at NASJRB Willow Grove. Aroclor-specific PCB data were collected based on routine methods for off-site laboratory analysis. At known areas of soil contamination at Site No. 1, "total PCBs" data were collected using field screening by immunoassay. Aroclor-specific data will be summed to calculate a "total PCBs" result at each location so that these data can be combined with the "total PCBs" immunoassay data from different locations. Split sample locations (where analysis was performed by both methods) will be evaluated using only the off-site laboratory data, which are generally considered to be more accurate.

3.1.2 Toxicity Assessment

The purpose of this section is to identify the potential health hazards associated with exposure to each of the COPCs. A toxicological evaluation characterizes the inherent toxicity of a compound. The literature indicates that the COPCs have the potential to cause carcinogenic and/or noncarcinogenic health effects in humans. Although the COPCs may cause adverse health effects, dose-response relationships and the potential for exposure must be evaluated before the risks to receptors can be determined. Dose-response relationships correlate the magnitude of the intake with the probability of toxic effects, as discussed below. Toxicity information for the COPCs at all sites at NASJRB Willow Grove is presented in Table 3-1 and Appendix J of the RI report in the form of toxicological profiles.

An important component of the risk assessment process is the relationship between the intake of a compound (the amount of a chemical that is absorbed by a receptor) and the potential for adverse health effects resulting from exposure to that dose. Dose-response relationships provide a means by which potential public health impacts can be quantified. The published information of doses and responses is used in conjunction with information on the nature and magnitude of human exposure to develop an estimate of potential health risks.

Reference doses (RfDs) and slope factors (SFs) have been developed by EPA (1997a, 1995a) and other sources for many organics and inorganics. This section provides a brief description of these parameters.

3.1.2.1 Reference Doses (RfDs)

The RfD is developed by EPA for chronic and/or subchronic human exposure to hazardous chemicals and is based solely on the noncarcinogenic effects of chemical substances. The RfD is usually expressed as a dose (mg) per unit body weight (kg) per unit time (day). It is generally derived by dividing a No-Observed-Adverse-Effect-Level (NOAEL) or a Lowest-Observed-Adverse-Effect-Level (LOAEL) by an

appropriate uncertainty factor. NOAELs, etc. are determined from laboratory animal or epidemiological toxicity studies. The uncertainty factor is based on the extent and applicability of toxicity data to human exposure.

Uncertainty factors are generally applied as multiples of 10 to represent specific areas of uncertainty in the available data. A factor of 10 is used to account for variations in the general population (to protect sensitive subpopulations), extrapolation of test results from animals to humans (to account for interspecies variability), derivation of a NOAEL from a subchronic study (instead of a chronic study) for developing the RfD, and use of a LOAEL instead of a NOAEL. In addition, EPA reserves the use of a modifying factor of up to 10 for professional judgment of uncertainties in the database not already accounted for. The default value of the modifying factor is 1. The RfD incorporates the reliability of the evidence for chronic human health effects. Even if applicable human data exist, the RfD (as reduced by the uncertainty factor) still maintains a margin of safety so that chronic human health effects are not underestimated. Thus, the RfD is an acceptable guideline for evaluation of noncarcinogenic risk, although the associated uncertainties preclude its use for precise risk quantitation. RfDs for NASJRB Willow Grove site contaminants are provided in Table 3-1.

Noncarcinogenic risks for lead were not quantified and compared to RfDs because EPA has implemented an approach to evaluating lead risks that goes beyond providing a single-point estimate output. Instead, expected blood-lead increases were estimated; a discussion of these results is presented in Section 3.1.5.9.

3.1.2.2 Cancer Slope Factors (SFs)

SFs are applicable for estimating the lifetime probability (assumed 70-year lifespan) of human receptors developing cancer as a result of exposure to known or potential carcinogens. This factor is generally reported in units of 1/(mg/kg/day) and is derived through an assumed low-dosage linear relationship of extrapolation from high to low dose responses determined from animal studies. The value used in reporting the slope factor is the upper 95 percent confidence limit. SFs for NASJRB Willow Grove site contaminants are provided in Table 3-1.

Carcinogenic risks for lead were not quantified because no EPA consensus currently exists with respect to an inorganic lead SF. Instead, potential lead exposures were calculated using a biokinetic model to estimate expected blood-lead increases; a discussion of these results is presented in Section 3.1.3.6.

TABLE 3-1

DOSE-RESPONSE PARAMETERS - CHEMICALS OF POTENTIAL CONCERN
NASJRB WILLOW GROVE

Chemical of Concern	Fraction of COPC Absorbed in the Gastrointestinal Tract (unitless)**	Toxicity Values						
		RfD*			SF			Weight of Evidence
		Oral* (mg/kg)/day	Dermal (mg/kg)/day	Inhalation* (mg/kg)/day	Oral* 1/(mg/kg)/day	Dermal 1/(mg/kg)/day	Inhalation* 1/(mg/kg)/day	
Volatiles								
1,1,1-trichloroethane	1.0	3.5E-02 E	3.5E-02	2.86E-01 W				D
1,1,2-trichloroethane	1.0	4.0E-03	4.0E-03		5.7E-02	5.7E-02	5.6E-02	C
1,1-dichloroethane	1.0	1.0E-01	1.0E-01	1.43E-01 A				
1,1-dichloroethene	1.0	9.0E-03	9.0E-03		6.0E-01	6.0E-01	1.75E-01	C
1,2-dichloroethane	1.0			2.86E-03 E	9.1E-02	9.1E-02	9.1E-02	B2
benzene	1.0			1.71E-03 E	2.9E-02	2.9E-02	2.9E-02	A
tetrachloroethene	1.0	1.0E-02	1.0E-02		5.2E-02 E	5.2E-02	2.03E-03 E	B2
trichloroethene	1.0	6.0E-03 E	6.0E-03		1.1E-02 W	1.1E-02	6.0E-03 E	B2
Semivolatiles								
benz(a)anthracene	1.0				7.3E-01 E		6.1E-01 E	B2
benzo(a)pyrene	1.0				7.3E+00 I		6.1E+00 W	B2
benzo(b)flouranthene	1.0				7.3E-01 E		6.1E-01 E	B2
benzo(k)fluoranthene	1.0				7.3E-02 E		6.1E-02 E	B2
chrysene	1.0				7.3E-03 E		6.1E-03 E	B2
dibenz(a,h)anthracene	1.0				7.3E+00 E		6.1E+00 E	B2
indeno(1,2,3-cd)pyrene	1.0				7.3E-01 E		6.1E-01 E	B2
bis(2-ethylhexyl)phthalate	0.55	2.0E-02	3.64E-02		1.4E-02	7.7E-03		B2
Pesticides/PCBs								
Polychlorinated biphenyls	1.0				2.0E+00 I	1.78E+00		B2
Aroclor-1260	1.0				2.0E+00 I	1.78E+00		B2
dieldrin	0.5	5.0E-05	1.0E-04		1.6E+01	8.0E+00	1.61E+01	B2
Metals								
aluminum	0.27	1.0E+00 E	3.7E+00					
arsenic	0.95	3.0E-04	3.16E-04		1.5E+00	1.43E+00	1.51E+01	A
barium	1.0	7.0E-02	7.0E-02	1.43E-04 A				D
beryllium	0.01	5.0E-03	5.0E-01		4.3E+00	4.3E-02	8.4E+00	B2
cadmium	0.05	5.0E-04 I	1.0E-02	5.710E-05 W			6.3E+00 I	
chromium	0.01	5.0E-03	5.0E-01				4.2E+01	D
iron	1.0	3.0E-01 E	3.0E-01					
lead	1.0							B2
manganese (water)	1.0	2.3E-02 I	2.3E-02	1.43E-05 I				
manganese (food)	1.0	1.4E-01	1.4E-01	1.43E-05				
thallium	1.0	6.5E-05	6.50E-05					
vanadium	0.0	7.0E-03 H	3.50E-01					
zinc	1.0	3.0E-01	3.00E-01					D
Dioxins/Furans								
1,2,3,4,6,7,8-HPCDD	0.5				1.560E+03	7.800E+02	1.160E+03	B2

TABLE 3-1

DOSE-RESPONSE PARAMETERS - CHEMICALS OF POTENTIAL CONCERN
NASJRB WILLOW GROVE

Chemical of Concern	Fraction of COPC Absorbed in the Gastrointestinal Tract (unitless)**	Toxicity Values						
		RfD*			SF			Weight of Evidence
		Oral* (mg/kg)/day	Dermal (mg/kg)/day	Inhalation* (mg/kg)/day	Oral* 1/(mg/kg)/day	Dermal 1/(mg/kg)/day	Inhalation* 1/(mg/kg)/day	
1,2,3,4,6,7,8-HPCDF	0.5				1.560E+03	7.800E+02	1.160E+03	B2
1,2,3,4,7,8,9-HPCDF	0.5				1.560E+03	7.800E+02	1.160E+03	B2
1,2,3,4,7,8-HXCDD	0.5				1.560E+04	7.800E+03	1.160E+04	B2
1,2,3,4,7,8-HXCDF	0.5				1.560E+04	7.800E+03	1.160E+04	B2
1,2,3,6,7,8-HXCDD	0.5				1.560E+04	7.800E+03	1.160E+04	B2
1,2,3,6,7,8-HXCDF	0.5				1.560E+04	7.800E+03	1.160E+04	B2
1,2,3,7,8,9-HXCDD	0.5				1.560E+04	7.800E+03	1.160E+04	B2
1,2,3,7,8,9-HXCDF	0.5				1.560E+04	7.800E+03	1.160E+04	B2
1,2,3,7,8-PECDD	0.5				7.800E+04	3.900E+04	5.800E+04	B2
1,2,3,7,8-PECDF	0.5				7.800E+03	3.900E+03	5.800E+03	B2
2,3,4,6,7,8-HXCDF	0.5				1.560E+04	7.800E+03	1.160E+04	B2
2,3,4,7,8-PECDF	0.5				7.800E+04	3.900E+04	5.800E+04	B2
2,3,7,8-tetrachlorodibenzo-p-di	0.5				1.560E+05	7.800E+04	1.160E+05	B2
2,3,7,8-tetrachlorodibenzofuran	0.5				1.560E+04	7.800E+03	1.160E+04	B2
octachlorodibenzo-p-dioxin	0.5				1.560E+02	7.800E+01	1.160E+02	B2
octachlorodibenzofuran	0.5				1.560E+02	7.800E+01	1.160E+02	B2

No Value = No dose-response value is available for this chemical in this classification
* = All toxicity values are from Integrated Risk Information System (IRIS) unless otherwise noted
** = Modifying factor applied only to dermal RfDs and SFs, from ATSDR
H = Health Effects Assessment Summary Tables
A = HEAST Alternative
E = EPA-NCEA Regional Support provisional service
W = Withdrawn from IRIS or HEAST

3.1.2.3 EPA Weight-of-Evidence

The weight-of-evidence designations indicate the preponderance of evidence regarding carcinogenic effects in humans and animals. The categories are defined in Table 3-2 (EPA, 1992d).

3.1.2.4 Adjustment of Dose-Response Parameters

Risks associated with dermal exposures are evaluated using toxicity values that are specific to dermally absorbed doses. Most oral toxicity values are based on administered doses rather than absorbed doses (TCE being an important exception). Therefore, in accordance with Region III EPA (1995b) and EPA (1989a, Appendix A), the toxicity values based on administered doses were adjusted before they were used for evaluation of absorbed doses. Dermal RfDs and SFs are obtained from oral RfDs and SFs via the following relationships:

$$RfD_{Adjusted} = RfD_{Oral} * ABSEFF_{Oral}$$

$$SF_{Adjusted} = {}^{SF_{Oral}}\!/_{ABSEFF_{Oral}}$$

where $ABSEFF_{Oral}$ = Absorption Efficiency in the study that is the basis of the oral toxicity value.

The default ABSEFFs are designated by EPA Region III for selected compounds (EPA, 1995b) and are shown on Table 3-3.

3.1.2.5 Relative Potency Factors for PAHs

Carcinogenic PAHs are related by chemical structure. Only benzo(a)pyrene [B(a)P] has an EPA-published SF (EPA, 1997a). All other carcinogenic PAHs have SFs based on their potency relative to B(a)Ps, and these factors are published by EPA (1997b). Table 3-4 shows the relative potency factors [which are also commonly known as toxicity equivalence factors (TEFs)].

3.1.2.6 Relative Potency Factors for Dioxins/Furans

Dioxins and furans are related by chemical structure. Only 2,3,7,8-tetrachlorodibenzodioxin (TCDD) has an EPA-published SF (EPA, 1995a). All other 2,3,7,8-substituted dioxins and furans have SFs based on their potency relative to 2,3,7,8-TCDD, and these factors are published by EPA (1992e). Table 3-5 shows the relative potency factors (which are also commonly known as TEFs).

TABLE 3-2

EPA WEIGHT OF EVIDENCE CARCINOGENIC CLASSIFICATIONS
NASTRB WILLOW GROVE

EPA Category	Description of Group	Description of Evidence
Group A	Human carcinogen	Sufficient evidence from epidemiologic studies to support a causal association between exposure and cancer
Group B1	Probable human carcinogen	Limited evidence of carcinogenicity in humans from epidemiologic studies
Group B2	Probable human carcinogen	Sufficient evidence of carcinogenicity in animals; inadequate evidence of carcinogenicity in humans
Group C	Possible human carcinogen	Limited evidence of carcinogenicity in animals
Group D	Not classified	Inadequate evidence of carcinogenicity in animals
Group E	No evidence of carcinogenicity	No evidence for carcinogenicity in at least two adequate animal tests or in both epidemiological and animal studies

TABLE 3-3

Absorption Factors For The Dermal Pathway
NASJRB, Willow Grove, Pennsylvania

Chemical	Absorption Factors For Dermal Pathway
PCBs	6%
Chlorinated Dioxins	3%
Cadmium	1%
Arsenic	3.2%
Ethylbenzene	3%
Toluene	3%
Xylenes	3%
Tetrachloroethene	3%
Pesticides	10%
Pentachlorophenol	24.4%
Other Inorganics	1%
Other Organics	10%

TABLE 3-4

Relative Potency Of Carcinogenic PAHs
NASJRB, Willow Grove, Pennsylvania

Chemical	Relative Potency Factors
Benz(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Benzo(a)pyrene	1
Chrysene	0.001
Dibenz(a,h)anthracene	1
Indeno(1,2,3-cd)pyrene	0.1

TABLE 3-5

Toxicity Equivalency Factors (TEFs) – Dioxin/Furan Congeners
NASJRB, Willow Grove, Pennsylvania

Dioxin/Furan Congener	TEFs
2,3,7,8-TCDD	1
2,3,7,8-PeCDD	0.5
2,3,7,8-HxCDD	0.1
2,3,7,8-HpCDD	0.01
OCDD	0.001
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.05
2,3,4,7,8-PeCDF	0.5
2,3,7,8-HxCDF	0.1
2,3,7,8-HpCDF	0.01
OCDF	0.001

3.1.3 Exposure Assessment

The purpose of this section is to evaluate the potential for human exposure to the chemicals detected in the environmental media at the NASJRB Willow Grove sites investigated under this RI. This section characterizes the exposure setting and the potentially exposed populations, identifies actual or potential exposure routes, presents a general conceptual site model, and summarizes the methods used to generate exposure estimates. The nature and extent of contamination upon which the exposures are based are presented in Sections 4.0 through 7.0 of this RI report. To determine whether there is an actual or potential exposure, the most likely pathways of contaminant release and transport, as well as the human and environmental activity patterns, must be considered. A complete exposure pathway has three components: a source, a route of transport, and an exposure point for receptors. These components are addressed in this section.

3.1.3.1 Characterization of the Exposure Setting

Section 3 provides a characterization of general site conditions, including meteorology, topography and surface water hydrology, soils, regional geology, regional hydrogeology, and ecology.

3.1.3.2 Potential Receptors

The receptors chosen for the sites at NASJRB Willow Grove are presented in this section. All the receptors listed below are applicable to every site because all selected media were sampled at each site.

The current exposure scenarios are as follows:

- Occupational Worker - The full-time on-site worker is an adult who works at NASJRB Willow Grove year round. This receptor is potentially exposed to COPCs in surface soil via ingestion, dermal contact, and inhalation.

- Adolescent and Adult Trespasser - A trespasser is an adult or adolescent who trespasses at NASJRB Willow Grove. These receptors are potentially exposed to COPCs in surface soil via ingestion, dermal contact, and inhalation and to COPCs in surface water via ingestion and dermal contact. Cancer and non-cancer risks will be estimated separately for adolescent and adult trespassers.

Future exposure scenarios are, as follows:

- Future Excavation Worker - A future excavation worker is an adult who is assumed to work at NASJRB Willow Grove in the future during any type of excavation activity. This receptor is potentially exposed to COPCs in surface and subsurface soil via ingestion, dermal contact, and inhalation. Additionally, this receptor is potentially exposed to VOCs in shallow groundwater via inhalation.

- Future Resident - A future resident is a person who will live in a residence at or near NASJRB Willow Grove in a hypothetical future scenario. This receptor resides at a residence as a child (from age 0 to 6 years) and as an adult (for 24 years exposure duration). This receptor is potentially exposed to COPCs in groundwater via ingestion, dermal contact, and inhalation (adult resident only) and to COPCs in surface soil via ingestion, dermal contact, and inhalation. Non-cancer risks will be estimated separately for child and adult; cancer risks are considered cumulative (risks are summed over child and adult periods of exposure). Potential exposure to subsurface soils following real estate development will be discussed qualitatively.

- Future Child Recreational Receptor - A future recreational receptor is a child who participates in recreational activities at NASJRB Willow Grove in a hypothetical future scenario. This receptor is potentially exposed to surface soil via ingestion, dermal contact, and inhalation and to surface water and sediment via ingestion and dermal contact.

3.1.3.3 Exposure Routes by Medium

There are five environmental media at NASJRB Willow Grove through which potential receptors (see previous section) can be either directly or indirectly exposed to site-related COPCs: surface soil, subsurface soil, sediment, surface water, and groundwater. Potential exposure routes include ingestion, dermal contact, and inhalation.

3.1.3.3.1 Surface Soil

Surface soil exposure routes include incidental ingestion, dermal contact, and inhalation of fugitive dust. All scenarios are based on COPC representative concentrations in surface soils. All three exposure routes will be evaluated using occupational workers (current scenario), adolescent and adult trespassers (current scenario), excavation workers (future scenario), residential receptors (future scenario), and

recreational receptors (future scenario). These receptors were chosen because it is unknown whether NASJRB Willow Grove will remain open to industrial employees only or whether NASJRB Willow Grove (or a portion of it) might become a residential or recreational area in the future. For fugitive dust emissions, the assumption of surface cover will resemble the type of vegetation, paving, and buildings that are currently in place.

For surface soil, low levels of VOCs did not warrant full-scale modeling and an estimation of the exposure. VOCs were generally not detected in surface soil. Therefore, exposure to volatilized chemicals is expected to be negligible at NASJRB Willow Grove, and ingestion and dermal contact would contribute to the bulk of the risk.

3.1.3.3.2 Subsurface Soil

Because there is currently no direct contact with subsurface soil, only potential future incidental ingestion, dermal contact, or inhalation of fugitive dusts could be evaluated. All three exposure routes were evaluated using excavation workers (future scenario). The exposure scenarios for subsurface soil are based on the assumption that subsurface soil could eventually become surface soil if excavations, erosion, construction, or landscaping activities occurred. Exposure scenarios related to concentrations in subsurface soil are conservative based on this assumption. For fugitive dust emissions from subsurface soil under the future industrial scenario, the assumption of surface cover would be based on the type of vegetation, paving, and buildings that are currently in place. Additionally, a qualitative discussion of the impact on real estate landscaping for future residential receptors will be presented.

3.1.3.3.3 Sediment

Sediment exposure routes include incidental ingestion and dermal contact. These exposure routes will be evaluated using adult and adolescent trespassers (current scenario) and recreational receptors (future scenario). Inhalation of chemicals in sediment was eliminated as a pathway because the sediment is not expected to be in a dry stream. Furthermore, the frequency of contact with sediment by these receptors is expected to be low.

3.1.3.3.4 Surface Water

Surface water exposure routes include incidental ingestion and dermal contact. These exposure routes will be evaluated using adult and adolescent trespassers (current scenario) and recreational receptors (future scenario). Inhalation of VOCs in surface water was eliminated as a pathway because VOCs were

detected infrequently in surface water. Furthermore, the frequency of contact with surface water by the these receptors is expected to be low.

3.1.3.3.5 Groundwater

The groundwater exposure route includes ingestion, dermal contact while bathing or showering, and inhalation of airborne vapors during showering. This exposure route will be evaluated using child and adult residential receptors (future scenario). Additionally, inhalation of VOCs in shallow groundwater during excavation activities will be evaluated. This exposure route will be evaluated using the excavation worker (future scenario). Future groundwater conditions at the site will not be modeled. For the HHRA, it is assumed that migration of COPCs in groundwater is currently occurring and current groundwater conditions adequately represent this phenomenon.

3.1.3.4 Conceptual Site Model

The conceptual site model for NASJRB Willow Grove incorporates information on the potential chemical sources, affected media, release mechanisms, routes of migration, and known or potential human receptors. The purpose of the conceptual site model is to provide a framework in which to identify potential exposure pathways occurring at the sites. Information provided on site characterization, chemical characterization, local land and water uses, and potential receptors is used to identify potential exposure pathways for the site. The general conceptual site model for NASJRB Willow Grove is presented in Figure 3-1.

3.1.3.5 Exposure Estimates

The estimation methods and models used in this section are consistent with current EPA risk assessment guidance (EPA, 1989a; EPA, 1991a; EPA, 1996c). Exposure estimates associated with each exposure route are presented below. All exposure scenarios incorporate the representative concentrations in the estimation of intakes. Two types of exposure scenarios are considered in this HHRA, reasonable maximum exposure (RME) and central tendency exposure (CTE). RME incorporates input parameters into the exposure scenarios that are protective of 90 or 95 percent of the population, and CTE incorporates input parameters that are representative of an average or median exposure scenario. CTE is only to be run at a particular site when the total cancer risk exceeds 1E-04 (considered the upper bound of EPA's acceptable risk range) or when the noncarcinogenic HI is greater than 1.0.

Noncarcinogenic risks are estimated using the concept of an average annual exposure. The intake incorporates terms describing the exposure time and/or frequency that represent the number of hours per

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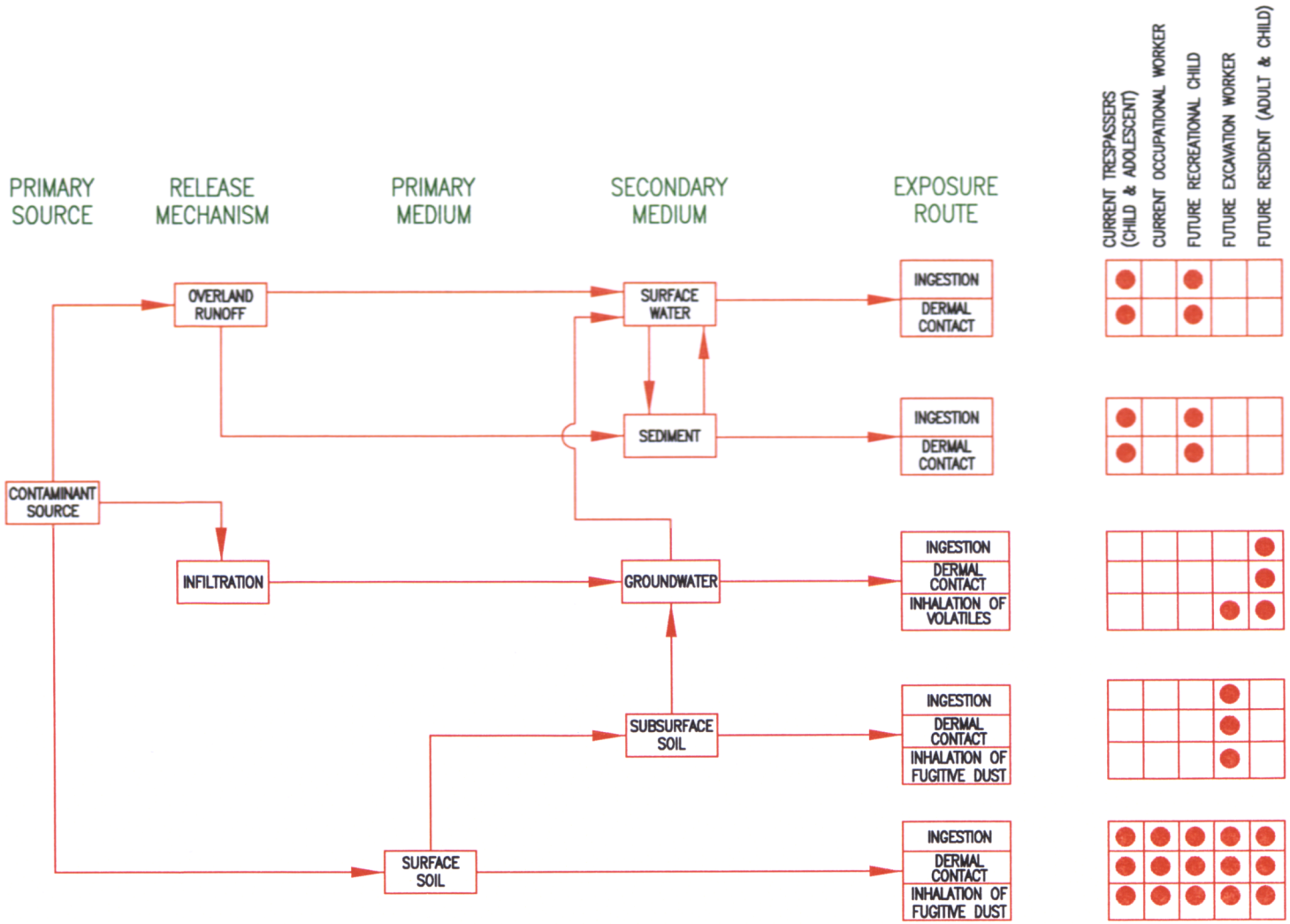

DRAWN BY LDL DATE 8/17/01	Tetra Tech NUS, Inc.	CONCEPTUAL SITE MODEL SITE 5 – FIRE TRAINING AREA NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	CONTRACT NO. 5466
CHECKED BY DATE			OWNER NO. 2207
REVISED BY DATE			APPROVED BY DATE
SCALE NONE			DRAWING NO. FIGURE 3–1 REV.

5466gf001.dwg

day and the number of days per year that exposure occurs. This is used along with the "averaging time," which converts the daily exposure frequency and duration to an annual exposure by dividing by 365 days per year of exposure. Noncarcinogenic risks for some exposure routes (e.g., soil) are generally greater for children than for adults because of the much lower body weights of children and their similar or higher ingestion rates. Carcinogenic risks, on the other hand, are calculated as an incremental lifetime risk and, therefore, incorporate terms to represent the exposure duration (years) over the course of a lifetime (70 years).

3.1.3.5.1 Surface and Subsurface Soil Exposure

Three potential exposure routes are associated with direct exposure to surface soil and subsurface soil at NASJRB Willow Grove. These exposure routes include ingestion, dermal contact, and inhalation of fugitive dust. The methods used to assess these routes of exposure are discussed in the following text. Incidental soil ingestion, dermal contact, and inhalation of fugitive dust exposure are estimated from the following equations (EPA, 1989a):

Ingestion

$$INTAKE_{INGESTION}(mg / kg) / day = \frac{CS * IR_{soil} * FI * CF_1 * EF * ED}{BW * AT * 365^{days/year}}$$

Dermal Contact

$$INTAKE_{DERMAL}(mg / kg) / day = \frac{DA_{event} * SA * EF * ED * EV}{BW * AT * 365^{days/year}} \text{ (Adults)}$$

$$INTAKE_{DERMAL} = \frac{DA_{event} * EV * EF}{AT * 365^{days/year}} * \sum_{i=m}^{n} \frac{SA_i * ED_i}{BW_i} \text{ (Children, accounts changing SA and BW)}$$

$$DA_{event} = CS * AF * ABS_{dermal} * CF_1$$

Inhalation of COPCs in Fugitive Dust

Fraction inhaled and retained in lungs:

$$INTAKE_{INHALATION-LUNG}(mg/kg)/day = I_{LUNG} = \frac{X * CS * IR_{air} * ET * EF * ED * IF_R}{BW * AT * 365^{days}/_{year}}$$

Fraction inhaled and eventually swallowed:

$$INTAKE_{INHALATION-INGESTION}(mg/kg)/day = I_{INGESTION} = \frac{X * CS * IR_{air} * ET * EF * ED * IF_O}{BW * AT * 365^{days}/_{year}} \text{ Total}$$

Inhalation is the sum of the two fractions:

$$INTAKE_{INHALATION-TOTAL}(mg/kg)/day = I_{LUNG} + I_{INGESTION}$$

$$X = Q_I * F_I * CF_2$$

$$Q_I = \frac{R_{10}}{P_R}$$

$$R_{10} = E_{10} * A$$

$$E_{10} = \left[(0.036) * (1 - V) * \left(\frac{U}{Ut}\right)^3 * F(x)\right]$$

$$Ut = U^* * \left[\frac{1}{0.4}\right] * \ln\left(\frac{z}{z_o}\right)$$

where:

CS	=	Chemical concentration in soil (mg/kg or µg/kg soil)
IR_{soil}	=	Soil ingestion rate (mg soil/day)
IR_{air}	=	Inhalation rate (m^3/hr)
FI	=	Fraction ingested from contaminated source (unitless)
ET	=	Exposure time (hr/day)
EF	=	Exposure frequency (days/yr)
ED	=	Exposure duration (years)
EV	=	Event frequency (events/day)
BW	=	Body weight (kg)

AT	=	Averaging time (years)
DA_{event}	=	Dose absorbed per unit area per event (mg/cm^2-event)
CF_1	=	Conversion factor (1 x 10^{-6} kg/mg for inorganics; 1 x 10^{-9} kg/µg for organics)
SA	=	Skin surface area available for contact (cm^2/day)
SA_i	=	Surface area exposed at age i (cm^2)
ED_i	=	Exposure duration at age i (years)
BW_i	=	Body weight at age i (kg)
AF	=	Soil-to-skin adherence factor (mg/cm^2)
ABS_{dermal}	=	Absorption fraction (unitless)
E_{10}	=	PM_{10} emission factor (g/m^2 sec)
V	=	vegetative cover
U	=	mean annual wind speed (m/s)
Ut	=	threshold value of wind speed at 7 m (m/s)
z	=	height above surface (m)
z_o	=	roughness height (m)
U^*	=	friction velocity (m/sec)
F(x)	=	function based on x = 0.886 x Ut/U
R_{10}	=	Emission rate of soil (g/sec)
A	=	source area (m^2)
Q_I	=	wind erosion scaling factor (g/sec)
P_R	=	fraction of time wind erosion occurs (0.296)
X	=	average annual downwind respirable concentration (mg/m^3)
F_I	=	unscaled conc. due to unit erosion rate [(ug/m^3)/(g/sec)]
CF_2	=	conversion factor (1 mg/1,000 ug)
IF_R	=	inhaled fraction retained in lungs (0.125)
IF_O	=	inhaled fraction eventually swallowed (0.625)

A sample calculation for ingestion of soil is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-6 through Table 3-15 for RME and CTE scenarios. As discussed in Section 3.1.3.2, the potential receptors for this scenario were current occupational workers, current adolescent and adult trespassers, future child and adult residents, future excavation workers, and future recreational children. EPA or conventional values were used for all input parameters.

A sample calculation for dermal contact with surface soil is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-6 through Table 3-15 for RME and CTE scenarios. As discussed in Section 3.1.3.2, the potential receptors for

TABLE 3-6

Exposure Parameters For Surface Soil Ingestion, Dermal Contact, And Inhalation
Occupational Worker – RME Scenario
NASJRB, Willow Grove, Pennsylvania

PARAMETER	OCCUPATIONAL WORKER	UNITS	SOURCE
CS	Chemical Specific	mg/kg or µg/kg	Analysis
IR_{soil}	50	mg/day	EPA, 1991a
FI	1	unitless	Assumption
$CF_{1\text{-inorganics}}$	1E-06	kg/mg	
$CF_{1\text{-organics}}$	1E-09	kg/µg	
EF	250	days/year	EPA, 1991a
ED	25	years	EPA, 1989a, 1991a
ET	8	hours/day	Assumption
EV	1	event/day	Assumption
AT_{cancer}	70	years	EPA, 1991a
$AT_{non\text{-}cancer}$	25	years	EPA, 1991a
SA	3,508*	cm^2	EPA, 1995
IR_{air}	0.833	m^3/hour	EPA, 1991a
BW	70	kg	EPA, 1991a
AF	1	mg/cm^2 per event	EPA, 1992a, 1995a
ABS_{dermal}	Chemical Specific	unitless	EPA, 1995a EPA, 1995h
E_{10}	Calculated	g/m^2 sec	
V	0.7	unitless	Estimated from site visit
U	4.3	m/s	Cowherd et al., 1984
Ut	Calculated	m/s	
F(x)	1.9	unitless	Cowherd et al., 1984
CF_2	0.001	Mg/ug	
R_{10}	Calculated	g/sec	
A	10000	M^2	Estimated from site visit
Q_i	Calculated	g/sec	
P_R	0.296	Unitless	Cowherd et al., 1984
X	Calculated	Mg/m^3	Cowherd et al., 1984
F_i	3.837	$(ug/m^3)/(g/sec)$	Cowherd et al., 1984
Z	7	M	Cowherd et al., 1984
z_o	0.7	M	Cowherd et al., 1984
U*	0.35	M/sec	Cowherd et al., 1984
IF_R	0.125	Unitless	Cowherd et al., 1984
IF_O	0.625	Unitless	Cowherd et al., 1984

*Average of male and female surface areas for arms and hands

TABLE 3-7

Exposure Parameters For Surface Soil Ingestion, Dermal Contact, And Inhalation Occupational Worker – CTE Scenario NASJRB, Willow Grove, Pennsylvania

PARAMETER	OCCUPATIONAL WORKER	UNITS	SOURCE
CS	Chemical Specific	mg/kg or µg/kg	Analysis
IR_{soil}	50	mg/day	EPA, 1991a
FI	1	unitless	Assumption
$CF_{1\text{-inorganics}}$	1E-06	kg/mg	
$CF_{2\text{-organics}}$	1E-09	kg/µg	
EF	250	days/year	EPA, 1991a
ED	9	years	EPA, 1989a, 1991a
ET	8	hours/day	Assumption
EV	1	Events/day	Assumption
AT_{cancer}	70	years	EPA, 1991a
$AT_{non\text{-}cancer}$	9	years	EPA, 1991a
SA	3,508*	cm^2	EPA, 1992a
IR_{air}	0.833	m^3/hour	EPA, 1991a
BW	70	kg	EPA, 1991a
AF	1	mg/cm^2 per event	EPA, 1992a, 1995a
ABS_{dermal}	Chemical Specific	unitless	EPA, 1995a EPA, 1995h
E_{10}	Calculated	g/m^2 sec	
V	0.7	unitless	Estimated from site visit
U	4.3	m/s	Cowherd et al., 1984
Ut	Calculated	m/s	
F(x)	1.9	unitless	Cowherd et al., 1984
R_{10}	Calculated	g/sec	
A	10000	m^2	Estimated from site visit
Q_I	Calculated	g/sec	
P_R	0.296	unitless	Cowherd et al., 1984
X	Calculated	mg/m^3	Cowherd et al., 1984
F_I	3.837	$(ug/m^3)/(g/sec)$	
Z	7	m	Cowherd et al., 1984
U*	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	mg/ug	
IF_R	0.125	unitless	Cowherd et al., 1984
IF_O	0.625	unitless	Cowherd et al., 1984

*Average of male and female surface areas for arms and hands

TABLE 3-8

Exposure Parameters For Surface Soil Ingestion, Dermal Contact, And Inhalation Adolescent And Adult Trespassers – RME Scenario NASJRB, Willow Grove, Pennsylvania

PARAMETER	ADOLESCENT	ADULT	UNITS	SOURCE
CS	Chemical Specific	Chemical Specific	mg/kg or µg/kg	Analysis
IR_{soil}	100	100	mg/day	EPA, 1991a
FI	1	1.0	unitless	Assumption
$CF_{1\text{-inorganics}}$	1E-06	1E-06	kg/mg	
$CF_{1\text{-organics}}$	1E-09	1E-09	kg/µg	
EF	30	24	days/year	EPA, 1991a
ED	11	19	years	EPA, 1989a, 1991a
ET	4	4	hours/day	Assumption
AT_{cancer}	70	70	years	EPA, 1991a
$AT_{non\text{-}cancer}$	11	19	years	EPA, 1991a
SA	See Appendix A	3,508*	cm^2	EPA, 1992a
IR_{air}	0.833	0.833	m^3/hour	EPA, 1991a
BW	40	70	kg	EPA, 1991a
AF	1	1	mg/cm^2 per event	EPA, 1992a, 1995a
ABS_{dermal}	Chemical Specific	Chemical Specific	unitless	EPA, 1995a EPA, 1995h
E_{10}	Calculated	Calculated	g/m^2 sec	
V	0.7	0.7	unitless	Estimated from site visit
U	4.3	4.3	m/s	Cowherd et al., 1984
Ut	Calculated	Calculated	m/s	
F(x)	1.9	1.9	unitless	Cowherd et al., 1984
R_{10}	Calculated	Calculated	g/sec	
A	10000	10000	m^2	Estimated from site visit
Q_t	Calculated	Calculated	g/sec	
P_R	0.296	0.296	unitless	Cowherd et al., 1984
X	Calculated	Calculated	mg/m^3	Cowherd et al., 1984
F_i	3.837	3.837	$(ug/m^3)/(g/sec)$	
Z	7	7	m	Cowherd et al., 1984
z_o	0.7	0.7	m	Cowherd et al., 1984
U*	0.35	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	0.001	mg/ug	
IF_R	0.125	0.125	unitless	Cowherd et al., 1984
IF_O	0.625	0.625	unitless	Cowherd et al., 1984
CA	Calculated	Calculated	mg/m^3	

*Average of male and female surface areas for arms and hands

TABLE 3-9

Exposure Parameters For Surface Soil Ingestion, Dermal Contact, And Inhalation Adolescent And Adult Trespassers – CTE Scenario NASJRB, Willow Grove, Pennsylvania

PARAMETER	ADOLESCENT	ADULT	UNITS	SOURCE
CS	Chemical Specific	Chemical Specific	mg/kg or µg/kg	Analysis
IR_{soil}	50	50	mg/day	EPA, 1991a
FI	1	1.0	unitless	Assumption
$CF_{1\text{-inorganics}}$	1E-06	1E-06	kg/mg	
$CF_{1\text{-organics}}$	1E-09	1E-09	kg/µg	
EF	15	12	days/year	EPA, 1991a
ED	2	7	Years	EPA, 1989a, 1991a
ET	4	4	hours/day	Assumption
AT_{cancer}	70	70	Years	EPA, 1991a
$AT_{non\text{-}cancer}$	2	7	Years	EPA, 1991a
SA	See Appendix A	5,750*	cm^2	EPA, 1992a
IR_{air}	0.833	0.833	m^3/hour	EPA, 1991a
BW	40	70	Kg	EPA, 1991a
AF	1	1	mg/cm^2 per event	EPA, 1992a, 1995a
ABS_{dermal}	Chemical Specific	Chemical Specific	Unitless	EPA, 1995a EPA, 1995h
E_{10}	Calculated	Calculated	g/m^2 sec	
V	0.7	0.7	Unitless	Estimated from site visit
U	4.3	4.3	m/s	Cowherd et al., 1984
Ut	Calculated	Calculated	m/s	
F(x)	1.9	1.9	Unitless	Cowherd et al., 1984
R_{10}	Calculated	Calculated	g/sec	
A	10000	10000	m^2	Estimated from site visit
Q_I	Calculated	Calculated	g/sec	
P_R	0.296	0.296	Unitless	Cowherd et al., 1984
X	Calculated	Calculated	mg/m^3	Cowherd et al., 1984
F_I	3.837	3.837	$(ug/m^3)/(g/sec)$	
Z	7	7	M	Cowherd et al., 1984
z_o	0.7	0.7	M	Cowherd et al., 1984
U*	0.35	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	0.001	mg/ug	
IF_R	0.125	0.125	Unitless	Cowherd et al., 1984
IF_O	0.625	0.625	Unitless	Cowherd et al., 1984

*Average of male and female surface areas for arms and hands

TABLE 3-10

Exposure Parameters For Surface Soil Ingestion, Dermal Contact, And Inhalation
Recreational Child – RME Scenario
NASJRB, Willow Grove, Pennsylvania

PARAMETER	CHILD 3-8	UNITS	SOURCE
CS	Chemical Specific	mg/kg or µg/kg	Analysis
IR_{soil}	200	mg/day	EPA, 1991a
FI	1.0	Unitless	Assumption
$CF_{1\text{-inorganics}}$	1E-06	kg/mg	
$CF_{1\text{-organics}}$	1E-09	kg/µg	
EF	7	Days/year	EPA, 1991a
ED	6	years	EPA, 1989a, 1991a
ET	8	Hours/day	Assumption
EV	1	Events/day	
AT_{cancer}	70	years	EPA, 1991a
$AT_{non\text{-}cancer}$	6	years	EPA, 1991a
SA	See Appendix A	cm^2	EPA, 1992a
IR_{air}	0.833	m^3/hour	EPA, 1991a
BW	21.3	kg	EPA, 1991a
AF	1	mg/cm^2 per event	EPA, 1992a, 1995a
ABS_{dermal}	Chemical Specific	Unitless	EPA, 1995a EPA, 1995h
E_{10}	Calculated	g/m^2 sec	Estimated from site visit
V	0.7	Unitless	Cowherd et al., 1984
U	4.3	m/s	
Ut	Calculated	m/s	Cowherd et al., 1984
F(x)	1.9	Unitless	
R_{10}	Calculated	g/sec	Estimated from site visit
A	10000	m^2	
Q_I	Calculated	g/sec	Cowherd et al., 1984
P_R	0.296	Unitless	Cowherd et al., 1984
X	Calculated	mg/m^3	
F_i	3.837	$(ug/m^3)/(g/sec)$	
Z	7	M	Cowherd et al., 1984
z_o	0.7	M	Cowherd et al., 1984
U*	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	mg/ug	
IF_R	0.125	Unitless	Cowherd et al., 1984
IF_O	0.625	Unitless	Cowherd et al., 1984
CA	Calculated	mg/m^3	

TABLE 3-11

Exposure Parameters For Surface Soil Ingestion, Dermal Contact, And Inhalation
Recreational Child – CTE Scenario
NASJRB, Willow Grove, Pennsylvania

PARAMETER	CHILD 3-8	UNITS	SOURCE
CS	Chemical Specific	mg/kg or µg/kg	Analysis
IR_{soil}	100	mg/day	EPA, 1991a
FI	1.0	Unitless	Assumption
$CF_{1\text{-inorganics}}$	1E-06	kg/mg	
$CF_{1\text{-organics}}$	1E-09	kg/µg	
EF	7	Days/year	EPA, 1991a
ED	2	years	EPA, 1989a, 1991a
ET	8	Hours/day	Assumption
AT_{cancer}	70	years	EPA, 1991a
$AT_{non\text{-}cancer}$	2	years	EPA, 1991a
SA	See Appendix A	cm^2	EPA, 1992a
IR_{air}	0.833	m^3/hour	EPA, 1991a
BW	21.3	kg	EPA, 1991a
AF	1	mg/cm^2 per event	EPA, 1992a, 1995a
ABS_{dermal}	Chemical Specific	Unitless	EPA, 1995a EPA, 1995h
E_{10}	Calculated	g/m^2 sec	Estimated from site visit
V	0.7	Unitless	Cowherd et al., 1984
U	4.3	m/s	
Ut	Calculated	m/s	Cowherd et al., 1984
F(x)	1.9	Unitless	
R_{10}	Calculated	g/sec	Estimated from site visit
A	10000	m^2	
Q_t	Calculated	g/sec	Cowherd et al., 1984
P_R	0.296	Unitless	Cowherd et al., 1984
X	Calculated	mg/m^3	
F_1	3.837	$(ug/m^3)/(g/sec)$	
Z	7	M	Cowherd et al., 1984
z_o	0.7	M	Cowherd et al., 1984
U*	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	mg/ug	
IF_R	0.125	Unitless	Cowherd et al., 1984
IF_O	0.625	Unitless	Cowherd et al., 1984

TABLE 3-12

Exposure Parameters For Surface Soil Ingestion, Dermal Contact, And Inhalation
Future Resident – RME Scenario
NASJRB, Willow Grove, Pennsylvania

PARAMETER	CHILD (0-6 YRS)	ADULTS	UNITS	SOURCE
CS	Chemical Specific	Chemical Specific	mg/kg	EPA 1989a
IR_{soil}	200	100	mg soil/day	EPA 1991d
IR_{air}	0.833	0.833	m^3/hour	EPA 1989a
FI	1	1	unitless	Assumption
ET	24	24	hours/day	Conventional
EF	350	350	days/year	EPA 1991d
ED	6	24	years	EPA 1989a, 1991d
EV	1	1	events/day	
BW	15	70	kg	EPA 1991d, 1989a
AT_{cancer}	70	70	years	EPA, 1989a
$AT_{non-cancer}$	6	24	years	EPA 1989a
DA_{event}	Chemical Specific	Chemical Specific	mg/cm^2-event	
$CF_{1-inorganics}$	1×10^{-6}	1×10^{-6}	kg/mg	
$CF_{1-organics}$	1×10^{-9}	1×10^{-9}	kg/ug	
SA	-	3,508*	cm^2	EPA 1996e
SA_i	Varies with age	-	cm^2	EPA 1989a
ED_i	1-year increments	-	years	EPA 1989a, 1991d
BW_i	Varies with age	-	kg	EPA 1996e
AF	1	1	mg/cm^2	EPA 1992e
ABS_{dermal}	Chemical Specific	Chemical Specific	unitless	EPA 1995a
E_{10}	Calculated	Calculated	g/m^2 sec	
V	0.7	0.7	unitless	Estimated from site visit
U	4.3	4.3	m/s	Cowherd et al., 1984
Ut	Calculated	Calculated	m/s	
F(x)	1.9	1.9	unitless	Cowherd et al., 1984
R_{10}	Calculated	Calculated	g/sec	
A	10000	10000	m^2	Estimated from site visit
Q_1	Calculated	Calculated	g/sec	
P_R	0.296	0.296	unitless	Cowherd et al., 1984
X	Calculated	Calculated	mg/m^3	Cowherd et al., 1984
F_I	3.837	3.837	(ug/m^3)/(g/sec)	
Z	7	7	m	Cowherd et al., 1984
z_o	0.7	0.7	m	Cowherd et al., 1984
U*	0.35	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	0.001	mg/ug	
IF_R	0.125	0.125	unitless	Cowherd et al., 1984
IF_O	0.625	0.625	unitless	Cowherd et al., 1984
CA	Calculated	Calculated	Mg/m^3	

*Average of male and female surface areas for arms and hands

TABLE 3-13

Exposure Parameters For Surface Soil Ingestion, Dermal Contact, And Inhalation
Future Resident – CTE Scenario
NASJRB, Willow Grove, Pennsylvania

PARAMETER	CHILD (0-6 YRS)	ADULTS	UNITS	SOURCE
CS	Chemical Specific	Chemical Specific	mg/kg	EPA 1989a
IR_{soil}	100	50	mg soil/day	EPA 1991d
IR_{air}	0.833	0.833	m^3/hour	EPA 1989a
FI	1	1	unitless	Assumption
ET	24	24	hours/day	Conventional
EF	350	350	days/year	EPA 1991d
ED	2	7	years	EPA 1989a, 1991d
EV	1	1	events/day	
BW	15	70	kg	EPA 1991d, 1989a
AT_{cancer}	70	70	years	EPA, 1989a
$AT_{non\text{-}cancer}$	2	7	years	EPA 1989a
DA_{event}	Chemical Specific	Chemical Specific	mg/cm^2-event	
$CF_{1\text{-}inorganics}$	1×10^{-6}	1×10^{-6}	kg/mg	
$CF_{1\text{-}organics}$	1×10^{-9}	1×10^{-9}	kg/ug	
SA	-	3,508*	cm^2	EPA 1996e
SA_i	Varies with age	-	cm^2	EPA 1989a
ED_i	1-year increments	-	years	EPA 1989a, 1991d
BW_i	Varies with age	-	kg	EPA 1996e
AF	1	1	mg/cm^2	EPA 1992e
ABS_{dermal}	Chemical Specific	Chemical Specific	unitless	EPA 1995a
E_{10}	Calculated	Calculated	g/m^2 sec	
V	0.7	0.7	unitless	Estimated from site visit
U	4.3	4.3	m/s	Cowherd et al., 1984
Ut	Calculated	Calculated	m/s	
F(x)	1.9	1.9	unitless	Cowherd et al., 1984
R_{10}	Calculated	Calculated	g/sec	
A	10000	10000	m^2	Estimated from site visit
Q_t	Calculated	Calculated	g/sec	
P_R	0.296	0.296	unitless	Cowherd et al., 1984
X	Calculated	Calculated	mg/m^3	Cowherd et al., 1984
F_i	Calculated	Calculated	$(ug/m^3)/(g/sec)$	
Z	7	7	m	Cowherd et al., 1984
z_o	0.7	0.7	m	Cowherd et al., 1984
U*	0.35	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	0.001	mg/ug	
IF_R	0.125	0.125	unitless	Cowherd et al., 1984
IF_O	0.625	0.625	unitless	Cowherd et al., 1984

*Average of male and female surface areas for arms and hands

TABLE 3-14

Exposure Parameters For Surface And Subsurface Soil Ingestion, Dermal Contact, And Inhalation Excavation Worker – RME Scenario NASJRB, Willow Grove, Pennsylvania

Parameter	Excavation Worker	Units	Source
CS	Chemical Specific	mg/kg or µg/kg	Analysis
IR_{soil}	480	mg/day	EPA, 1991a
FI	1	unitless	Assumption
$CF_{1\text{-inorganics}}$	1E-06	kg/mg	
$CF_{2\text{-organics}}$	1E-09	kg/µg	
EF	30	days/year	EPA, 1991a
ED	1	years	EPA, 1989a, 1991a
ET	8	hours/day	Assumption
EV	1	Events/day	
AT_{cancer}	70	years	EPA, 1991a
$AT_{non\text{-}cancer}$	1	years	EPA, 1991a
SA	3,508*	cm^2	EPA, 1992a
IR_{air}	2.5	m^3/hour	EPA, 1991a
BW	70	kg	EPA, 1991a
AF	1	mg/cm^2 per event	EPA, 1992a, 1995a
ABS_{dermal}	Chemical Specific	unitless	EPA, 1995a EPA, 1995h
E_{10}	Calculated	g/m^2 sec	
V	0.7	unitless	Estimated from site visit
U	4.3	m/s	Cowherd et al., 1984
Ut	Calculated	m/s	
F(x)	1.9	unitless	Cowherd et al., 1984
R_{10}	Calculated	g/sec	
A	10000	m^2	Estimated from site visit
Q_i	Calculated	g/sec	
P_R	0.296	unitless	Cowherd et al., 1984
X	Calculated	mg/m^3	Cowherd et al., 1984
F_i	3.837	$(ug/m^3)/(g/sec)$	
Z	7	m	Cowherd et al., 1984

TABLE 3-14
Exposure Parameters For Surface And Subsurface Soil Ingestion, Dermal Contact, And Inhalation Excavation Worker – RME Scenario
NASJRB, Willow Grove, Pennsylvania
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Parameter	Excavation Worker	Units	Source
z_o	0.7	m	Cowherd et al., 1984
U*	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	mg/ug	
IF_R	0.125	unitless	Cowherd et al., 1984
IF_O	0.625	unitless	Cowherd et al., 1984

*Average of male and female surface areas for arms and hands

TABLE 3-15

Exposure Parameters For Surface And Subsurface Soil Ingestion, Dermal Contact, And Inhalation
Excavation Worker – CTE Scenario
NASJRB, Willow Grove, Pennsylvania

Parameter	Excavation Worker	Units	Source
CS	Chemical Specific	mg/kg or µg/kg	Analysis
IR_{soil}	480	mg/day	EPA, 1991a
FI	1	unitless	Assumption
$CF_{1\text{-inorganics}}$	1E-06	kg/mg	
$CF_{1\text{-organics}}$	1E-09	kg/µg	
EF	15	days/year	EPA, 1991a
ED	1	years	EPA, 1989a, 1991a
ET	8	hours/day	Assumption
EV	1	Event/day	
AT_{cancer}	70	years	EPA, 1991a
$AT_{non\text{-}cancer}$	1	years	EPA, 1991a
SA	3,508*	cm^2	EPA, 1992a
IR_{air}	2.5	m^3/hour	EPA, 1991a
BW	70	kg	EPA, 1991a
AF	1	mg/cm^2 per event	EPA, 1992a, 1995a
ABS_{dermal}	Chemical Specific	unitless	EPA, 1995a EPA, 1995h
E_{10}	Calculated	g/m^2 sec	
V	0.7	unitless	Estimated from site visit
U	4.3	m/s	Cowherd et al., 1984
Ut	Calculated	m/s	
F(x)	1.9	unitless	Cowherd et al., 1984
R_{10}	Calculated	g/sec	
A	10000	m^2	Estimated from site visit
Q_I	Calculated	g/sec	
P_R	0.296	unitless	Cowherd et al., 1984
X	Calculated	mg/m^3	Cowherd et al., 1984
F_I	3.837	$(ug/m^3)/(g/sec)$	
Z	7	m	Cowherd et al., 1984

TABLE 3-15
Exposure Parameters For Surface And Subsurface Soil Ingestion, Dermal Contact, And Inhalation
Excavation Worker – CTE Scenario
NASJRB, Willow Grove, Pennsylvania
Page 2 Of 2

Parameter	Excavation Worker	Units	Source
z_o	0.7	m	Cowherd et al., 1984
U*	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	mg/ug	
IF_R	0.125	unitless	Cowherd et al., 1984
IF_O	0.625	unitless	Cowherd et al., 1984

this scenario were current occupational workers, current adolescent and adult trespassers, future child and adult residents, future excavation workers, and future recreational children. EPA or conventional values were used for most input parameters. For the dermal pathway, it was assumed that the primary areas of skin available for adult receptors (current and future) contact would be the hands and arms; for children (future) and adolescents (current), 25 percent of body surface area would be exposed.

A sample calculation for inhalation of fugitive dust is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-6 through Table 3-15 for RME and CTE scenarios. As discussed in Section 3.1.3.2, the potential receptors for this scenario were current occupational workers, current adolescent and adult trespassers, future child and adult residents, future excavation workers, and future recreational children. EPA or conventional values were used for most input parameters. Inhalation exposure to fugitive dust was calculated for receptors only using the equations established by EPA (1989a) and Cowherd, et al. (1984). Exposure to fugitive dust emissions from surface soil in an area of interest can be estimated by first calculating the average annual rate of PM_{10} particulate emissions, the average annual PM_{10} concentration downwind from the source area, and the downwind COPC concentration associated with PM_{10} and then applying this concentration to estimate the intake rate for the receptors. The input parameters were generally those provided in the Cowherd model, which allows limited parameter choices for area and distance to the area of interest. Specific details regarding the application of the model can be found in the source document (Cowherd, et al., 1984).

3.1.3.5.2 Sediment Exposure

Two potential exposure routes are associated with direct contact with sediment at NASJRB Willow Grove: ingestion and dermal contact. These scenarios were evaluated using the same basic equations as ingestion and dermal exposures for surface soil, which were explained above.

Ingestion

$$INTAKE_{INGESTION}(mg/kg)/day = \frac{CS * IR_{sediment} * FI * CF * EF * ED}{BW * AT * 365^{days}/_{year}}$$

Dermal Contact

$$INTAKE_{DERMAL}(mg/kg)/day = \frac{DA_{event} * SA * EF * ED * EV}{BW * AT * 365^{days}/_{year}} \text{ (Adults)}$$

$$INTAKE_{DERMAL} = \frac{DA_{event} * EV * EF}{AT * 365 \, {}^{days}/_{year}} * \sum_{i=m}^{n} \frac{SA_i * ED_i}{BW_i}$$ (Children, accounts changing SA and BW)

$$DA_{event} = CS * AF * ABS_{dermal} * CF_1$$

where:

CS	=	Chemical concentration in sediment (mg/kg or µg/kg sediment)
$IR_{sediment}$	=	Sediment ingestion rate (mg soil/day)
FI	=	Fraction ingested from contaminated source (unitless)
EF	=	Exposure frequency (days/yr)
ED	=	Exposure duration (years)
EV	=	Event frequency (events/day)
BW	=	Body weight (kg)
AT	=	Averaging time (days)
CF	=	Conversion factor (1×10^{-6} kg/mg for inorganics; 1×10^{-9} kg/µg for organics)
SA	=	Skin surface area available for contact (cm^2/day)
SA_i	=	Surface area exposed at age i (cm^2)
ED_i	=	Exposure duration at age i (years)
BW_i	=	Body weight at age i (kg)
AF	=	Soil-to-skin adherence factor (mg/cm^2)
ABS_{dermal}	=	Absorption factor (unitless)

A sample calculation for ingestion of sediment is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-16 through Table 3-19 for RME and CTE scenarios. As discussed in Section 3.4.3, the potential receptors for this scenario were current adolescent and adult trespassers and future recreational children. EPA or conventional values were used for all input parameters.

A sample calculation for dermal contact with sediment is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-16 through Table 3-19 for RME and CTE scenarios. As discussed in Section 3.1.3.2, the potential receptors for this scenario were current adolescent and adult trespassers and future recreational children.

TABLE 3-16

Exposure Parameters For Sediment Ingestion And Dermal Contact
Trespasser Adolescent And Adult – RME Scenario
NASJRB, Willow Grove, Pennsylvania

PARAMETER	ADOLESCENT	ADULT	UNITS	SOURCE
CS	Chemical-Specific	Chemical-Specific	mg/kg	EPA 1989a
$IR_{sediment}$	100	100	mg sed/day	EPA 1991d
FI	1	1	unitless	Professional judgment
EF	30	24	days/year	Assumption
ED	11	19	years	EPA 1991d
BW	40	70	kg	EPA 1996e
AT_{cancer}	70	70	years	EPA 1989a
$AT_{non\text{-}cancer}$	11	19	years	EPA 1989a
EV	1	1	events/day	
DA_{event}	Chemical-Specific	Chemical-Specific	mg/cm^2-event	
$CF_{inorganics}$	1×10^{-6}	1×10^{-6}	kg/mg	
$CF_{organics}$	1×10^{-9}	1×10^{-9}	kg/ug	
SA	-	4,734*	Cm^2	EPA, 1995
SA_i	Varies with age	-	cm^2	EPA 1985
ED_i	1-year increments	-	years	EPA 1989a, 1991d
BW_i	Varies with age	-	kg	EPA 1985
AF	1	1	mg/cm^2	EPA 1992e
ABS_{dermal}	Chemical-Specific	Chemical-Specific	unitless	EPA 1995a

* Average of male and female surface area for hands, arms, and feet

TABLE 3-17

Exposure Parameters For Sediment Ingestion And Dermal Contact
Trespasser Adolescent And Adult – CTE Scenario
NASJRB, Willow Grove, Pennsylvania

PARAMETER	ADOLESCENT	ADULT	UNITS	SOURCE
CS	Chemical-Specific	Chemical-Specific	mg/kg	EPA 1989a
$IR_{sediment}$	50	50	mg sed/day	EPA 1991d
FI	1	1	Unitless	Professional judgment
EF	15	12	days/year	Assumption
ED	2	7	years	EPA 1991d
BW	40	70	kg	EPA 1996e
AT_{cancer}	70	70	years	EPA 1989a
$AT_{non\text{-}cancer}$	2	7	years	EPA 1989a
EV	1	1	events/day	
DA_{event}	Chemical-Specific	Chemical-Specific	mg/cm^2-event	
$CF_{inorganics}$	1×10^{-6}	1×10^{-6}	kg/mg	
$CF_{organics}$	1×10^{-9}	1×10^{-9}	kg/ug	
SA	-	4,734*	Cm^2	EPA, 1995
SA_i	Varies with age	-	cm^2	EPA 1985
ED_i	1-year increments	-	years	EPA 1989a, 1991d
BW_i	Varies with age	-	kg	EPA 1985
AF	1	1	mg/cm^2	EPA 1992e
ABS_{dermal}	Chemical-Specific	Chemical-Specific	unitless	EPA 1995

* Average of male and female surface area for hands, arms, and feet

TABLE 3-18

Exposure Parameters For Sediment Ingestion And Dermal Contact
Recreational Child – RME Scenario
NASJRB, Willow Grove, Pennsylvania

PARAMETER	CHILD VALUE (3-8 YRS)	UNITS	SOURCE
CS	Chemical-Specific	mg/kg	EPA 1989a
$IR_{sediment}$	200	mg sed/day	EPA 1991d
FI	1	unitless	Professional judgment
EF	7	days/year	Assumption
ED	6	years	EPA 1991d
BW	21.3	kg	EPA 1996e (Ave. 3-8 yrs.)
AT_{cancer}	70	years	EPA 1989a
$AT_{non\text{-}cancer}$	6	years	EPA 1989a
EV	1	events/day	
DA_{event}	Chemical-Specific	mg/cm^2-event	
$CF_{inorganics}$	1×10^{-6}	kg/mg	
$CF_{organics}$	1×10^{-9}	kg/ug	
SA_i	Varies with age	cm^2	EPA 1985
ED_i	1-year increments	years	EPA 1989a, 1991d
BW_i	Varies with age	kg	EPA 1985
AF	1	mg/cm^2	EPA 1992e
ABS_{dermal}	Chemical-Specific	unitless	EPA 1995

TABLE 3-19

Exposure Parameters For Sediment Ingestion And Dermal Contact
Recreational Child – CTE Scenario
NASJRB, Willow Grove, Pennsylvania

PARAMETER	CHILD VALUE (3-8 YRS)	UNITS	SOURCE
CS	Chemical-Specific	mg/kg	EPA 1989a
$IR_{sediment}$	100	mg sed/day	EPA 1991d
FI	1	unitless	
EF	7	days/year	Assumption
ED	2	years	EPA 1991d
BW	21.3	kg	EPA 1996e (Ave. 3-8 yrs.)
AT_{cancer}	70	years	EPA 1989a
$AT_{non\text{-}cancer}$	2	years	EPA 1989a
EV	1	events/day	
DA_{event}	Chemical-Specific	mg/cm^2-event	
$CF_{inorganics}$	1×10^{-6}	kg/mg	
$CF_{organics}$	1×10^{-9}	kg/ug	
SA_i	Varies with age	cm^2	EPA 1985
ED_i	1-year increments	years	EPA 1989a, 1991d
BW_i	Varies with age	kg	EPA 1985
AF	1	mg/cm^2	EPA 1992e
ABS_{dermal}	Chemical-Specific	unitless	EPA 1995

EPA or conventional values were used for most input parameters. For the dermal pathway, it was assumed that the primary areas of skin available for adult receptors (current) contact would be the hands, arms, and feet; for children (future) and adolescents (current), 25 percent of body surface area would be exposed.

3.1.3.5.3 Surface Water Exposure

Two potential exposure routes are associated with surface water exposure at NASJRB Willow Grove: ingestion and dermal contact. These scenarios were evaluated using the same basic equations as ingestion and dermal exposures for groundwater, which were explained above.

Ingestion

$$INTAKE_{INGESTION}\ (mg/kg)/day = \frac{CW * IR_{surfacewater} * CF_1 * EF * ED}{BW * AT * 365\ {}^{days}/_{year}}$$

Dermal Contact

$$INTAKE_{DERMAL}(mg/kg)/day = \frac{DA_{event} * SA * EF * ED * EV}{BW * AT * 365\ {}^{days}/_{year}}$$ (Adults)

$$INTAKE_{DERMAL} = \frac{DA_{event} * EV * EF}{AT * 365\ {}^{days}/_{year}} * \sum_{i=m}^{n} \frac{SA_i * ED_i}{BW_i}$$ (Children, accounts for varying SA and BW)

$$DA_{event} = PC_{event} * CW * CF_1 * CF_2$$

For Inorganics (Steady State Approach):

$$PC_{event} = K_{pw-inorg} * t_{event}$$

For Organics (Non-steady State Approach):

Case 1: $$DA_{event} = PC_{event} * CW * CF_1 * CF_2$$

$$PC_{event} = 2 * K_{pw-org} * \sqrt{\frac{6 * \tau * t_{event}}{\pi}}$$

where $t_{event} < t^*$ (for the specific organic chemical)

Case 2: $$DA_{event} = PC_{event} * CW * CF_1 * CF_2$$

$$PC_{event} = K_{pw-org} * ((t_{event}/(1+B)) + 2\tau * ((1+3B)/(1+B))$$

where $t_{event} > t^*$ (for the specific organic chemical)

where:

CW	=	Concentration of contaminant in surface water (µg/L)
$IR_{groundwater}$	=	Surface water ingestion rate (L/day)
CF_1	=	Conversion factor (mg/10^3 µg)
CF_2	=	Conversion factor (L/10^3 cm^3)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
EV	=	Event frequency (events/day)
AT	=	Averaging time (years)
SA	=	Surface area (cm^2)
BW	=	Body weight (kg)
DA_{event}	=	Dose absorbed per unit area per event [mg/(event-cm^2)]
PC_{event}	=	Diffusion depth per event (cm/event)
$K_{pw-inorg}$	=	Permeability coefficient from water (cm/hr)
t_{event}	=	Duration of event (hr/event)
K_{pw-org}	=	Permeability coefficient from water (cm/hr)
τ	=	Lag time (hr)
t^*	=	Time to reach steady state (hr)
B	=	Octanol water partition coefficient divided by 10^4 (dimensionless)
SA_i	=	Surface area exposed at age i (cm^2)
ED_i	=	Exposure duration at age i (years)
BW_i	=	Body weight at age i (kg)

A sample calculation for ingestion of surface water is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-20 through Table 3-23 for RME and CTE scenarios. As discussed in Section 3.1.3.2, the potential receptors for this scenario were current adolescent and adult trespassers and future recreational children. EPA or conventional values were used for all input parameters.

TABLE 3-20

Exposure Parameters For Surface Water Ingestion And Dermal Contact
Trespasser Adolescent And Adult – RME Scenario
NASJRB, Willow Grove, Pennsylvania

PARAMETER	ADOLESCENT	ADULT	UNIT	SOURCE
CW	Chemical-Specific	Chemical-Specific	ug/liter	EPA 1989a
$IR_{surface\ water}$	0.065	0.065	liters/day	EPA 1989a
CF_1	0.001	0.001	mg/10^3 ug	
CF_2	0.001	0.001	liters/10^3 cm^3	
EF	30	24	days/year	EPA 1989a
ED	11	19	years	EPA 1991d
EV	1	1	events/day	
BW	40	70	Kg	EPA 1996e
AT_{cancer}	70	70	Years	EPA 1989a
$AT_{non\text{-}cancer}$	11	19	Years	EPA 1989a
DA_{event}	Chemical-Specific	Chemical-Specific	Mg/event-cm^2	
SA	-	3,508*	Cm^2	EPA 1985
SA_i	Varies with Age	-	Cm^2	EPA 1985
ED_i	1 year increments	-	Years	EPA 1989a
BW_i	Varies with Age	70	Kg	EPA 1985
AF	1	1	Mg/cm^2	EPA 1992e
$K_{pw\text{-}inorg}$	0.001	0.001	Cm/hour	EPA 1992e
$K_{pw\text{-}org}$	Chemical-Specific	Chemical-Specific	Cm/hour	EPA 1992e
t_{event}	2.6	2.6	Hour/event	
t*	Chemical-Specific	Chemical-Specific	Hour	EPA 1992e
τ	Chemical-Specific	Chemical-Specific	Hour	EPA 1992e
PC_{event}	Chemical-Specific	Chemical-Specific	Cm/event	
B	Chemical-Specific	Chemical-Specific	Unitless	EPA 1992e

TABLE 3-21

Exposure Parameters For Surface Water Ingestion And Dermal Contact
Trespasser Adolescent And Adult – CTE Scenario
NASJRB, Willow Grove, Pennsylvania

PARAMETER	ADOLESCENT	ADULT	UNITS	SOURCE
CW	Chemical-Specific	Chemical-Specific	ug/liter	EPA 1989a
$IR_{surface\ water}$	0.065	0.065	liters/day	EPA 1989a
CF_1	0.001	0.001	mg/10^3 ug	
CF_2	0.001	0.001	liters/10^3 cm^3	
EF	15	12	days/year	EPA 1989a
ED	2	7	years	EPA 1991d
EV	1	1	events/day	
BW	40	70	kg	EPA 1996e
AT_{cancer}	70	70	years	EPA 1989a
$AT_{non\text{-}cancer}$	2	7	years	EPA 1989a
DA_{event}	Chemical-Specific	Chemical-Specific	mg/event-cm^2	
SA	-	3,508*	Cm^2	EPA 1995
SA_i	Varies with Age	-	cm^2	EPA 1985
ED_i	1 year increments	-	years	EPA 1989a
BW_i	Varies with Age	70	kg	EPA 1985
AF	1	1	mg/cm^2	EPA 1992e
$K_{pw\text{-}inorg}$	0.001	0.001	cm/hour	EPA 1992e
$K_{pw\text{-}org}$	Chemical-Specific	Chemical-Specific	cm/hour	EPA 1992e
t_{event}	2.6	2.6	hour/event	
t*	Chemical-Specific	Chemical-Specific	hour	EPA 1992e
τ	Chemical-Specific	Chemical-Specific	hour	EPA 1992e
PC_{event}	Chemical-Specific	Chemical-Specific	cm/event	
B	Chemical-Specific	Chemical-Specific	unitless	EPA 1992e

TABLE 3-22

Exposure Parameters For Surface Water Ingestion And Dermal Contact
Recreational Child – RME Scenario
NASJRB, Willow Grove, Pennsylvania

PARAMETER	CHILD VALUE (3-8 YEAR)	UNITS	SOURCE
CW	Chemical-Specific	ug/liter	EPA 1989a
$IR_{surface\ water}$	0.065	liters/day	EPA 1989a
CF_1	0.001	mg/10^3 ug	
CF_2	0.001	liters/10^3 cm^3	
EF	7	days/year	EPA 1989a
ED	6	years	EPA 1991d
EV	1	events/day	
BW	21.3	kg (Ave. 3-8 yrs.)	EPA 1996e
AT_{cancer}	70	years	EPA 1989a
$AT_{non\text{-}cancer}$	6	years	EPA 1989a
DA_{event}	Chemical-Specific	mg/event- cm^2	
SA_i	Varies with Age	cm^2	EPA 1985
ED_i	1 year increments	years	EPA 1989a
BW_i	Varies with Age	kg	EPA 1985
AF	1	mg/cm^2	EPA 1992e
$K_{pw\text{-}inorg}$	0.001	cm/hour	EPA 1992e
$K_{pw\text{-}org}$	Chemical-Specific	cm/hour	EPA 1992e
t_{event}	2.6	hour/event	
t^*	Chemical-Specific	hour	EPA 1992e
τ	Chemical-Specific	hour	EPA 1992e
PC_{event}	Chemical-Specific	cm/event	
B	Chemical-Specific	unitless	EPA 1992e

TABLE 3-23

Exposure Parameters For Surface Water Ingestion And Dermal Contact
Recreational Child – CTE Scenario
NASJRB, Willow Grove, Pennsylvania

PARAMETER	CHILD VALUE (3-8 YRS)	UNITS	SOURCE
CW	Chemical-Specific	ug/liter	EPA 1989a
$IR_{surface\ water}$	0.065	liters/day	EPA 1989a
CF_1	0.001	mg/10^3 ug	
CF_2	0.001	liters/10^3 cm^3	
EF	7	days/year	EPA 1989a
ED	2	years	EPA 1991d
EV	1	events/day	
BW	21.3	kg (Ave. 3-8 yrs.)	EPA 1996e
AT_{cancer}	70	years	EPA 1989a
$AT_{non\text{-}cancer}$	2	years	EPA 1989a
DA_{event}	Chemical-Specific	mg/event- cm^2	
SA_i	Varies with Age	cm^2	EPA 1985
ED_i	1 year increments	years	EPA 1989a
BW_i	Varies with Age	kg	EPA 1985
AF	1	mg/cm^2	EPA 1992e
$K_{pw\text{-}inorg}$	0.001	cm/hour	EPA 1992e
$K_{pw\text{-}org}$	Chemical-Specific	cm/hour	EPA 1992e
t_{event}	2.6	hour/event	
t^*	Chemical-Specific	hour	EPA 1992e
τ	Chemical-Specific	hour	EPA 1992e
PC_{event}	Chemical-Specific	cm/event	
B	Chemical-Specific	unitless	EPA 1992e

A sample calculation for dermal contact with surface water is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-20 through Table 3-23 for RME and CTE scenarios. As discussed in Section 3.1.3.2, the potential receptors for this scenario were current adolescent and adult trespassers and future recreational children. EPA or conventional values were used for all input parameters. The approach for dermal contact with surface water is based on the assumption that water contaminants are present in dilute solution and that percutaneous absorption is controlled by the flux of water. K_{pw}, B, τ, and t* were chemical-specific values obtained from EPA (1992e) or derived from the molecular weight and Kow as demonstrated therein. As recommended by the guidance, default $K_{pw\text{-}inorg}$ values of 1E-3 cm/hr were used for metals for which experimental values had not been obtained (EPA, 1992e). For the dermal pathway, it was assumed that the primary areas of skin available for adult receptors (current and future) contact would be the hands, arms, and feet; for children (future) and adolescents (current), 25 percent of body surface area would be exposed.

3.1.3.5.4 Groundwater Exposure

Three potential exposure routes are associated with direct contact with groundwater at the site: ingestion, dermal contact, and inhalation of vapors during showering or excavation activities (from shallow groundwater). The methods used to assess these routes of exposure are discussed in the following text.

Exposures via incidental groundwater ingestion, dermal contact, and inhalation of volatile organic vapors are estimated using the following equations (EPA, 1989a):

Ingestion

$$INTAKE_{INGESTION}\ (mg/kg)/day = \frac{CW * IR_{groundwater} * CF_1 * EF * ED}{BW * AT * 365\ {}^{days}/_{year}}$$

Dermal Contact

$$INTAKE_{DERMAL}\ (mg/kg)/day = \frac{DA_{event} * SA * EF * ED * EV}{BW * AT * 365\ {}^{days}/_{year}} \text{ (Adults)}$$

$$INTAKE_{DERMAL} = \frac{DA_{event} * EV * EF}{AT * 365\ {}^{days}/_{year}} * \sum_{i=m}^{n} \frac{SA_i * ED_i}{BW_i} \text{ (Children, accounts for varying SA and BW)}$$

$$DA_{event} = PC_{event} * CW * CF_1 * CF_2$$

For Inorganics (Steady State Approach):

$$PC_{event} = K_{pw-inorg} * t_{event}$$

For Organics (Non-steady State Approach):

Case 1: $$DA_{event} = PC_{event} * CW * CF_1 * CF_2$$

$$PC_{event} = 2 * K_{pw-org} * \sqrt{\frac{6 * \tau * t_{event}}{\pi}}$$

where $t_{event} < t^*$ (for the specific organic chemical)

Case 2: $$DA_{event} = PC_{event} * CW * CF_1 * CF_2$$

$$PC_{event} = K_{pw-org} * ((t_{event}/(1+B)) + 2\tau * ((1+3B)/(1+B))$$

where $t_{event} > t^*$ (for the specific organic chemical)

Inhalation of COPCs in Volatile Organic Vapors (Showering)

$$INTAKE_{INHALATION}(mg / kg) / day = \frac{D * EF * ED}{AT * 365\ days/year}$$

Where:

$$D = \frac{IR_{air} * S}{BW * Ra * CF_3} * Q \quad \text{AND} \quad Q = Ds + \left\{\frac{e^{-Ra*Dt}}{Ra}\right\} - \left\{\frac{e^{-Ra*(Ds-Dt)}}{Ra}\right\} \quad \text{AND}$$

$$S = \frac{Cwd * Fr}{Sv} \quad \text{AND} \quad Cwd = CW * \left(1 - e^{-KaL*ts*6/d*CF_4*CF_5}\right) \quad \text{AND}$$

$$KaL = \frac{KL}{\sqrt{\frac{T_1 * \mu_S}{T_S * \mu_1}}} \quad \text{AND} \quad KL = \frac{1}{\left(\frac{1}{kl}\right) + \left(\frac{R * T_2}{H * kg}\right)} \quad \text{AND}$$

$$kg = kH * \sqrt{\frac{MWH}{MW}} \quad \text{AND} \quad kl = kC * \sqrt{\frac{MWC}{MW}}$$

Inhalation of COPCs in Volatile Organic Vapors (Excavation)

$$INTAKE_{INHALATION}\ (mg/kg)/day = \frac{C_{air,chemical} * IR * EF * ED}{AT * 365\ {}^{days}/_{year}}$$

$$C_{air,chemical} = CW * CF_1 * H * {}^{1}/_{R} * {}^{1}/_{T_3}$$

where:

CW	=	Concentration of contaminant in groundwater (µg/L)
$IR_{groundwater}$	=	Groundwater ingestion rate (L/day)
CF_1	=	Conversion factor (mg/10^3 µg)
CF_2	=	Conversion factor (L/10^3 cm^3)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
EV	=	Event frequency (events/day)
AT	=	Averaging time (years)
SA	=	Surface area (cm^2)
BW	=	Body weight (kg)
DA_{event}	=	Dose absorbed per unit area per event [mg/(event-cm^2)]
PC_{event}	=	Diffusion depth per event (cm/event)
$K_{pw-inorg}$	=	Permeability coefficient from water (cm/hr)
t_{event}	=	Duration of event (hr/event)
K_{pw-org}	=	Permeability coefficient from water (cm/hr)
τ	=	Lag time (hr)
t*	=	Time to reach steady state (hr)
B	=	Octanol water partition coefficient divided by 10^4 (dimensionless)
SA_i	=	Surface area exposed at age i (cm^2)
ED_i	=	Exposure duration at age i (years)
BW_i	=	Body weight at age i (kg)
D	=	Inhalation dose (mg/kg/shower)
CF_3	=	Conversion factor: 10^6 ug x L / (mg x m^3)
Q	=	Function of air exchange rate and time in shower and shower room (min)
IR_{air}	=	Inhalation rate (L/min)
S	=	Indoor VOC generation rate (ug/m^3/min)
Ra	=	Rate of air exchange (min^{-1})
Ds	=	Duration of shower (min)

Dt	=	Total time in shower room (min)
Cwd	=	Concentration leaving water droplet (ug/L)
Fr	=	Shower flow rate (L/min)
Sv	=	Shower room air volume (m^3)
KaL	=	Adjusted overall mass transfer coefficient (cm/hr)
ts	=	Shower droplet time (sec)
6/d	=	Specific interfacial area (1/mm)
CF_4	=	Conversion factor (1hr/3600 sec)
CF_5	=	Conversion Factor (10 mm/cm)
d	=	Shower droplet diameter (mm)
KL	=	Mass transfer coefficient (cm/hr)
T_1	=	Calibration water temperature of KL (°K)
Ts	=	Shower water temperature (°K)
μ_1	=	Water viscosity at T1 (centipoise)
μ_s	=	Water viscosity at Ts (centipoise)
R	=	Ideal gas law constant [atm-m^3/(mole-°K)]
T_2	=	Absolute temperature (°K)
H	=	Henry's Law constant (atm-m^3/mole)
kg	=	Gas-film mass transfer coefficient (cm/hr)
kl	=	Liquid-film mass transfer coefficient (cm/hr)
kH	=	kg for water (cm/hr)
kC	=	kl for carbon dioxide (cm/hr)
MWH	=	Molecular weight of water (g/mole)
MWC	=	Molecular weight of carbon dioxide (g/mole)
MW	=	Molecular weight of the chemical (g/mole)
$C_{air,chemical}$	=	Concentration in Air (mg/m^3)
T_3	=	Temperature (°K)

A sample calculation for ingestion of groundwater is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-24 and Table 3-25 for RME and CTE scenarios. As discussed in Section 3.1.3.2, the potential receptors for this scenario were future adult and child residential receptors. EPA or conventional values were used for all input parameters.

A sample calculation for dermal contact with groundwater is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-24 and Table 3-25 for RME and CTE scenarios. As discussed in Section 3.1.3.2, the potential receptors for this

TABLE 3-24

Exposure Parameters For Groundwater Ingestion, Dermal Contact, And Inhalation
Residential Child And Adult Receptors – RME Scenario
NASJRB, Willow Grove, Pennsylvania

PARAMETER	CHILD VALUE (0-6 YRS)	ADULT	UNIT	SOURCE
CW	Chemical-Specific	Chemical-Specific	ug/liter	EPA 1989a
$IR_{groundwater}$	1	2	liters/day	EPA 1991d
CF_1	0.001	0.001	mg/10^3 µg	
CF_2	0.001	0.001	liters/10^3 cm^3	
EF	350	350	days/year	EPA 1991d
ED	6	24	years	EPA 1989a, 1991d
EV	1	1	event/day	
AT_{cancer}	70	70	years	EPA 1989a
$AT_{non-cancer}$	6	24	years	EPA 1989a
SA	-	18150	cm^2	EPA 1996e
BW	15	70	kg	EPA 1989a, 1991d
DA_{event}	Chemical-Specific	Chemical-Specific	mg/event-cm^2	
PC_{event}	Chemical-Specific	Chemical-Specific	cm/event	
$K_{pw - inorganic}$	0.001	0.001	cm/hour	EPA 1992e
t_{event}	0.33	0.25	hr/event	Assumption
$K_{pw - organic}$	Chemical-Specific	Chemical-Specific	cm/hour	EPA 1992e
τ	Chemical-Specific	Chemical-Specific	hours	EPA 1992e
t*	Chemical-Specific	Chemical-Specific	hour	EPA 1992e
B	Chemical-Specific	Chemical-Specific	unitless	EPA 1992e
SA_i	Varies with Age	-	cm^2	EPA 1985
ED_i	1 year increments	-	years	EPA 1989a, 1991d
BW_i	Varies with Age	-	kg	EPA 1985, 1991d
D	-	Chemical-Specific	mg/kg/shower	
CF_3	-	1000000	ug*L/mg*m^3	
Q	-	Chemical-Specific	minutes	
IR_{air}	-	14	liters/minutes	EPA 1989a
S	-	Chemical-Specific	ug/m^3/min	
Ra	-	0.01667	min^{-1}	Foster and Chrostowski, 1987
Ds	-	15	minutes	EPA, 1996e
Dt	-	20	minutes	Professional judgment
Cwd	-	Chemical-Specific	ug/liter	
Fr	-	20	liters/minute	Professional judgment
Sv	-	6	m^3	Professional judgment
KaL	-	Chemical-Specific	cm/hour	
ts	-	2	seconds	
d	-	1	mm	
KL	-	Chemical-Specific	cm/hour	
T_1	-	293	°K	
Ts	-	318	°K	Foster and Chrostowski, 1987

TABLE 3-24
Exposure Parameters For Groundwater Ingestion, Dermal Contact, And Inhalation
Residential Child And Adult Receptors – RME Scenario
NASJRB, Willow Grove, Pennsylvania
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PARAMETER	CHILD VALUE (0-6 YRS)	ADULT	UNIT	SOURCE
μ_1	-	1.002	centipoise	
μ_s	-	0.596	centipoise	
R^*T_2	-	0.0241	atm/m^3-mole	
CF_4	-	1/3600	Hr/sec	
CF_5	-	10	Mm/cm	
T_3	-	298	°K	
$C_{air,chemical}$	-	Calculated	Mg/m^3	
H	-	Chemical-Specific	atm-m^3/mole	
Kg	-	Chemical-Specific	cm/hour	
Kl	-	Chemical-Specific	cm/hour	
KH	-	3000	cm/hour	
KC	-	20	cm/hour	
MWH	-	18	g/mole	
MWC	-	44	g/mole	
MW	-	Chemical-Specific	g/mole	

TABLE 3-25

Exposure Parameters For Groundwater Ingestion, Dermal Contact, And Inhalation
Residential Child And Adult Receptors – CTE Scenario
NASJRB, Willow Grove, Pennsylvania

PARAMETER	CHILD VALUE (0-6 YRS)	ADULT	UNIT	SOURCE
CW	Chemical-Specific	Chemical-Specific	ug/liter	EPA 1989a
$IR_{groundwater}$	0.7	1.4	liters/day	EPA 1991d
CF_1	0.001	0.001	mg/10^3 µg	
CF_2	0.001	0.001	liters/10^3 cm^3	
EF	350	350	days/year	EPA 1991d
ED	2	7	years	EPA 1989a, 1991d
EV	1	1	event/day	
AT_{cancer}	70	70	years	EPA 1989a
$AT_{non-cancer}$	2	7	years	EPA 1989a
SA	2728	18150	cm^2	EPA 1996e
BW	15	70	kg	EPA 1989a, 1991d
DA_{event}	Chemical-Specific	Chemical-Specific	mg/event-cm^2	
PC_{event}	Chemical-Specific	Chemical-Specific	cm/event	
$K_{pw\ -\ inorganic}$	0.001	0.001	cm/hour	EPA 1992e
t_{event}	0.33	0.25	hr/event	Assumption
$K_{pw\ -\ organic}$	Chemical-Specific	Chemical-Specific	cm/hour	EPA 1992e
τ	Chemical-Specific	Chemical-Specific	hours	EPA 1992e
t*	Chemical-Specific	Chemical-Specific	hour	EPA 1992e
B	Chemical-Specific	Chemical-Specific	unitless	EPA 1992e
SA_i	Varies with Age--See Text	-	cm^2	EPA 1985
ED_i	1 year increments	-	years	EPA 1989a, 1991d
BW_i	Varies with Age--See Text	-	kg	EPA 1985, 1991d
D	-	Chemical-Specific	mg/kg/shower	
CF_3	-	1000000	ug*L/mg*m^3	
Q	-	Chemical-Specific	minutes	
IR_{air}	-	14	liters/minutes	EPA 1989a
S	-	Chemical-Specific	ug/m^3/min	
Ra	-	0.01667	min^{-1}	Foster and Chrostowski, 1987
Ds	-	15	minutes	EPA, 1996e
Dt	-	20	minutes	Professional judgment
Cwd	-	Chemical-Specific	ug/liter	
Fr	-	20	liters/minute	Professional judgment
Sv	-	6	m^3	Professional judgment
KaL	-	Chemical-Specific	cm/hour	
ts	-	2	seconds	
d	-	1	mm	
KL	-	Chemical-Specific	cm/hour	

TABLE 3-25
Exposure Parameters For Groundwater Ingestion, Dermal Contact, And Inhalation
Residential Child And Adult Receptors – CTE Scenario
NASJRB, Willow Grove, Pennsylvania
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PARAMETER	CHILD VALUE (0-6 YRS)	ADULT	UNIT	SOURCE
T_1	-	293	°K	
Ts	-	318	°K	Foster and Chrostowski, 1987
μ_1	-	1.002	centipoise	
μ_s	-	0.596	centipoise	
R^*T_2	-	0.0241	atm/m^3-mole	
CF_4	-	1/3600	Hr/sec	
CF_5	-	10	Mm/cm	
T_3	-	298	°K	
$C_{air,chemical}$	-	Calculated	Mg/m^3	
H	-	Chemical-Specific	atm-m^3/mole	
Kg	-	Chemical-Specific	cm/hour	
Kl	-	Chemical-Specific	cm/hour	
KH	-	3000	cm/hour	
KC	-	20	cm/hour	
MWH	-	18	g/mole	
MWC	-	44	g/mole	
MW	-	Chemical-Specific	g/mole	

scenario were future adult (showering) and child (bathing) residential receptors. EPA or conventional values were used for most input parameters. The approach for dermal contact with groundwater is based on the assumption that water contaminants are present in dilute solution and that percutaneous absorption is controlled by the flux of water. Adult and child residents were assumed to take daily showers and baths, respectively, and therefore their total body surface areas were used. K_{pw}, B, τ, and t* were chemical-specific values obtained from EPA (1992f) or derived from the molecular weight and Kow as demonstrated therein. As recommended by the guidance, default $K_{pw\text{-}inorg}$ values of 1E-3 cm/hr were used for metals for which experimental values had not been obtained (EPA, 1992f). The age-adjusted, body-weight-normalized surface areas exposed while bathing for a resident child is 2728 cm^2-year/kg.

A sample calculation for inhalation of volatile COPCs during showering is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-24 and 3-25. As discussed in Section 3.1.3.3, the potential receptors for this scenario were future adult (showering) residential receptors and future excavation workers (excavation scenario). EPA or conventional values were used for most input parameters. Inhalation exposure to groundwater (during showering) was calculated for adult residents only using the equations established by EPA (1989a) and Foster and Chrostowski (1987).

3.1.3.6 Blood-Lead Modeling

As outlined in OSWER Directive 9355.4-12 (EPA, 1994a), EPA has implemented an approach to evaluating lead risks that recognizes the multimedia nature of lead exposures, incorporating absorption and pharmacokinetic information. Research has been done concerning lead intake and resultant blood-lead levels. Determinations of lead uptake from soil, sediment, drinking water, and surface water were considered. For the purposes of this risk assessment, each pathway was evaluated separately so that the contribution of lead from each source and each exposure route could be evaluated. Potential blood-lead level increases were estimated and are discussed, along with the potential implications of blood-lead results for each site. The following paragraphs present information that is useful in estimating lead exposure.

No threshold has been defined for effects related to blood-lead increases. The estimated increases at these sites are well below the concentrations at which effects such as anemia and neuropathy occur (40 µg/dL and above) (Doull et al., 1986). Effects below 10 µg/dL are difficult to define. Inhibition of certain enzymes involved in red blood cell metabolism has been reported to occur at 10 to 15 µg/dL and possibly lower (EPA, 1991b). Small increases in blood pressure have been related to adults with blood-lead levels down to 7 µg/dL (EPA, 1991b). Probably the subpopulation most sensitive to effects at the 3 to 7 µg/dL range (where the concentrations estimated for this study area would fall) would be infants, whose early

neurological development can be affected by blood-lead concentrations reportedly down to 5 µg/dL (EPA, 1991b). Lead is also a fairly common environmental contaminant and, for this reason, typical blood-lead levels in the population at large may already exceed the concentrations discussed here.

For drinking water exposure, children 0 through 6 months old are expected to experience blood-lead increases at the rate of 0.26 µg/dL per µg/L lead in water up to 15 µg/L and at the rate of 0.04 µg/dL for every µg/L lead in water above 15 µg/L (EPA, 1991b). For older children, the ratio is 0.12 µg/dL blood lead per µg/L lead in water up to 15 µg/L and 0.06 µg/dL for every µg/L lead in water above 15 µg/L (EPA, 1991b). For adults, the ratio is approximately 0.06 µg/dL blood lead per µg/L in water (EPA, 1991b).

Dietary intake of lead is assumed to produce increases of 0.02 to 0.04 µg/dL blood lead per µg/day ingested by adults and 0.16 µg/dL blood lead per µg/day ingested by infants (EPA, 1986).

Blood-lead levels are estimated to increase by 0.6 to 6.8 µg/dL per 1,000 mg/kg lead in soil (EPA, 1986). Estimates of blood-lead levels in residential children (age 0 through 6 years) were made using the Integrated Exposure and Uptake Biokinetic (IEUBK) Model (version 0.99) developed by EPA. The model was applied to each site where lead was selected as a COPC in surface soil. The output for each run of the IEUBK Model is a histogram that presents the estimated percentage of residential children (age 0 through 6 years) with a blood-lead level above 10 µg/dL (considered to be the significant cutoff level above which adverse effects cannot be ruled out). When the percentage of the population estimated to have blood levels above 10 µg/dL is greater than five percent, EPA considers the potential for adverse effects to be significant (EPA, 1994b). These histograms, along with input information particular to each run of the IEUBK model, are presented in Appendix A of the Supplemental RFI/RI Report. The estimated percentage of residential children (age 0 through 6 years) with a blood-lead level above 10 µg/dL is also presented in the site-specific text contained in subsequent sections of this report. Uncertainties associated with the IEUBK model are discussed in Section 3.1.5.9.

Noncarcinogenic risks for occupational workers from exposures to lead in soil were estimated using the Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil (EPA, 1996). The model is based on a biokinetic slope factor that estimates fetal blood-lead concentration in women exposed to lead-contaminated soil. A simplified (linear) representation of lead biokinetics is used to predict quasi-steady-state blood-lead concentrations among adults who have relatively steady patterns of site exposures (exposure duration of at least 90 days and exposure frequencies greater than once per week). The intake assumptions used in the model were the maximum (RME) and the average (CTE) soil lead concentrations at the site, a 50 mg-per-day soil ingestion rate, and a 219 days-per-year exposure frequency. The biokinetic model input parameters were a biokinetic slope factor (ug/dl adult blood-lead per ug/day uptake) of 0.4, a constant of proportionality between fetal blood-lead concentration at birth and

maternal blood-lead concentration of 0.9, a soil absorption factor of 0.12 (equal to the product of the relative bioavailability of 0.6 and a soluble lead absorption factor of 0.2), a background blood lead (typical concentration for women of childbearing age not exposed to the site) of 1.7 ug/dl, and a geometric standard deviation of 1.8 (representative of a relatively homogeneous population demographic).

3.1.4 Risk Characterization

Potential human health risks resulting from the exposures outlined in the preceding sections are characterized on a quantitative and qualitative basis in this section. Quantitative risk estimates are generated based on risk assessment methods outlined in current EPA guidance (EPA, 1989a).

Noncarcinogenic risk estimates are presented in the form of Hazard Quotients (HQs) and Hazard Indices (HIs) that are determined through integration of estimated intakes with published RfDs. Incremental cancer risk estimates are provided in the form of dimensionless probabilities based on SFs. Estimated human intakes were developed for each of the specific exposure routes discussed in the preceding sections. Both carcinogenic and noncarcinogenic risks are summarized for each exposure route on a series of tables in this section.

3.1.4.1 Carcinogenic Risks

Incremental cancer risk estimates are generated for each of the exposure pathways using the estimated intakes and published SFs, as follows:

$$\text{Risk} = \text{Intake} * \text{SF}$$

If the above equation results in a risk greater than 0.01, the following equation is used:

$$\text{Risk} = 1 - e^{-(\text{Intake}*\text{SF})}$$

The risk determined using these equations is a unitless expression of an individual's increased likelihood of developing cancer as a result of exposure to carcinogenic chemicals. An incremental cancer risk of 1E-06 indicates that the exposed receptor has a one in a million chance of developing cancer under the defined exposure scenario. Alternatively, such a risk may be interpreted as representing one additional case of cancer in an exposed population of one million persons. The calculated cancer risks should be recognized as upper-limit estimates. SFs are the upper 95 percent confidence limit of a dose-response

curve generally derived from animal studies. Actual human risk, while not identifiable, is not expected to exceed the upper limit based on the SFs and may, in fact, be lower.

EPA has generally defined risks in the range of 1E-04 to 1E-06 or less as being acceptable for most hazardous waste facilities addressed under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA). For CERCLA activities, residual risks on the order of 1E-06 are the primary goal but are often modified by such regulatory requirements as MCLs or chemical-specific clean-up goals.

3.1.4.2 Noncarcinogenic Risks

Noncarcinogenic risks are estimated using the concept of HQs and HIs. The HQ is the ratio of the estimated intake and the RfD for a selected chemical of concern, as follows:

$$HQ = \frac{\text{Intake}}{\text{RfD}}$$

HIs are the sums of the individual HQs for the COPCs. If the value of the HQ or the HI exceeds unity (1.0), the potential for noncarcinogenic health risks associated with exposure to that particular chemical or particular chemical mixture, respectively, cannot be ruled out (EPA, 1986b). If the individual HQs are less than 1.0 and the HI is greater than 1.0, particular attention should be paid to the target organ(s) affected by each chemical because these are generally the organ(s) associated with RfD-derived effects, and toxicity for different organs is not truly additive. The HI is not a mathematical prediction of the severity of toxic effects; it is simply a numerical indicator of the possibility of the occurrence of noncarcinogenic (threshold) effects.

3.1.4.3 Lead Risks

EPA's approach to evaluating lead risks goes beyond providing a single-point estimate output and incorporates absorption and pharmacokinetic properties. Section 3.1.3.6 discusses background information related to blood-lead estimation methods. Soil concentrations for lead were assessed for each applicable site where lead was selected as a COPC.

3.1.4.4 Receptor Risks

Receptor risks are presented for each NASJRB Willow Grove site in the form of tables and summary text. Each of these sections includes summaries of risks estimated by the exposure scenarios. It should be noted that, in each risk summary table where HQs are reported as "N/A," the HQs were not calculable because no RfD has been established. Usually in such cases, carcinogenicity is considered to be more

important, since carcinogenicity will generally be seen at lower doses than noncarcinogenic effects. Cancer risks of zero or "N/A" generally indicate that the chemical is not carcinogenic or that an SF has not yet been developed.

3.1.5 Uncertainty Analysis

As discussed in EPA (1989a), the risk measures used in Superfund site risk assessments are not fully probabilistic estimates of risk but rather are conditional estimates based on a considerable number of assumptions about exposure and toxicity. There are uncertainties associated with each aspect of risk assessment, from environmental data collection through risk characterization. To support decision-making processes, significant uncertainties in the risk assessment for NASJRB Willow Grove are noted in the following sections.

3.1.5.1 Uncertainties in the Physical Setting and Receptor Exposure Pathways

Reliable information on current land uses at NASJRB Willow Grove sites was based on actual current land use. Current occupational., current trespasser, future excavation, residential, and recreational land use scenarios were considered in the risk assessment for each site. Future land use at the site is unknown; this is source of uncertainty for this risk assessment. Based on known and projected activity patterns, current and future receptors in the study area were considered to engage in a range of activities adequately approximated by default exposure parameter assumptions. It is unknown whether some of these receptors will actually exist, adding to the uncertainty in the risk assessment. However, for any future land use, the receptors chosen are expected to adequately define any significant change in the current land use pattern.

3.1.5.2 Environmental Data Collection Uncertainties

Selection of Locations and Number of Samples

For each site, the areal extent of the samples (including the number collected and location of the sampling points) in a particular medium impacts the calculation of representative concentrations. Every effort was made to collect samples that reflect actual site conditions and to include areas thought to contain the most significant contamination or exposure problems. In addition, a dynamic sampling plan was utilized that allowed expansion of the initial sampling plan in order to collect sufficient data to resolve important contaminant attribution questions. Therefore, the magnitude of this uncertainty on risks is expected to be low.

Selection of Samples with Naturally Occurring Background Levels

A number of background samples were collected that measure the range of concentrations of substances in each medium that are associated with non-site-related sources within the vicinity of the NASJRB Willow Grove. The diversity and abundance of inorganics in soil and sediment samples are determined by the soil's content in bedrock or other deposits and the effects of climatic and biological factors. However, if native soil types are encountered in site-related samples that are unlike those of background samples, then the evaluation of naturally occurring levels could be biased and might lead to overestimation or underestimation of the amount of contamination attributable to the NASJRB Willow Grove sites.

The abundance of inorganics in groundwater samples is determined by, among other things, the particular geological formation in which the well is screened and the content of suspended solids occurring as a result of the well sampling process. If groundwater results from a particular site are compared to background wells that are constructed and sampled in a different manner, then this could lead to an over- or underestimation of the amount of contamination attributable to the NASJRB Willow Grove.

3.1.5.3 Analytical Data Uncertainties

Incorporation of Data from Different Investigations

Because of uncertainties regarding the validation status and usability of results from earlier investigations performed by various parties, only validated data were used from this RI/FS for the risk assessment. Data obtained during earlier investigations were examined during project planning and were used to focus the sample collection effort to include potential areas of interest. Historical data were used in this risk assessment from solid and some aqueous media. Data were collected over several years at all eight sites. The contaminant concentrations could have changed at the sites based on migration or physical removal of contaminated media. Therefore, uncertainty exists in using historical data because current conditions may not be represented by historical data. Areal extent of the samples (including the number collected and location of the sampling points) in a particular medium at a site was one such uncertainty. Every effort was made to collect samples that reflect actual site conditions. However, biased sampling may have occurred if an unknown area of contamination at a particular site was under- or over-sampled. Established data validation procedures were applied to define uncertainties in terms of qualifying data as inaccurate or imprecise and eliminate data points that are unusable for risk assessment. This treatment does not eliminate all uncertainty but focuses attention on potential areas of concern regarding accuracy, precision, and data gaps.

Analytical Data Usability

Established data validation procedures were applied to define analytical uncertainties in terms of qualifying data as inaccurate or imprecise and to eliminate data points that are unusable for risk assessment. This treatment does not eliminate all uncertainty but focuses attention on potential areas of concern regarding accuracy, precision, and data gaps. As discussed in Section 1.5, the overall percentages of rejected data points were acceptably low on site-by-site basis, and data rejection was limited to substances that were neither associated with site activities nor present at high levels.

3.1.5.4 Data Evaluation Uncertainties

Accuracy of Statistical Tests Used in Background Comparisons

When a limited number of points are sampled, such as occurred for surface water or sediment samples, reduced accuracy is expected for the upper 95 percent tolerance limit. In such cases, this statistic is still expected to, on the average, estimate the upper 95 percentile of the population. However, for an individual case, the true percentage of the population that exceeds the calculated tolerance limit will be more likely to differ markedly from the predicted five percent when too few samples are collected. In the event that the upper 95 percent tolerance limit for background samples is overestimated, this could defeat the attempt to identify site-related samples with levels greater than naturally occurring background and may lead to an underestimate of the risk attributable to a site. To help ensure that data points above background were not overlooked, a conservative combination of several background tests was used (the test of proportions, Fisher's exact test, the upper ranks test, the quantile test, the 95 percent UTL test, the Mann-Whitney U-test, Gehan's test, the student's t-test, and Satterthwaite's t-test).

Statistically Representative Exposure Concentrations

Uncertainties exist regarding selection of a concentration for input into the quantitative risk assessment. The use of the representative concentration to estimate risk is generally regarded as a conservative estimate since this entails using either the upper 95 percent confidence limit on the arithmetic mean (based on normal or log-transformed data distribution) or the maximum concentration. The choice of the representative concentration as the value for input into the risk assessment generally lowers the chances of under estimation of the actual risk present in a pathway at a particular area of interest to a potential receptor. However, the use of the representative concentration may overestimate the actual risk present in an exposure pathway at a particular area of interest.

Distributional Shape of the Sample Population

The ability (power) of the W test to be able to correctly identify genuine differences between the shape of a sample population versus a reference normal or lognormal population is reduced when too few samples are collected. If an incorrect distributional assumption is made based on this test, this could lead to an over- or underestimate of the upper 95 percent concentration, which in turn would create some additional uncertainty as to whether the calculated risk is a reasonable approximation of high end exposure.

3.1.5.5 Exposure Model Applicability and Assumptions

Uncertainties in Chemical-Specific Properties

The chemical-specific parameters such as Koc were literature-derived values that are measured under conditions that may or may not be representative of on-site conditions. Parameters such as vapor pressure and solubility were not always obtainable at the desired temperature. Parameters such as the Kd for metals are strongly influenced by other factors such as the chemical form of the metal, the soil type, and pH.

Groundwater Concentration Uncertainties

Uncertainties associated with the lack of groundwater modeling at the site include the assumption that current conditions are indicative of future concentrations of contaminants. Contaminants may increase (due to migration, sediment loading, or chemical transformation) or decrease (due to migration or transformation) over time and vary from area to area.

To prevent use of metals data that might not be representative of the formation, the selection of unfiltered or unfiltered monitoring well results for use in the risk assessment was based upon a sample-by-sample evaluation of turbidities and aluminum, iron, and manganese concentrations. In addition, low-flow bladder pumps used in all new monitoring wells to minimize the chances of suspended solids occurring during the sampling process.

Fugitive Dust Emissions Model Assumptions

Exposure to fugitive dust emissions conservatively assumes that residents will be exposed to the same concentration indoors as outdoors (a very conservative assumption), that soils within an area have unlimited erosion potential, that emissions can be estimated from mean annual windspeed and vegetative cover, and that dispersion concentrations can be estimated from source area, downwind distance to receptors, and region-wide meteorological factors. For receptors exposed to fugitive dust emissions, it was assumed that

future conditions would approximate typical light industrial conditions in terms of the estimated fraction vegetative cover. If future vegetative cover is different in a residential area, then dust exposures could be lower or higher than estimated by the model. However, the impact of this error would not be significant because a worst-case (no vegetative cover) scenario would only increase exposures calculated by the model by a factor of 5, while inhalation exposures at NASJRB Willow Grove sites were estimated as several orders of magnitude below levels of concern.

Soil Dermal Absorption Model Applicability

The model for dermal exposure to soil and sediment assumes that only a very thin, constant thickness layer of soil is available for contaminant transfer to the stratum corneum and that a constant amount of contaminant, proportional to the soil concentration, will be absorbed per unit area of skin and per exposure event. However, adherence to skin varies with such factors as particle size, soil type, and organic carbon content. As estimated by EPA (1992e), the absorbed dermal dose could vary by as much as a factor of 50 from the model estimates, even assuming that activity patterns lead to the exposure duration applied in the experimental trials used to develop absorption factors. Because of the lack of reliable data regarding dermal absorption factors, the risk assessment provides default soil absorption factors for all substances except four chemicals for which well documented absorption factors are available (arsenic, cadmium, pentachlorophenol, PCBs, chlorinated dioxins, ethylbenzene, toluene, xylenes, and PCE). Even so, considerable uncertainty exists with the accuracy of estimates applied for these four chemicals.

Dermal Absorption from Contaminant Exposures in Aqueous Media

Prediction of absorption rates for lipophilic compounds is difficult due to, among other reasons, the possibility of a second absorption pathway that depends on the lipid content of the stratum corneum at the application site. Experimental determination of absorption rates indicates that interspecies differences are considerable, which, along with other variabilities related to condition and age of skin, differences in lag time, and site of application effects, yields appreciable uncertainty in estimated dermal exposures by using published chemical-specific permeation functions. In addition, literature data indicate a variation by as much as a factor of 300 in chemical absorption rates for skin in different anatomical areas of the body. It should also be noted that children generally have greater absorption rates than adults.

Model Assumptions for Inhalation of VOCs During Showering

Uncertainties exist in the exposure model for the inhalation of volatiles during showering such as chemical-specific rates of volatilization, droplet size, and droplet residence time in the shower. Most of the inputs into

the models were considered conservative; therefore, the output may overestimate the exposure for this route.

3.1.5.6 Exposure Intake Parameter Uncertainties

Standard Default Exposure Assumptions

Exposure assumptions can add uncertainty into the risk assessment process based on input values selected for each exposure route. For example, not all people weigh 70 kilograms, drink 2 liters of water per day, and live at the same residence for 30 years. The rationale for each assumption was provided in each table of input parameters. Receptor characteristics, such as age and body weight, were based on published values. Conservative values (based on reasonable maximum exposure or professional judgment) were used in most exposure equations, except where average values were expected to better correspond to actual site conditions.

Soil Ingestion Rates

In the case of current and future residential receptors, soil ingestion rates were based on noncontact-intensive activities. A higher level of short-term incidental soil ingestion by workers engaged in residential home construction (excavation, underground utility work, road repair/construction) or heavy landscaping (tree and shrub planting, drainage routing, or land re-sloping) results. However, contact-intensive activities are typically event driven (for construction) and so should average out to less than 1-month duration per year for a typical exposed individual. Other receptors that are exposed to surface soil at the site should have risks below that of the residential receptor.

The use of current subsurface soil concentrations to represent future subsurface excavation exposure concentrations assumes two things that add to the uncertainty of this risk assessment. First, this exposure scenario assumes that soil would be excavated to the sampling depth. Second, this exposure scenario assumes that once the soil is excavated to the subsurface soil sampling depth, no degradation of the chemicals in the subsurface soil would have taken place and/or no additional contamination would be transported to the soils. These uncertainties may cause either an under- or over-estimation of the exposure at a particular site.

3.1.5.7 Toxicity Assessment Uncertainty

There is uncertainty associated with the RfDs and SFs. The uncertainty results from the extrapolation of animal data to humans, the extrapolation of carcinogenic effects from the laboratory high-dose to the

environmental low-dose scenarios, and interspecies and intraspecies variations in toxicological endpoints caused by chemical exposure. The use of EPA SF values is generally considered to be conservative because the doses are based on no-effect or lowest-observed-effect levels and then further reduced with uncertainty factors to increase the margin of safety by a factor in the neighborhood of 10 to 1,000-fold. The RfDs and SFs of some chemicals have not been established, and therefore toxicity could not be quantitatively assessed. In most cases, where RfDs were unavailable for carcinogens, the carcinogenic risk is considered to be much more significant since carcinogenic effects usually occur at much lower doses.

Additional uncertainties were associated with the adjustment of oral dose-response parameters to compute dermally absorbed doses. As noted, when absorption factors were not available, the chemical was assumed to be 100 percent absorbed during the RfD or SF study. While this is likely to be realistic for volatile compounds, the assumption could be underprotective for chemicals absorbed less than 100 percent.

For chemicals coded with a "W" in Table 3-1, toxicity constants were utilized that have been withdrawn from IRIS, pending further agency review. In these cases, there may be additional uncertainty in the associated SFs or RfDs, based on the original or new studies that were the basis for considering a reevaluation of toxicological properties. If the uncertainty related to using a withdrawn toxicity constant is critical (i.e., found to drive a significant risk at a site), then additional information be can obtained on the exact reasons for withdrawal from the EPA Environmental Criteria and Assessment Office (ECAO), Cincinnati, Ohio.

3.1.5.8 Risk Characterization Uncertainty

From a toxicological standpoint, it is not strictly correct to add HQs for a total HI, because RfDs are based on effects to various target organs. However, if the HI is less than 1.0, this demonstrates that, even when this conservative calculation is performed, the noncarcinogenic HI does not indicate a hazard for a particular exposure pathway. This is a conservative approach that will generally overestimate the HI for a particular pathway. To reduce the extent of overestimation when significant risks occurred at an area of interest, a less conservative approach was used wherein noncancer risks were grouped and summed together for only those chemicals affecting the same target organ/organ system. One additional source of uncertainty in the HI approach is that these models assumed that chemicals did not interact synergistically (a possible underestimate of the actual risk) or antagonistically (a possible overestimate of the actual risk).

3.1.5.9 IEUBK Modeling Uncertainty

The IEUBK model accounts for the multimedia nature of lead exposure, incorporates absorption and pharmacokinetic information, and allows the risk manager to consider the potential distributions of exposure and risk likely to occur at a site (the model goes beyond providing a single-point estimate output). Although

uncertainties are associated with blood-lead modeling using the IEUBK model, these uncertainties are considered lower than those that conceivably would result from similar lead evaluations performed using a traditional toxicity slope-based approach. Important uncertainties and limitations in the use of the IEUBK model are as follows:

The IEUBK model is predictive of blood lead for residential children in the range of 6 months to 7 years of age, which typically is considered to be a more sensitive subpopulation than adults. The model does not apply to adults in either residential or occupational settings. In addition, the IEUBK model does not predict the blood-lead levels of pregnant women and does not include an exposure component based on the transfer of lead from the mother's blood to the fetus before birth, although a significant potential exists for adverse effects of prenatal lead exposure on neurobehavioral and physical development (EPA, 1994b).

The IEUBK model uses a default of 30 percent lead absorption from soil. However, the bioavailability of lead from different sources may be variable due to differences in lead speciation, particle size, and mineral matrix and may also vary as a function of physiological parameters such as age, nutritional status, gastric pH, and transit time. For example, lead absorption from paint chips in soil may be different than lead absorption from other chemical forms.

Blood-lead variability in the IEUBK model is characterized by a single number, the geometric standard deviation, which is set to a default value of 1.6. This value represents the aggregate uncertainty in all sources of population variability, including biological, uptake, exposure, sampling, and analytical components. Child blood-lead level predictions obtained using the IEUBK model reflect only the contributions of sources entered into the model and do not take into account any existing body burden that may be the result of prior exposures or any exposures that may have taken place at alternate locations away from the household or neighborhood level, such as parks or daycare centers.

3.2 ECOLOGICAL RISK ASSESSMENT APPROACH

Ecological receptors at NASJRB Willow Grove may be at risk from contaminants associated with Sites 1, 2, 3, and 5. Therefore, an ecological risk assessment (ERA) was performed to characterize the potential risks from site-related contaminants to ecological receptors that inhabit the installation. The ERA was based on laboratory analyses of surface soil, surface water, and sediment samples collected from each site. This section provides an outline of the approach that was taken to assess the impacts of site contamination on ecological receptors and the habitats that support these organisms. This assessment followed a two-step process:

Step 1: Preliminary Problem Formulation and Ecological Effects Evaluation (Section 3.2.1)

- Preliminary Problem Formulation - This is the first phase of an ERA, which discusses the goals, breadth, and focus of the assessment. It includes general descriptions of NASJRB Willow Grove sites with emphasis on the habitats and ecological receptors present. This phase also involves characterization of contaminant sources and migration pathways, evaluation of routes of contaminant exposure, and selection of analytes to be assessed. Assessment and measurement endpoints are also selected in this phase. In addition, a conceptual model is developed that describes how contaminants associated with the RI sites may come into contact with ecological receptors.

- Preliminary Ecological Effects Evaluation - In this phase, medium-specific ecological screening levels for each analyte (i.e., concentrations of each contaminant above which adverse effects to ecological receptors may occur) are identified. This step is undertaken concurrently with the exposure assessment described below.

Step 2: Preliminary Exposure Assessment and Risk Calculation (Section 3.2.2)

- Preliminary Exposure Estimate - This portion of the ERA includes the identification of contaminant concentration data used to represent ecological exposure in various media and the selection of exposure point contaminant concentrations from those data.

- Preliminary Risk Calculation - In this step, exposure point concentrations are compared to screening levels in order to characterize potential risks to ecological receptors of concern. Analytes found to pose potential risk after these comparisons are selected as ecological chemicals of potential concern (COPCs).

When these two steps are completed, the results are interpreted and the uncertainties associated with the ERA are addressed. The above process, described in further detail below, represents the general approach recommended in the most recent U.S. EPA guidance for performing ecological risk assessments (U.S. EPA, 1997), which served as the basis for the ERA methodology. Additional guidance consulted for this ERA includes Department of the Navy ERA policy (DON, 1999), EPA Region III BTAG ERA guidelines (USEPA, 1994), and other ERA guidance documents and publications (Calabrese and Baldwin, 1993; Suter, 1993; Wentsel et al., 1996).

Due to the potential complexity of ERAs, they are usually conducted using a tiered approach and punctuated with Scientific/Management Decision Points (SMDPs). SMDPs are meetings involving the risk managers and risk assessment team and are conducted to evaluate the work up to that point and to ensure that the ecological risk assessment is proceeding in an efficient manner. Information analyzed in one tier is evaluated to determine whether the objectives of the study have been met. The results are

then used to identify the data required for the next tier, if necessary. The Tier 1 ERA is also known as a Screening Risk Assessment. The Screening Risk Assessment uses conservative (i.e., stringent) assumptions to evaluate site data and determine whether additional ecological risk assessment or accelerated site cleanup may be warranted, or that the site poses negligible ecological risks.

The second tier is a baseline ERA (BERA), which is conducted if the results of the screening-level ERA indicate that additional study is warranted. The BERA comprises Steps 3 through 7 of the 8-step ERA process, and is a more focused study of the initial COPCs. The beginning of the BERA also presents a more balanced evaluation of the conservativeness inherent in the first two steps of the ERA process (DON, 1999).

3.2.1 Preliminary Problem Formulation and Ecological Effects Evaluation

Section 3.2.1.1 discusses the components of problem formulation and Section 3.2.1.2 discusses the components of ecological effects evaluation.

3.2.1.1 Preliminary Problem Formulation

Ecological Setting

The preliminary problem formulation contains a description of the background of the site and a general description of the ecological setting at NASJRB Willow Grove. These topics are presented in Section 1.4. The main areas of interest at NASJRB Willow Grove for this ERA are Sites 1, 2, 3, and 5. These sites are described in detail in site-specific sections.

Habitat Types and Ecological Receptors

Descriptions of habitat types and ecological receptors were composed for Sites 1, 2, 3, and 5, and are presented in site-specific sections of this report. Data regarding habitats and ecological receptors were obtained from previous reports and from biological characterizations conducted at the installation during this investigation. Information on the occurrence of threatened and endangered species on and near the four sites was obtained from the U.S. Fish and Wildlife Service, the Pennsylvania Game Commission, the Pennsylvania Fish and Boat Commission, the Pennsylvania Department of Environmental Protection, and the Natural Resources Manager at NASJRB Willow Grove.

Contaminant Sources, Release Mechanisms, and Migration Pathways

Site-specific contaminant sources, release mechanisms, and migration pathways are discussed in site-specific sections of this report. The general transport mechanisms that were investigated include combustion, volatilization, wind erosion, overland runoff, and infiltration of contaminants. Constituents in soil could volatilize from surficial material or become airborne through wind erosion. Contaminated fugitive dust could be generated during ground-disturbing activities such as construction or excavation. Contaminants could then be dispersed in the surrounding environment and transported to downwind locations, where they could become deposited in surface soil, surface water, or sediment. Combustion was probably a major transport mechanism during the period when the landfills and fire training area were in use. However, combustion is assumed to currently represent a negligible transport mechanism at NASJRB Willow Grove since open burning activities have ceased.

Precipitation runoff could carry constituents to nearby surface water and sediment. Infiltrating precipitation could cause the contamination of subsurface soil and groundwater. Upon infiltrating the soil column and reaching the water table, a contaminant may be carried with the flow of groundwater to downgradient locations. Groundwater from the site may eventually discharge to surface water; contaminants could be subsequently deposited in sediment or accumulate in the tissues of aquatic organisms.

Exposure Routes

Terrestrial animals could be exposed to soil contaminants through the ingestion of contaminated food items. Animals can also incidentally ingest soil while grooming fur, preening feathers, digging, grazing close to the soil, or feeding on items to which soil has adhered (such as roots and tubers). Terrestrial vegetation could be exposed to contaminants via direct aerial deposition and root translocation. However, aerial deposition was not investigated, primarily because the contaminant sources at the sites under investigation are largely covered by vegetation. Terrestrial animal receptors may also come into contact with contaminants in surface water through drinking, although this exposure route represents a negligible portion of total exposure for most receptors. Exposure to contaminants in the soil via dermal contact may occur but is unlikely to represent a major exposure pathway because fur, feathers, and chitinous exoskeletons minimize transfer of contaminants across dermal tissue.

Inhalation does not represent a significant exposure pathway because air contaminant concentrations are assumed to be quite low, even for burrowing wildlife. In addition, inhalation ecotoxicity data for chronic exposure are lacking. Therefore, the air pathway was not considered for ecological receptors.

Aquatic and semi-aquatic organisms at NASJRB Willow Grove could be exposed to contaminants via direct contact with surface water and sediments, incidental ingestion of surface water and sediments, and consumption of contaminated food items. Aquatic and semi-aquatic organisms could also be exposed to constituents from contaminated groundwater that potentially discharges into nearby surface water.

Selection of Analytes to be Investigated

All analytes detected in surface water, sediment, and surface soil samples collected during 1991 Phase I and 1997 Phase II sampling activities were assessed in this investigation. However, calcium, magnesium, potassium, and sodium were excluded in the screening process since they are essential nutrients that are toxic only in extremely high concentrations. Due to the scarcity of data for these essential nutrients, it was not possible to develop ranges of toxicity even at high concentrations. The limited toxicity data available indicate that high dietary intake of these nutrients is well tolerated.

Assessment and Measurement Endpoints

One of the major tasks in problem formulation is the selection of assessment and measurement endpoints. An assessment endpoint is "an explicit expression of actual environmental values that are to be protected" and measurement endpoints are "measurable ecological characteristics that are related to the valued characteristic chosen as the assessment endpoint" (USEPA, 1997). For this ERA, the assessment endpoint was the maintenance of aquatic and terrestrial receptor populations. Therefore, the specific objectives of this assessment were to determine if exposure to contaminants present in the surface water, sediment, and soil on and near the sites are likely to result in declines in ecological receptor populations. Declines in populations could result in a shift in community structure and possible elimination of resident species from aquatic, semi-aquatic, and terrestrial environments.

Measurement endpoints serve as surrogates for assessment endpoints, since they are more easily quantified or observed than assessment endpoints. Measurement endpoints consisted of contaminant concentrations associated with adverse effects on growth, survival, and reproduction of aquatic organisms (surface water screening levels), benthic organisms (sediment screening levels), and terrestrial vegetation and soil invertebrates (surface soil screening levels).

Conceptual Site Model

The conceptual model is designed to diagrammatically identify potentially exposed receptor populations and applicable exposure pathways, based on the physical nature of the site and the potential contaminant source areas. Actual or potential exposures of ecological receptors associated with the sites were determined by identifying the most likely pathways of contaminant release and transport. A complete

exposure pathway has three components: a source of contaminants that can be released to the environment; a route of contaminant transport through an environmental medium; and an exposure or contact point for an ecological receptor. The conceptual model for each site is presented in site-specific sections of this report.

3.2.1.2 Preliminary Ecological Effects Evaluation

For this ERA, exposure-point concentrations of detected analytes in surface water, sediment, and surface soil were compared to ecologically based guidelines to determine if the analytes should be selected as COPCs. Although groundwater-to-surface-water migration of groundwater contaminants is possible at NASJRB Willow Grove, ecological receptors are not directly exposed to groundwater. Additionally, no groundwater thresholds have been developed based on ecological concerns. Potential ecological risks associated with groundwater contaminants are reflected in the evaluation of the potential risks associated with surface water and sediment, since the sources of contamination at the sites under investigation have been in place long enough for groundwater plumes to discharge into nearby surface water and sediment. Thus, groundwater contaminants were not screened against surface water contaminants in the ecological risk assessment. It is noted that an artesian flowing well formerly existed downstream from the pond near Site 3. However, this well has been permanently capped so that flow from this monitoring well is nonexistent. There are no other flowing artesian wells near any other site investigated in this report. The Navy corrected the problem of flowing artesian monitoring wells during RI field investigations in the spring of 1997 by repairing the leaking sample assemblies. Long-term annual inspection and maintenance of these artesian monitoring wells will ensure no flow of groundwater to surface water.

Methods used for the selection of medium-specific benchmarks used in this ERA are provided below.

Surface Water Screening Levels

Actual exposures of aquatic receptors to surface water contaminants at NASJRB Willow Grove were assumed to be primarily chronic (long-term) exposures, usually at sublethal concentrations. Initial screening levels for this ERA were chronic screening values obtained from USEPA Region III BTAG (EPA, 1995), EPA chronic ambient water quality criteria (AWQC), EPA final chronic values (FCVs), and Tier II values (EPA, 1996b).

Sediment Screening Levels

Initial contaminant screening levels for benthic organisms were preferentially EPA Region III BTAG screening levels (EPA, 1995). These values are primarily Effects Range-Low (ER-L) values from Long and Morgan (1990) and Long et al. (1995), and Apparent Effects Thresholds (AETs).

Surface Soil Screening Levels

Initial screening levels for soil organisms consisted primarily of USEPA Region III BTAG screening levels (EPA, 1995), Oak Ridge National Laboratory (ORNL) surface soil screening levels, and Dutch "B" levels that represent ecological toxicity endpoints (Netherlands, 1994).

3.2.2 Preliminary Exposure Estimate and Risk Calculation

Section 3.2.2.1 describes the components of preliminary exposure estimate and Section 3.2.2.2 describes the components of preliminary risk calculation.

3.2.2.1 Preliminary Exposure Estimate

The maximum detected concentrations of analytes in surface water, sediment, and surface soil were used as exposure point contaminant concentrations for comparison to ecological screening levels in the risk calculation step. Detailed descriptions of sampling locations, data validation, data treatment, and data selection were presented in previous sections.

3.2.2.2 Preliminary Risk Calculation

The preliminary risk calculation step in the ERA process compares exposure-point contaminant concentrations with screening levels protective of ecological receptors (EPA, 1997). The ratio of the exposure-point contaminant concentration to the screening level is called the hazard quotient (HQ) and is defined as follows:

$$HQ_i = EPC_i/ESL_i$$

where: HQ_i = Hazard Quotient for analyte "i" (unitless)

EPC_i = Exposure Point Concentration for analyte "i" (μg/L or mg/kg)

ESL_i = Ecological Screening Level for analyte "i" (μg/L or mg/kg)

When the ratio of the exposure point concentration to its respective screening level equaled or exceeded 1.0, adverse impacts were considered possible, and the contaminant was retained as a COPC. The HQ value should not be construed as being probabilistic; rather, it is a numerical indicator of the extent to which an exposure point concentration exceeds or is less than a screening level. HQ values equal or greater than 1.0 indicate that ecological receptors are potentially at risk; additional evaluation or data may be necessary to confirm with greater certainty whether ecological receptors are actually at risk.

The use of HQs is probably the most common method used for risk characterization in ERAs. Advantages of this method, according to Barnthouse et al. (1986), include the following:

- The HQ method is relatively easy to use, is generally accepted, and can be applied to any data.
- The method is useful when a large number of contaminants must be screened.

This method of risk characterization has some inherent limitations. One primary limitation is that it is a "no/maybe" method for relating toxicity to exposure. That is, it uses single values for exposure concentrations and screening levels. The HQ method does not account for the variability in both these parameters or for incremental or cumulative toxicity.

The comparisons of maximum contaminant concentrations in each medium to screening levels are presented in screening tables. The screening tables include the frequency of detection for each analyte, the range of detected values, and contaminant-specific screening levels.

3.2.3 Step 3a: Refinement of Contaminants of Potential Concern

The ERA methods described above constitute the first two steps of the 8-step ERA process. Thus, the ERA, up to this point, can be considered to be a "screening-level" assessment, or "Tier 1" assessment, since it is based primarily on a conservative initial screening of contaminant concentrations against contaminant-specific screening levels. As will be seen in site-specific ERAs, maximum concentrations of several analytes exceed ecological screening levels. Because of this, and since the locations and number of samples appears to be adequate to determine the nature and extent of site related contamination, a more thorough assessment is warranted. Therefore, in accordance with EPA (1997) and Navy policy (DON, 1999), and as per discussions with Region III BTAG, a portion of Step 3 of the 8-step ERA process was included in this assessment.

Step 3 of the 8-step ERA process is BERA problem formulation (EPA, 1997). This step consists of several sub-steps designed to develop the goals, breadth, and focus of the BERA. The initial sub-step within Step 3 is refinement of contaminants of potential concern, and is referred to as "Step 3a - Refinement of Conservative Exposure Assumptions" in the Navy's ERA guidance (DON, 1999).

The use of conservative guidelines and maximum detected concentrations in the screening-level assessment is necessary to ensure that potential risks are not underestimated. However, if the hazard quotients derived from comparisons of maximum concentrations to conservative screening levels are used as the single factor for including a COPC in a baseline ERA without consideration of other relevant information, additional ecological studies such as toxicity testing or tissue analyses could be undertaken

for COPCs that do not actually pose significant risks. For this reason, refinement of COPCs, the first sub-step within Step 3, was incorporated into the ERA. Step 3a involves the consideration of factors such as background data (mainly for inorganics), toxicological evaluation of COPCs, frequency of detection, and comparisons of COPCs to alternate guidelines (EPA, 1997; DON, 1999).

3.2.3.1 Alternate Guidelines

Less conservative guidelines are presented in Step 3a of this ERA to provide balance to the conservative screening-level assessment. For example, some sediment screening values in Steps 1 and 2 consisted of ER-L values obtained from Long et al. (1995). However, an ER-L is defined as the concentration below which adverse ecological effects "would rarely be observed", and the effects range-medium (ER-M) is the concentration below which adverse effects "would occasionally occur" (Long et al., 1995). Therefore, ascribing risk to a sediment contaminant detected in a concentration that exceeds the ER-L but is below the ER-M can be misleading. Recent studies have indicated that ER-Ms are much better indicators of potential adverse effects than ER-Ls (Long et al., 1998), and thus, ER-Ms are included in Step 3a.

Less conservative sediment guidelines also include Probable Effects Levels (PELs) developed by the Florida Department of Environmental Protection (FDEP, 1994). The PELs are loosely analogous to ER-Ms. The data set used by Long et al. (1995) to develop ER-Ls and ER-Ms was used also by FDEP. However, unlike the ER-Ls and ER-Ms, PELs also incorporate chemical concentrations observed or predicted to be associated with no adverse biological effects (no effects data). The PEL is the geometric mean of the 50th percentile in the effects data set and 85th percentile in the no effects data set. The PEL represents the lower limit of the range of contaminant concentrations that are usually, or always, associated with adverse biological effects (FDEP, 1994).

Other less conservative sediment guidelines such as Severe Effects Levels (SELs) developed by the Ontario Ministry of the Environment (MOE) are also presented in Step 3a. MOE guidelines are based exclusively on observed effects in the field (absence of certain species). The SEL represents the contaminant level that could potentially eliminate most of the benthic organisms. Unlike National Oceanic and Atmospheric Administration (NOAA) and FDEP guidelines, MOE guidelines are based on freshwater sediments. Probable Effects Concentrations (PECs) developed as part of EPA's Assessment and Remediation of Contaminated Sediments Program (EPA, 1996c), and other guidelines are also presented in Step 3a.

Alternate guidelines for surface water are not as plentiful as for sediments. Therefore, a broad range of alternate guidelines for surface water could not be developed. However, alternate guidelines are presented, when available, for surface water COPCs in Step 3a for each site investigated herein.

Alternate surface soil guidelines for some COPCs were available from ORNL (Efroymson et al., 1997a; 1997b) and are presented in Step 3a. These data were derived to be used as screening values for investigating the potential effects of contaminants on soil litter invertebrates (i.e. earthworms), soil microbes, and plants. Other alternate ecological soil guidelines include Dutch "B" soil valves indicative of "moderate soil contamination that requires further study" (Beyer, 1990), and Canadian Council of Ministers of the Environment Soil Quality Guidelines (CCME, 1997).

3.2.3.2 Toxicological Evaluation of COPCs

Toxicity data and information from various sources in the literature are discussed as they relate to the interpretation of potential risks from each COPC. These sources include the USFWS Chemical Hazard Reviews, commonly referred to as the "Eisler" publications, ATSDR Toxicity Profiles on CD-ROM, and ecotoxicological journals.

3.2.3.3 Other Considerations

The establishment of background concentrations was discussed in Section 2.3. Background data were obtained from the sampling and analysis of surface water, sediment, and surface soil during Phase II activities. As a result, background data are available for use in assessing the extent to which chemical concentrations at Sites 1, 2, 3, and 5 are due to site-related activities, since concentrations of inorganic contaminants can be naturally elevated and exceed screening values.

The frequency of detection and spatial analysis of elevated contaminant concentrations were evaluated to determine whether potential risks are widespread or limited to a small area. The magnitude of the HQs was also considered. As described earlier, the relationship between the magnitude of an HQ and toxicity is not necessarily linear. However, the magnitude of an HQ can be used as a rough approximation of the extent of potential risks, especially if there is sufficient confidence in the guideline used.

3.2.4 Ecological Risk Assessment Approach Summary

Due to past contaminant releases at Sites 1, 2, 3, and 5, a screening-level ERA was conducted for each of these sites. Maximum contaminant concentrations in surface water, sediment, and surface soil were compared to screening level toxicity values that are protective of ecological receptors. Potential risks to ecological receptors were investigated in the form of HQ values, which is the ratio of the representative contaminant concentration to the screening level toxicity value. Risks were considered possible when an HQ value was equal to or greater than 1.0. Subsequently, other quantitative and qualitative factors were investigated in Step 3a to more fully assess potential risks. A "weight-of-evidence" approach (EPA, 1997) was used as part of Step 3a to determine the extent of potential risks when HQ values exceeded 1.0. Information in Step 3a was used to determine final ecological contaminants of concern (COCs).

3.2.5 Screening Level and Step 3a Uncertainty Analysis

Once an ERA is complete, the results must be reviewed and evaluated to identify the types and magnitudes of uncertainties involved. Relying on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. This section provides a summary of the general uncertainties involved in this ERA, and discusses how the uncertainties may affect the final risk values and conclusions. Discussions of site-specific uncertainties are contained in site-specific sections of this report.

3.2.5.1 Uncertainty in the Preliminary Problem Formulation

Uncertainty in problem formulation can result from limited information regarding contaminant sources, release mechanisms, and exposure routes. For example, the sites investigated in this ERA receive contaminant inputs from more than one source. Thus, uncertainties can exist regarding whether risk characterized at a discrete site stems from site-related contaminants.

3.2.5.2 Uncertainty in the Ecological Effects Evaluation

Uncertainty in the ecological effects evaluation results from the nature and quality of the available toxicity data used to derive toxicity screening values. This uncertainty is reduced when similar effects are observed across species, strain, gender, and exposure route; when the magnitude of the response is clearly dose related; and when postulated mechanisms of toxicity are similar for laboratory and wildlife species.

Unlike human health risk assessments, ERAs must consider risks to many different species. However, calculation of risk values for each potential receptor species is not possible. For this ERA, conservative screening values protective of a wide range of ecological receptors were sought. The underlying assumption associated with the use of these screening values is that contaminant concentrations in excess of these values are indicative of potential impacts to actual receptors inhabiting the area. However, species-specific physiological differences that may influence an organism's response to a contaminant or subtle behavioral differences that may increase or decrease a receptor's contact with a contaminant are seldom known. Also, contaminants were present in some media for which no suitable benchmarks were available, and as a result, these contaminants could not be quantitatively assessed. Risks may be biased low in these instances.

Potential risks may be under- or overestimated due to the interactive effects of contaminants. Contaminants with similar modes of action may have additive effects (e.g., organochlorine pesticides) or synergistic effects. In this case, potential risks could be underestimated. Contaminants can also have ameliorating effects on certain receptors. In this case, potential risks could be overestimated.

3.2.5.3 Uncertainty in the Exposure Estimate

Uncertainty in the exposure estimate is primarily a result of the methods used to obtain exposure point concentrations. The maximum detected contaminant concentrations were used to represent the highest contaminant concentrations to which ecological receptors might be exposed. If the maximum concentration of a chemical in a given medium was collected in a "hot spot" of contamination and was much higher than the remaining values in the data set, potential risks might be greatly overestimated. Conversely, if undiscovered hot spots exist at a site, then potential risks might be greatly underestimated.

Dermal and inhalation exposures were not evaluated in this ERA. Dermal exposure is usually limited by the outer coverings of most receptors. Nevertheless, certain portions of some receptors, such as footpads, eyes, and nose do not contain fur or feathers, and may have a higher chance of exposure. Inhalation of contaminants is insignificant for most receptors, but burrowing species such as woodchucks could be exposed to some contaminants via inhalation. However, data regarding inhalation exposure and toxicity for wildlife were not available. In summary, the dermal and inhalation exposure routes are considered to be miniscule, but since they cannot be quantitatively assessed, the associated potential risks are inherently underestimated.

3.2.5.4 Uncertainty in the Risk Calculation

Uncertainty in the risk calculation is affected by all aspects of the ERA process described in the above sections. To try to reduce the overall uncertainty in the risk assessment, the weight-of-evidence approach is used to make risk decisions. This approach considers all aspects of the assessment, including the uncertainties, to make determinations of potential risks.

4.0 SITE 5 - THE FIRE TRAINING AREA

4.1 DESCRIPTION AND HISTORY

The Fire Training Area is located in the south-central portion of the Naval Air Station, approximately midway between Runway 10/28 and State Route 463 (Figures 1-2 and 4-1). The site is located immediately south of Taxiway Juliet and covers an irregularly shaped area of approximately 1.25 acres. The training area was used from 1942 to 1975 for large-scale fire fighting exercises, which included the disposal and burning of flammable liquid wastes generated by the Naval Air Station. Wastes including solvents, paint chemicals, xylenes, toluene, and various petroleum compounds were consumed at the rate of at least 4,000 gallons per year in these fire fighting exercises (EA, May 1990). The area was also reportedly used for drum storage of these flammable materials during the periods between burning exercises.

The Fire Training Area is primarily covered by grasses, with some woody and brushy vegetation present within the southern portion of the area. The burn area is located in the south-central portion of the site. Two small (generally dry) soil depression areas referred to as "ponds" are immediately south of the former burning area.

4.1.1 Historical Aerial Photographs

Historical aerial photographs depicting surface conditions at Site 5 during the years 1942, 1958, 1964, 1971, 1978, and 1984 were reviewed by the EPA and the Navy. In a report forwarded to the Navy in April 1999 EPA indicated a series of unidentified anomalies that were considered potential environmental concerns. The Navy attempted to ascertain the identity of the anomalies through interviews with site representatives and site visits. The Navy also reviewed the photographs in conjunction with site mapping from the RI activities. Ultimately, the Navy concluded that all of the anomalies at Site 5 had been subjected to some level of field investigation during either the Phase I or Phase II RI. The full report of his investigation, prepared by the Navy, is included as Appendix N.

4.2 HYDROLOGY

The ground surface in the vicinity of the Fire Training Area slopes toward the south at a grade of approximately two percent. Runoff during normal precipitation events should be minimized by the relatively gentle slope and the abundant vegetation, which serves to decrease runoff velocity and increase infiltration. Two small ponds are located within 100 feet of the site in the downslope direction. The two small "ponds" do not always contain water and tend to dry out.

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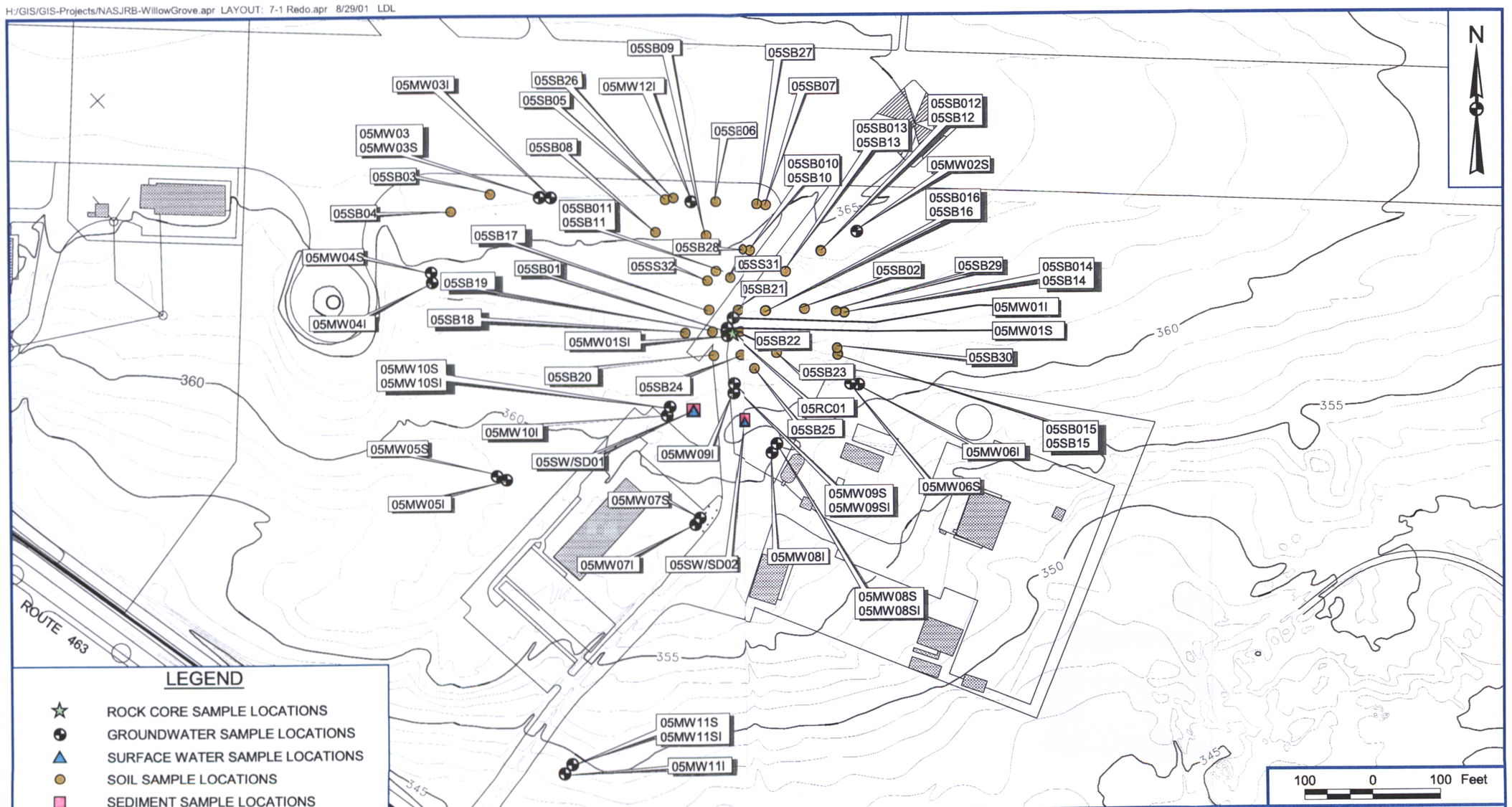

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SCALE AS NOTED	

Tetra Tech NUS, Inc.

SAMPLE LOCATION MAP
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NUMBER 5466	OWNER NUMBER 2207
APPROVED BY	DATE
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Based on the local topography, any runoff from the site area may be expected to flow off base through a small intermittent drainage that crosses the base boundary approximately 2,000 feet south of the Fire Training Area. This drainage, which also carries runoff from the Antenna Field Landfill, flows into Pennypack Creek approximately 3,000 feet from the base property line.

4.3 SITE 5 GROUNDWATER FLOW PATTERNS

The former fire training area is situated atop a southwest-northeast-trending ridge that is the highest topographic feature within the region (see Figure 4-2, topographic map of Site 5). This ridge serves as a divide for the regional surface water bodies (watershed divide), as surface water to the north of the divide flows toward the Little Neshaminy Creek, and surface water to the south of the divide flows toward the Pennypack Creek.

Typically within the Triassic Basin, surface water and groundwater flow patterns are generally similar, and regional groundwater divides coincide with regional surface water divides. To test and confirm this hypothesis and to determine the regional groundwater flow patterns on and in the vicinity of the base, the USGS performed a regional groundwater study (concurrent with this investigation and with the assistance of TtNUS) and constructed a regional potentiometric surface map (USGS, 2001). The results of the USGS investigation confirm that the topographic ridge forms both a surface water divide and a groundwater divide. That is, groundwater to the north of the divide flows regionally in a northwest direction, and groundwater to the south of the divide flows regionally in a southeast direction. The USGS interpretation indicates that the regional groundwater divide trends southwest-to-northeast in the vicinity of Site 5 and passes directly beneath the Fire Training Area.

4.4 GEOLOGY AND HYDROGEOLOGY OF SITE 5 - THE FIRE TRAINING AREA

4.4.1 Geology

The geologic interpretation of the Fire Training Area is based on the subsurface data (boring logs and geophysical logs) obtained during this current and previous site investigations. These data indicate that the local geology beneath this site is generally consistent with the regional geology.

The numerous soil borings encountered a variably thick overburden section underlain by weathered siltstone and sandstone. The overburden generally consisted of silty clay and clay, with minor amounts of silty sand. The thickness of the overburden (or the depth to the top of the weathered bedrock) ranged from 9 to 18 feet.

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CHECKED BY RET	DATE	TOPOGRAPHIC MAP SITE 5 - FIRE TRAINING AREA NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	APPROVED BY — / DATE —
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 4-2 / REV

The maximum depth of the monitoring well boreholes at Site 5 is 261 feet (the monitoring wells generally are shallower than the total depth of the borehole because the boreholes typically were backfilled in order to screen the most significant water-bearing zone, which was not necessarily at the bottom of the borehole). The bedrock to this depth typically consisted of alternating sequences of siltstone and sandstone. Thin but laterally consistent beds of mudstone and claystone were encountered within the lower portions of the penetrated section. In general, the bedrock beneath this site was characterized by its predominantly coarse-grained lithology.

The structural geology beneath the site is illustrated by a pair of hydrogeologic cross-sections (Figures 4-3, 4-4, and 4-5). These sections indicate that the structure (dip) of the bedrock is similar to that predicted by the regional geology. A 3-point correlation of geophysical logs from the Site 5 boreholes produced a bedrock strike of North 76^0 East and a bedrock dip of 7^0 Northwest.

A fine-grained claystone that occurs at a subsurface depth of about 100 feet beneath the source area at monitoring well cluster 05MW01 is fairly correlatable throughout the site (both on the drilling lithology logs and the geophysical logs), and served as the key marker bed for the subsurface correlations. The lateral continuity of this bed is consistent with the observation (noted by TtNUS at several sites within the region) that in general, the finer-grained rocks within the Triassic Basin are more laterally continuous and traceable than the coarser-grained rocks.

4.4.2 Hydrogeology

4.4.2.1 Monitoring Well Installation and Rationale

Seventeen additional monitoring wells were installed to further delineate the nature and horizontal and vertical extent of groundwater contamination at the site and to provide the additional hydraulic head data needed to refine the hydrogeologic interpretation of the site. The Site 5 monitoring well locations are illustrated in Figure 4-6. The construction details for all monitoring wells are listed in Table 4-1.

A new intermediate monitoring well (05MW01I) was installed at cluster location 05MW01 to further investigate and define the vertical extent of groundwater contamination at this previously identified source area of volatile organic compounds. Three new monitoring well clusters (05MW08, 05MW09, and 05MW10) were installed downgradient of location 05MW01 to further investigate the nature and extent of contamination in the area downgradient of the source area. Each new well cluster consists of a shallow, shallow-intermediate, and intermediate monitoring well.

A new intermediate monitoring well (05MW03I) was installed at well location 05MW03 to be paired with the

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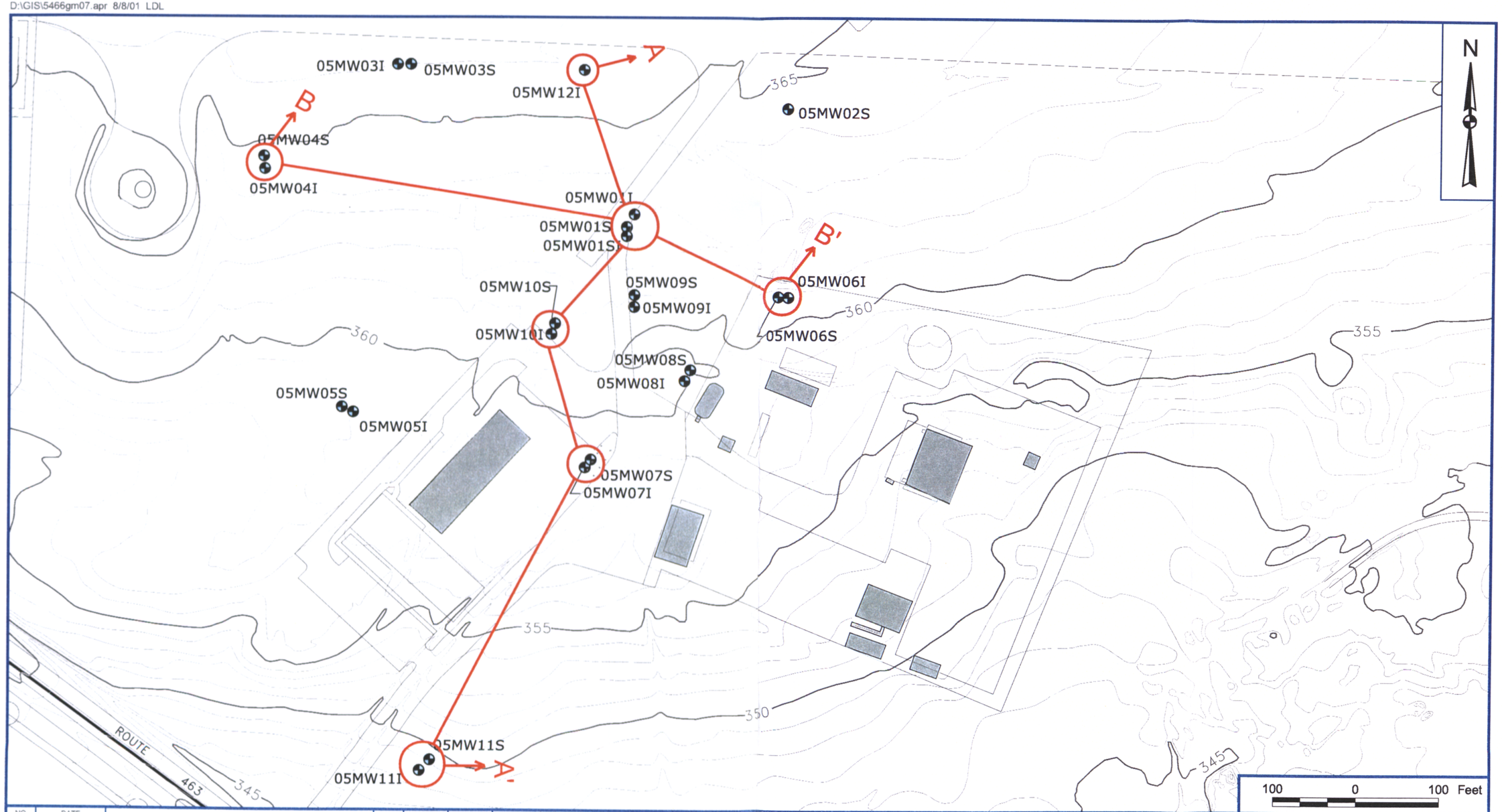

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COST/SCHEDULE-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

HYDROGEOLOGIC CROSS-SECTION
LOCATION MAP
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NUMBER 5466 — OWNER NUMBER 2207
APPROVED BY — DATE
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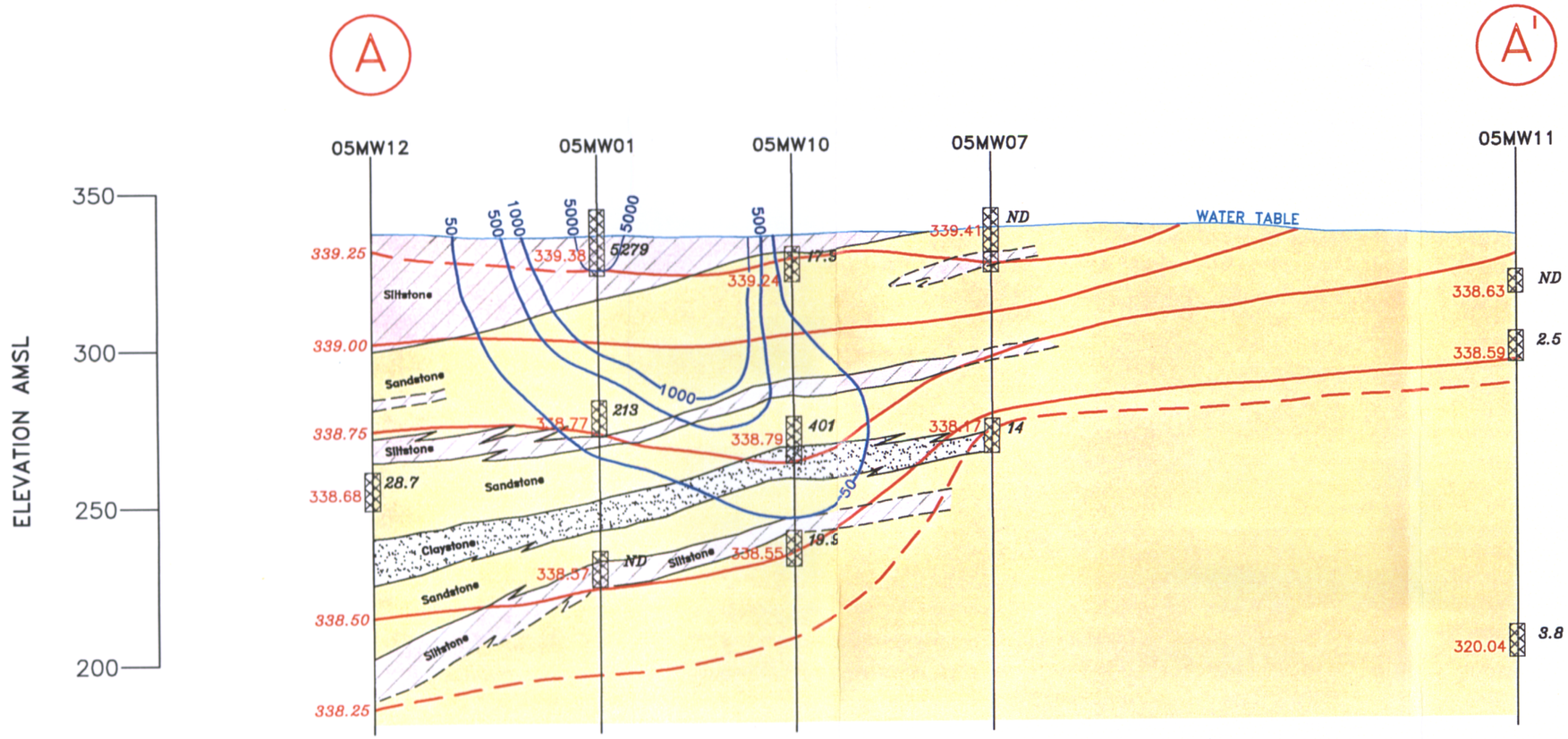
LEGEND

339.00 = HYDRAULIC HEAD

1000 = TOTAL VOC's (μg/L)

DATA ACQUIRED 9/00



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HORIZONTAL SCALE IN FEET

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CHECKED BY DATE			OWNER NO. 2207
REVISED BY DATE			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4-4 REV.

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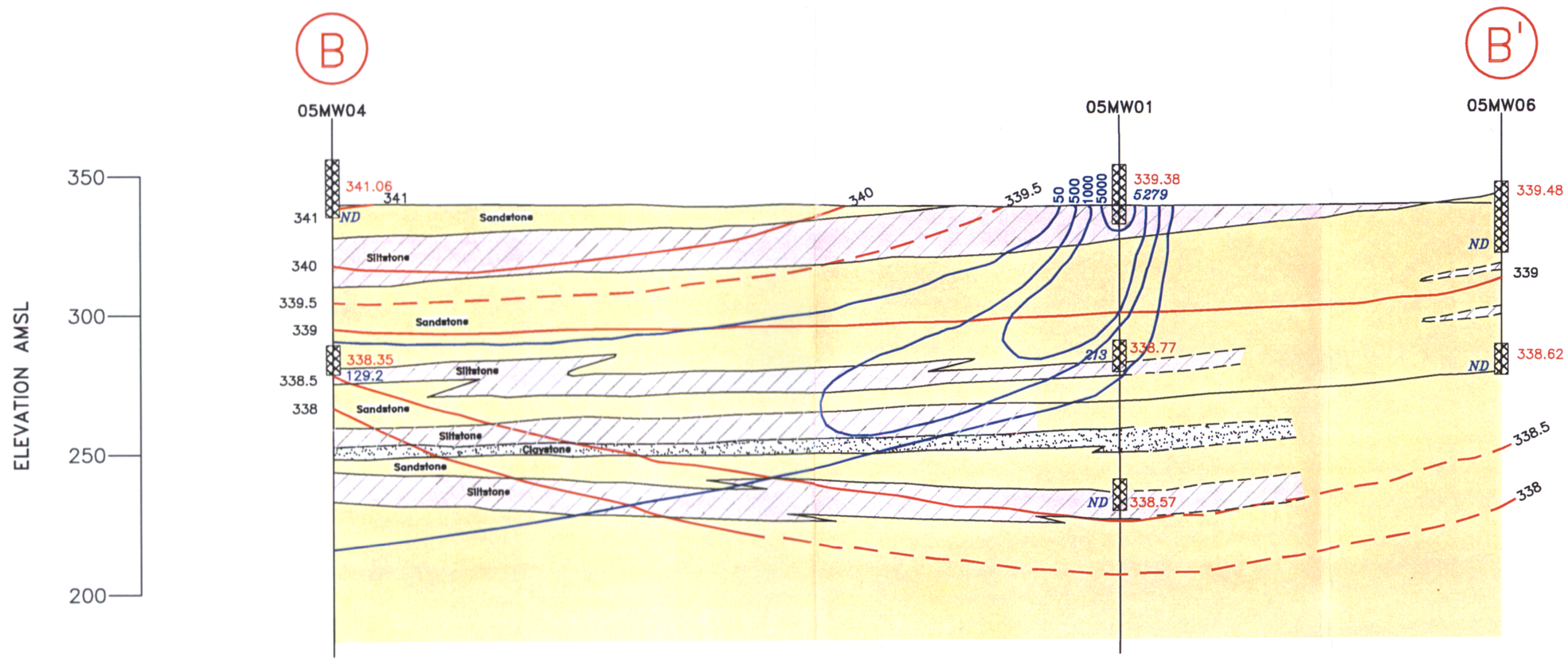
LEGEND

339.00 = HYDRAULIC HEAD

1000 = TOTAL VOC's (µg/L)

DATA ACQUIRED 9/00



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HORIZONTAL SCALE IN FEET

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SCALE AS NOTED			DRAWING NO. FIGURE 4-5 REV.

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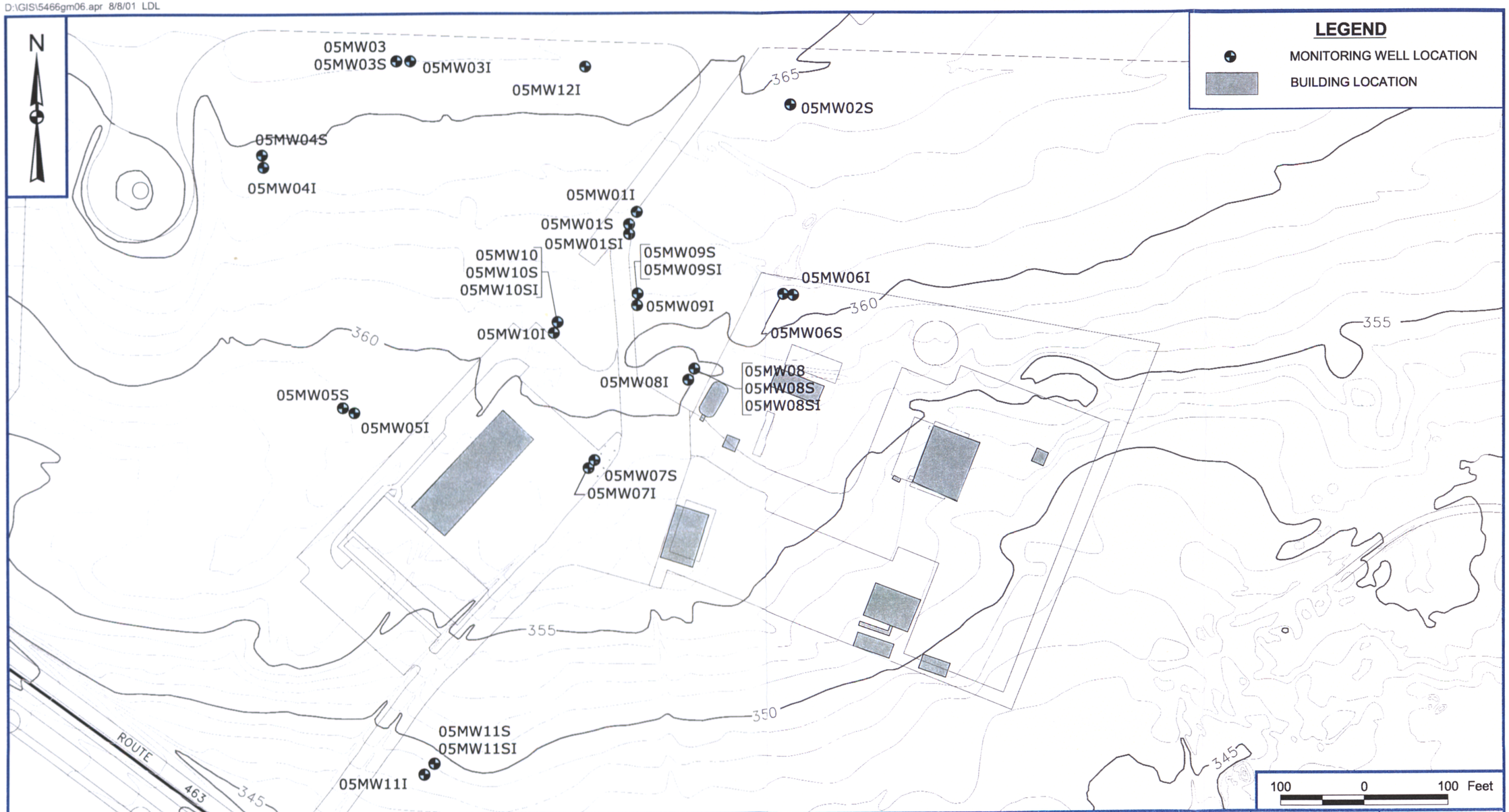

NO.	DATE	REVISIONS	BY	CHKD	APP'D	REFERENCES

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COST/SCHEDULE-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

MONITORING WELL LOCATIONS
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NUMBER 5466 — OWNER NUMBER 2207
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DRAWING NO. FIGURE 4-6 — REV

TABLE 4-1

SITE 5: FIRE TRAINING AREA
WELL CONSTRUCTION DETAILS

PREVIOUSLY EXISTING WELLS (ALL ARE 4-INCH DIAMETER)					
Previous Designation	New Designation	Well Depth (feet bgs)	Screen Interval (feet bgs)	Elevation (TOC)	Monitored Zone
FTAW-1	05MW01S	32	12 - 32	364.11	Shallow
FTAW-1B	05MW01SI	84.5	74.5 - 84.5	363.64	Intermediate
FTAW-2	05MW02S	30	10 - 30	365.48	Shallow
FTAW-3	05MW03S	31	11 - 31	367.18	Shallow
FTAW-4	05MW04S	30	10 - 30	365.62	Shallow
FTAW-5	05MW05S	40	20 - 40	359.92	Shallow
FTAW-6	05MW06S	37.5	17.5 - 37.5	362.38	Shallow
FTAW-6B	05MW06I	84	74 - 84	361.08	Intermediate
FTAW-7	05MW07S	26	6 - 26	360.73	Shallow
FTAW-7B	05MW07I	84	74 - 84	360.20	Intermediate
NEW MONITORING WELLS (ALL ARE 2-INCH DIAMETER)					
- -	05MW01I	135	125 - 135	363.99	Deep
- -	05MW03I	128	118 - 128	367.35	Intermediate
- -	05MW04I	84.5	74.5 - 84.5	364.75	Intermediate
- -	05MW05I	209.5	189.5 - 209.5	358.89	Deep
- -	05MW08S	36	26 - 36	360.88	Shallow
- -	05MW08SI	65	55 - 65	360.92	Shallow
- -	05MW08I	99	89 - 99	361.02	Intermediate
- -	05MW09S	32	27 - 32	361.91	Shallow
- -	05MW09SI	74	59 - 74	361.74	Intermediate
- -	05MW09I	106	96 - 106	362.11	Deep
- -	05MW10S	32	22 - 32	362.54	Shallow
- -	05MW10SI	94	79 - 94	362.44	Intermediate
- -	05MW10I	126	116 - 126	362.48	Deep
- -	05MW11S	25	20 - 25	349.50	Shallow
- -	05MW11I	50	40 - 50	349.51	Intermediate
- -	05MW11D	149	139 - 149	348.96	Deep
- -	05MW12I	113.5	103.5 - 113.5	365.98	Intermediate

TOC = Top of casing

bgs = Below ground surface

existing shallow well, and a new intermediate monitoring well (05MW12I) was installed at new well location 05MW12. Well locations 05MW03 and 05MW12 are structurally located downdip from the source area for volatile organic compounds near well location 05MW01. Well location 05MW12 is located directly downdip from 05MW01, as its location was not selected until after the site-specific strike and dip were determined using the stratigraphic information obtained through the geophysical logging of borehole 05MW03I. The intermediate wells 05MW03I and 05MW12I were installed to investigate the potential structural (bedrock) control on the migration of contaminants from the source area, particularly the potential for contaminants to migrate downdip (rather than downgradient) along bedding planes separating overlying, more permeable rocks from underlying, less permeable rocks.

New shallow, intermediate, and deep monitoring wells were installed at new well location 05MW11 to define the hydrogeologic conditions and groundwater quality in an area located downgradient from the source area and between the source area and the off-site public supply well Horsham Township Well No. 26. Monitoring well cluster 05MW11 was located as close to the base fence line as logistically possible in an area underlain by several utility lines.

At the time of their installation, the monitoring wells were designated either shallow (S), intermediate (I), deep (D), or shallow-intermediate transitional (SI) monitoring wells. These well designations reflect the relative subsurface depths of the well screens, and were not meant to imply a hydrogeological significance. After all of the hydrogeologic data were acquired and interpreted, it was determined that in order to simplify subsequent discussions, the monitored portion of the aquifer beneath the site (which is entirely within the shallow, unconfined zone) could generally be divided into a shallow, intermediate, and deep groundwater zone. The portion of the aquifer monitored by each well is listed in Table 4-1.

4.4.2.2 Groundwater Occurrence and Flow Characteristics

The occurrence and distribution of groundwater within the bedrock was similar to that typically reported for aquifers within the Triassic Basin. During drilling, the bulk of the groundwater entered the boreholes through discrete water-entry zones. Subsequent analyses of the drilling logs, borehole video tape (when present), and borehole geophysical logs revealed that the discrete water-entry zones were either bedding-plane partings at lithologic contacts or fractures within a relatively homogeneous lithologic unit. Typically, both types of water-entry zones were present within any particular borehole. The primary porosity of the various lithologic units (particularly the sandstones) most likely contributed groundwater to each borehole, but the volume or yield could not be quantified due to the low volume of groundwater entering the borehole through the primary pore spaces relative to the volume of groundwater entering through the secondary openings.

The hydraulic head data collected during this investigation indicate that two hydrogeologic units (an upper,

unconfined zone and a deeper, semi-confined to confined zone) exist beneath the Fire Training Area. All of the monitoring wells were completed within the unconfined zone, as interpreted by the vertical distribution of hydraulic head and the existence of downward vertical flow within the borehole at that particular screen depth.

Hydraulic gradients

Flowmeter logs run in the open boreholes revealed that both upward and downward vertical gradients exist at Site 5. Typically, the vertical gradients were oriented downward in the shallower portions of the borehole and oriented upward in the deeper portions of the borehole, although not all boreholes exhibited an upward vertical gradient. The transition from downward to upward flow did not appear to be strictly controlled by lithology or stratigraphy. In boreholes 05MW03I, 05MW04I, and 05MW12I, the transition from downward to upward flow occurred at the claystone (discussed above) that can be correlated throughout the site. In borehole 05MW05I, however, the vertical flow was downward throughout the borehole, even below the claystone.

The magnitude of the vertical hydraulic gradient within the unconfined zone is quite variable and complex at Site 5. The hydraulic head measurements at the monitoring well cluster locations (where wells monitor several subsurface depth zones at a single surface location) indicate that the vertical gradients between most wells (wells with screen elevations shallower than a subsurface depth of about 140 feet, or above a topographic elevation of approximately 230 feet amsl) are fairly low, which suggests that these wells are monitoring different vertical zones within a common aquifer or hydrogeologic unit. The vertical gradient between the water table (an elevation of approximately 340 feet amsl) and an elevation of 230 feet amsl is typically in the range of hundreths of a foot of head difference per foot of vertical elevation. South of monitoring well cluster 05MW10, the vertical gradient increases considerably below an elevation of 230 feet amsl. Based on the hydraulic head measured in wells 05MW05I and 05MW11I, the vertical gradient between the water table and the deeper zones within the aquifer is one tenth of a foot of head difference per foot of vertical elevation, or an order of magnitude higher than the vertical gradient at the shallower depths (or higher elevations).

The horizontal hydraulic gradient across the site is very low, with the exception of the gradient at the water table in the vicinity of the runway. The horizontal gradient at the water table ranges from about 0.01 foot of head difference per foot of horizontal distance near the runway to about 0.002 foot of head difference per foot of horizontal distance near the source area at well cluster 05MW01. The horizontal gradients decrease markedly with increasing subsurface depth to a subsurface depth of about 140 feet (or an elevation of approximately 230 feet amsl), where the horizontal gradients range from about 0.002 foot of head difference per foot of horizontal distance near the source area at well cluster 05MW01 to about 0.0006 foot of head

difference per foot of horizontal distance in the vicinity of well cluster 05MW04.

Groundwater flow directions

Groundwater flow directions beneath the Fire Training Area were determined from the contouring of the static-water level elevations measured in the site's monitoring wells. Three complete rounds of static-water level measurements were conducted for this investigation. These data are included in Table 4-2. Contour maps were constructed for the water elevations collected September 2000, since this represents the most inclusive data set.

Groundwater flow directions were calculated for the shallow (water table) groundwater zone (Figure 4-7) and for an intermediate-depth groundwater zone (Figure 4-8). For the intermediate zone, the water level data were selected from wells screened from approximately the same elevations, to remove as much influence from the vertical hydraulic gradient as possible.

The groundwater flow directions calculated during the Phase I RI indicated that the direction of groundwater flow appeared to vary with depth. That is, groundwater appeared to flow to the south-southeast in the shallow (water table) zone, and to the southwest to depths of about 80 feet. During the planning of the Phase II RI investigation, it was hypothesized that the difference in flow directions could be an artifact of data availability (there were less hydraulic head data available for the intermediate zone).

The groundwater flow directions calculated for this current investigation indicate that the groundwater flow direction beneath the Fire Training Area does indeed vary with depth. Groundwater at the water table and within the shallow groundwater zone (which is most directly influenced by the surface topography) flows in an overall southeastward to southwestward direction, depending on surface location (Figure 4-7). The hydraulic gradient near the runway is relatively steep, but the gradient flattens considerably in the vicinity of the source area near monitoring well cluster 05MW01.

Groundwater within the intermediate groundwater zone is influenced by the regional groundwater divide that underlies the site (Figure 4-8). Based on the most recent round of comprehensive water level measurements, the groundwater divide is interpreted to trend southwest-northeast through the site and occur approximately 100 feet east of the source area near monitoring well cluster 05MW01. As discussed, the horizontal hydraulic gradient is very low in this area (which is not unusual in the area of a divide), and the divide has been defined on hydraulic head differences of 0.1 foot or less. However, the position and orientation of the divide agree well with the regional groundwater divide as interpreted by USGS. The full USGS hydrogeological investigation report for Site 5 is included as Appendix O.

TABLE 4-2

SITE 5 STATIC-WATER-LEVEL MEASUREMENTS
FIRE TRAINING AREA
NASJRB WILLOW GROVE, PENNSYLVANIA

Well Number	TOC[1] Elevation	Date	SWL[2]	Groundwater Elevation (feet amsl[3])	Date	SWL	Groundwater Elevation (feet amsl)	Date	SWL	Groundwater Elevation (feet amsl)
05MW01S	364.11	07/02/97	25.97	338.14	08/07/97	27.62	336.49	09/11/00	24.73	339.38
05MW01SI	363.64	07/02/97	26.01	337.63	08/07/97	27.49	336.15	09/11/00	24.87	338.77
05MW01I	363.99	07/02/97	26.37	337.62	08/07/97	27.95	336.04	09/11/00	25.42	338.57
05MW02S	365.48	07/02/97	26.73	338.75	08/07/97	28.05	337.43	09/11/00	25.59	339.87
05MW03S	367.18	07/02/97	27.02	340.16	08/07/97	27.61	339.57	09/11/00	24.83	342.35
05MW03I	367.35	07/02/97	30.44	336.91	08/07/97	31.63	335.72	09/11/00	28.77	338.58
05MW04S	365.62	07/02/97	26.09	339.53	08/07/97	27.23	338.39	09/11/00	24.56	341.06
05MW04I	NA	NA	NA	NA	NA	NA	NA	09/11/00	26.20	338.55
05MW05S	359.92	07/02/97	21.90	338.02	08/07/97	23.55	336.37	09/11/00	20.96	338.96
05MW05I	NA	NA	NA	NA	NA	NA	NA	09/11/00	38.89	320.00
05MW06S	362.38	07/02/97	23.92	338.46	08/07/97	25.66	336.72	09/11/00	22.89	339.49
05MW06I	361.08	07/02/97	23.21	337.87	08/07/97	24.84	336.24	09/11/00	22.46	338.62
05MW07S	360.73	07/02/97	22.16	338.57	08/07/97	23.85	336.88	09/11/00	21.32	339.41
05MW07I	360.20	07/02/97	22.96	337.24	08/07/97	24.59	335.61	09/11/00	22.03	338.17
05MW08S	360.88	07/02/97	22.63	338.25	08/07/97	24.32	336.56	09/11/00	21.80	339.08
05MW08SI	360.92	07/02/97	23.10	337.82	08/07/97	24.73	336.19	09/11/00	22.15	338.77
05MW08I	361.02	07/02/97	23.23	337.79	08/07/97	24.87	336.15	09/11/00	22.28	338.74
05MW09S	361.91	07/02/97	23.65	338.26	08/07/97	25.31	336.60	09/11/00	22.55	339.36
05MW09SI	361.74	07/02/97	23.96	337.78	08/07/97	25.55	336.19	09/11/00	22.92	338.82
05MW09I	362.11	07/02/97	24.42	337.69	08/07/97	26.03	336.08	09/11/00	23.46	338.65
05MW10S	362.54	07/02/97	24.40	338.14	08/07/97	26.01	336.53	09/11/00	23.30	339.24
05MW10SI	362.44	07/02/97	24.67	337.77	08/07/97	26.26	336.18	09/11/00	23.65	338.79
05MW10I	362.48	07/02/97	24.85	337.63	08/07/97	26.46	336.02	09/11/00	23.91	338.55
05MW11S	NA	NA	NA	NA	NA	NA	NA	09/11/00	10.87	338.63
05MW11I	NA	NA	NA	NA	NA	NA	NA	09/11/00	10.92	338.59
05MW11D	NA	NA	NA	NA	NA	NA	NA	09/11/00	28.92	320.04
05MW12I	NA	NA	NA	NA	NA	NA	NA	09/11/00	27.30	338.68

1 TOC = Top of casing.
2 SWL = Static water level.
3 amsl = Above mean sea level
NA = Not Available. Well had not been installed at time of sampling round.

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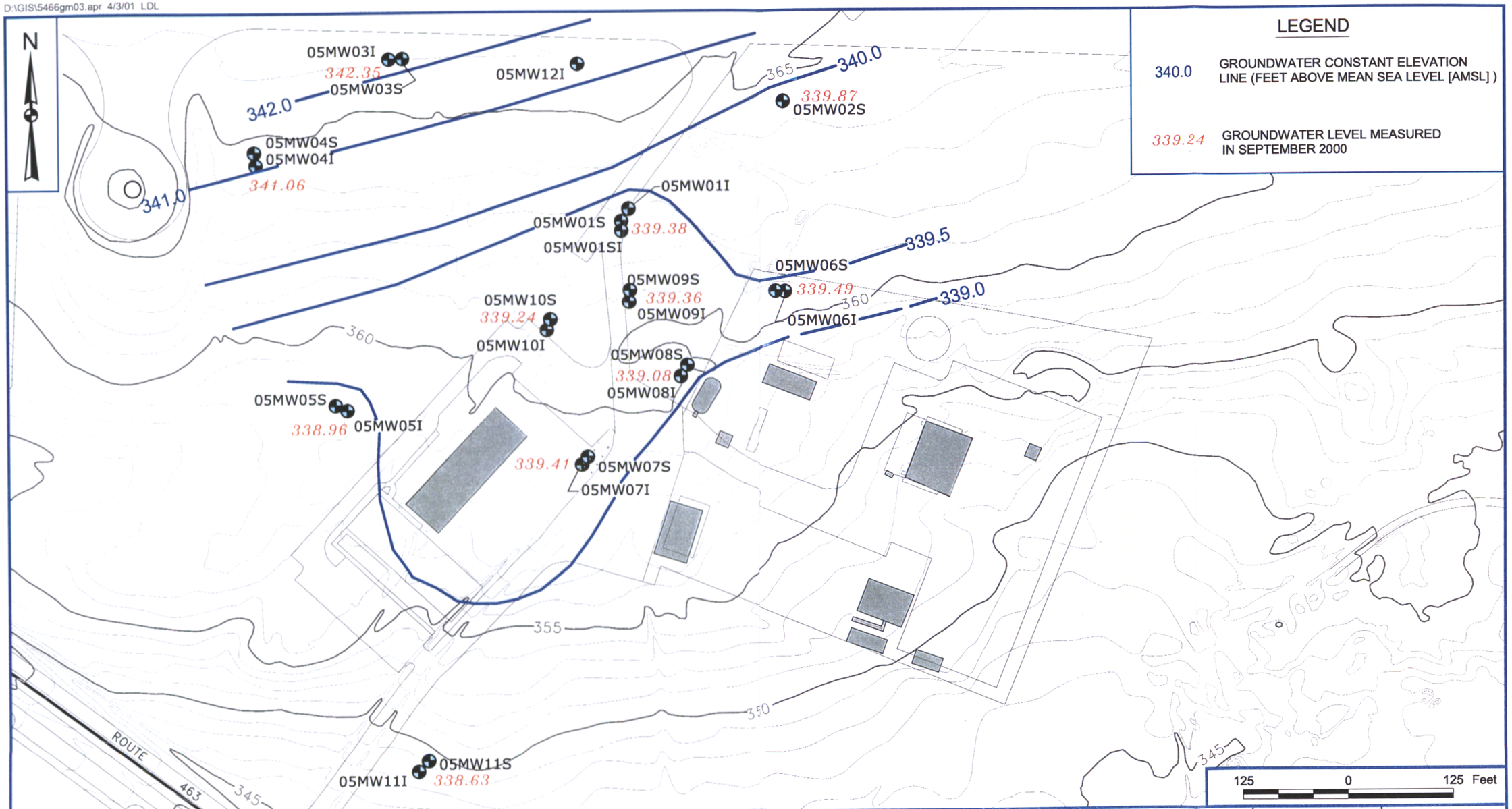

NO	DATE	REVISIONS	BY	CHKD	APP'D	REFERENCES

DRAWN BY LDL	DATE 8/14/01
CHECKED BY	DATE
COST/SCHEDULE-AREA	
SCALE AS NOTED	

Tetra Tech NUS, Inc.

GROUNDWATER ELEVATION MAP
SHALLOW GROUNDWATER ZONE
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NUMBER 5466	OWNER NUMBER 2207
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DRAWING NO. FIGURE 4-7	REV

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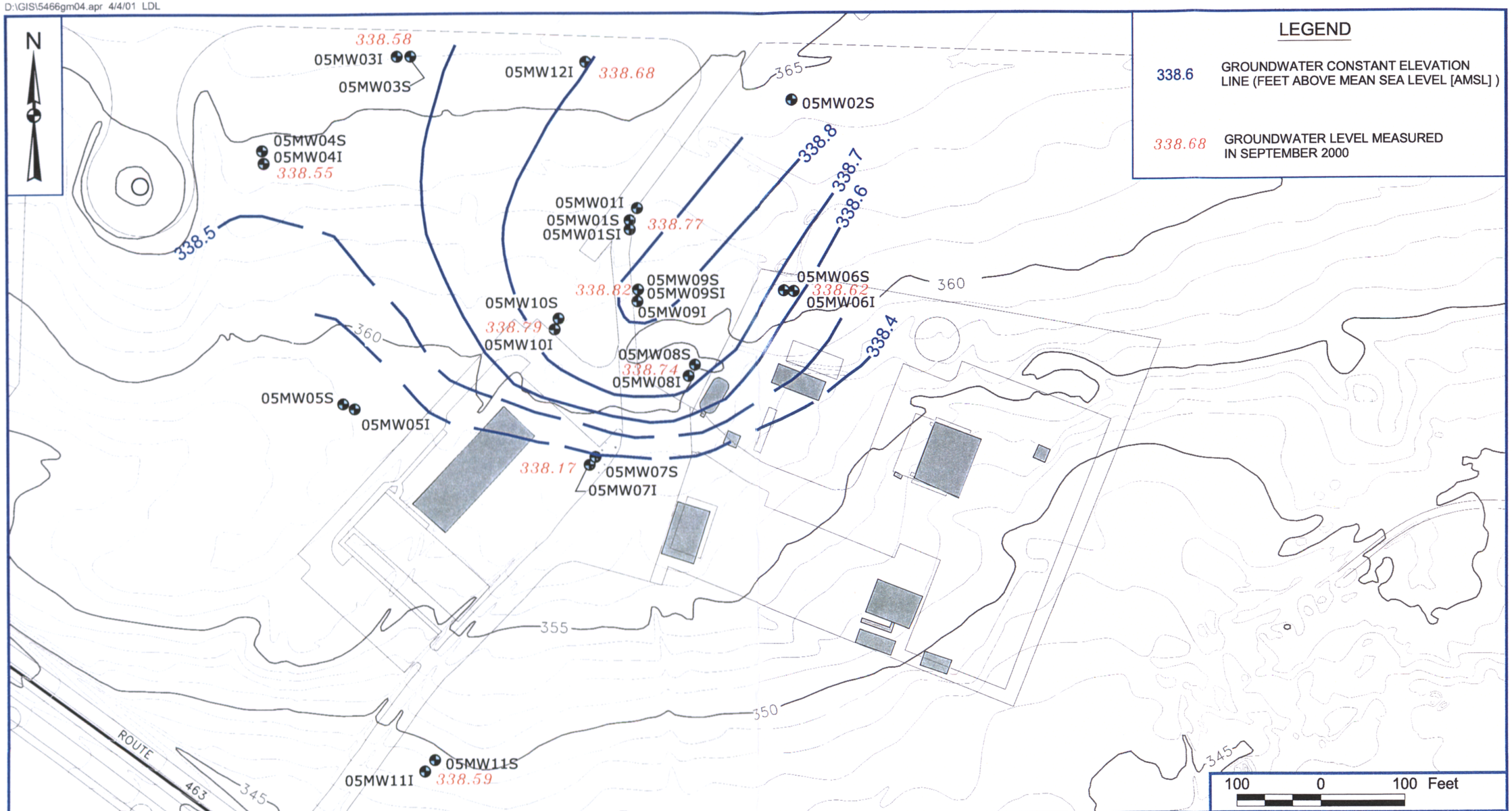


NO	DATE	REVISIONS	BY	CHKD	APP'D	REFERENCES

DRAWN BY LDL	DATE 8/8/01
CHECKED BY	DATE
COST/SCHEDULE-AREA	
SCALE AS NOTED	

Tetra Tech NUS, Inc.

GROUNDWATER ELEVATION MAP
INTERMEDIATE GROUNDWATER ZONE
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NUMBER 5466	OWNER NUMBER 2207
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO. FIGURE 4-8	REV

Groundwater within the intermediate zone flows in variable directions ranging from southeast to northwest. The groundwater flow direction at any particular location is dependent on the position of that location relative to the groundwater divide. As mapped with the September 2000 hydraulic head data, the divide occurs just to the east of the source area, creating a northwestward direction of groundwater flow beneath and from the source area. Because the divide is created and defined by differences in groundwater elevation of 0.1 foot or less, however, it is possible that the position of the divide may migrate laterally throughout the year as the hydraulic gradients vary.

The hydrogeologic cross-sections (Figures 4-4 and 4-5) illustrate the horizontal and vertical distribution of hydraulic head. These sections reflect the recharge and the dominantly downward flow of groundwater at the site, and the fact that although relatively low, the vertical gradient is still steeper than the horizontal gradient throughout most of the site. The vertical gradient increases considerably south of monitoring well cluster 05MW10 (Figure 4-4). This same increasing vertical gradient is also reflected at well cluster 05MW05 (see Table 4-2), which is not included on the cross-section, but is located at approximately the same southerly coordinates as 05MW07.

4.5 NATURE AND EXTENT OF CONTAMINATION

This section evaluates all sampling data from the 1991 Phase I RI, the Phase II RI including 1997/98 initial field activities and the 2000 follow-on field activities. Details of the samples collected (number of samples, location, sample identifier) during each phase are presented. Data were compared to ARARs and background as detailed in Section 3.1.

4.5.1 Surface Soil

During the Phase II RI field activities, 18 surface soil samples (05SS12, 05SS14, and 05SS17 through 05SS30) were collected from Site 5 to determine detected contaminants of concern (Figure 4-1). Thirteen samples were analyzed for TAL metals and TCL SVOCs. Fifteen locations were selected for PCB immunoassay field screening, one sample was submitted for TCL PCB confirmation analysis, and two samples were submitted for dioxin analysis. No surface soil samples were collected during Phase I field activities.

Table 4-3 presents the occurrence and distribution of inorganic and organic chemicals detected in site-related surface soil samples and compares them to background. Table 4-4 presents results from the background comparison tests. Table 4-5 presents a comparison of detected compounds to ARARS and TBCs. Figure 4-9A shows sample locations and concentrations of compounds that exceed ARARS and TBCs.

Table 4-3
Occurrence and Distribution of Organics and Inorganics in Surface Soils, Site 5
NASJRB Willow Grove, Pennsylvania

	Background Data					Site-Related Data				
Substance	Freq. of Detection	Range of Positive Detection Min. - Max.	Mean of All Data	Sampling Round and Location of Maximum		Freq. of Detection	Range of Positive Detection Min. - Max.	Mean of All Data	Sampling Round and Location of Maximum	Representative Concentration
aluminum	12/12	9090 - 15000	11400	04/07/97 BGSS06		15/15	7890 - 12400	10000	05SS25 04/16/97	10600
antimony	0/2	-		NA		2/4	8.2 - 9.2	5.45	05SS20 04/16/97	9.2
arsenic	12/12	3.7 - 10.6	6.61	04/07/97 BGSS03		15/15	1.3 - 10.5	4.87	05SS19 04/16/97	6.04
barium	12/12	77.8 - 111	96	04/07/97 BGSS04		15/15	33.1 - 108	80.1	05SS17 04/16/97	93.5
beryllium	12/12	0.75 - 1.3	0.988	04/07/97 BGSS11		15/15	0.3 - 1.1	0.806	05SS17 04/16/97	0.894
cadmium	0/12	-		NA		3/15	2.8 - 4.7	1.17	05SS28 04/16/97	1.73
calcium	12/12	614 - 1600	1020	04/07/97 BGSS12		15/15	1150 - 69400	13000	05SS30 05/28/97	32500
chromium	12/12	12.4 - 20.8	15.4	04/07/97 BGSS02		15/15	8.8 - 56.5	19.1	05SS27 04/16/97	23.8
cobalt	12/12	6.8 - 9.3	7.9	04/07/97 BGSS02		15/15	4.3 - 13	7.45	05SS19 04/16/97	8.42
copper	12/12	8 - 13.4	10.7	04/07/97 BGSS09		15/15	6.5 - 28.4	18.1	05SS29 04/16/97	21.1
iron	12/12	12800 - 17600	14900	04/07/97 BGSS06		15/15	9320 - 21600	14900	05SS29 04/16/97	16700
lead	12/12	16.3 - 64.7	31	04/07/97 BGSS04		15/15	7.4 - 412	89.7	05SS22 04/16/97	217
magnesium	12/12	1300 - 1940	1510	04/07/97 BGSS06		15/15	1410 - 42700	7890	05SS30 05/28/97	15100
manganese	12/12	429 - 1190	641	04/07/97 BGSS04		15/15	202 - 873	507	05SS19 04/16/97	582
nickel	12/12	7.4 - 11.2	9.78	04/07/97 BGSS04		15/15	5.2 - 23.6	9.49	05SS19 04/16/97	11.5
potassium	7/12	436 - 771	434	04/07/97 BGSS05		12/15	447 - 2050	770	05SS19 04/16/97	1290
sodium	2/12	112 - 120	63.9	04/07/97 BGSS09		9/15	113 - 448	149	05SS17 04/16/97	247
thallium	7/12	0.25 - 0.34	0.226	04/07/97 BGSS07		7/15	0.24 - 0.39	0.2	05SS29 04/16/97	0.256
vanadium	12/12	20.9 - 28.2	25	04/07/97 BGSS02		15/15	14.3 - 36.3	24.3	05SS29 04/16/97	27.7
zinc	12/12	21.7 - 597	90.5	04/07/97 BGSS04		15/15	17 - 137	62.3	05SS29 04/16/97	87.6
1,2,3,4,6,7,8-HPCDD	0/0	-				2/2	0.972 - 5.15	3.06	05SS14 04/17/97	5.15
1,2,3,4,6,7,8-HPCDF	0/0	-				2/2	0.0467 - 0.19	0.118	05SS14 04/17/97	0.19
1,2,3,4,7,8,9-HPCDF	0/0	-				2/2	0.0028 - 0.0128	0.0078	05SS14 04/17/97	0.0128
1,2,3,4,7,8-HXCDD	0/0	-				2/2	0.0091 - 0.0271	0.0181	05SS14 04/17/97	0.0271
1,2,3,4,7,8-HXCDF	0/0	-				2/2	0.0109 - 0.0116	0.0113	05SS14 04/17/97	0.0116
1,2,3,6,7,8-HXCDD	0/0	-				2/2	0.0224 - 0.124	0.0732	05SS14 04/17/97	0.124
1,2,3,6,7,8-HXCDF	0/0	-				2/2	0.0031 - 0.006	0.00455	05SS14 04/17/97	0.006

Table 4-3
Occurrence and Distribution of Organics and Inorganics in Surface Soils, Site 5
NASJRB Willow Grove, Pennsylvania

	Background Data					Site-Related Data					
Substance	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Representative Concentration
1,2,3,7,8,9-HXCDD	0/0	-				2/2	0.0123	0.0508	0.0316	05SS14 04/17/97	0.0508
1,2,3,7,8,9-HXCDF	0/0	-				2/2	0.002	0.0059	0.00395	05SS14 04/17/97	0.0059
1,2,3,7,8-PECDD	0/0	-				2/2	0.0054	0.0146	0.01	05SS14 04/17/97	0.0146
1,2,3,7,8-PECDF	0/0	-				2/2	0.0016	0.0019	0.00175	05SS12 04/17/97	0.0019
2,3,4,6,7,8-HXCDF	0/0	-				2/2	0.0044	0.016	0.0102	05SS14 04/17/97	0.016
2,3,4,7,8-PECDF	0/0	-				2/2	0.0021	0.0029	0.0025	05SS12 04/17/97	0.0029
2,3,7,8-tetrachlorodibenzo-p-dio	0/0	-				2/2	0.0035	0.0451	0.0243	05SS14 04/17/97	0.0451
2,3,7,8-tetrachlorodibenzofuran	0/0	-				2/2	0.0026	0.0026	0.0026	05SS12 04/17/97	0.0026
octachlorodibenzo-p-dioxin	0/0	-				2/2	5.16	45.08	25.1	05SS14 04/17/97	45.1
octachlorodibenzofuran	0/0	-				2/2	0.0763	0.0843	0.0803	05SS14 04/17/97	0.0843
TOTAL HPCDD	0/0	-				2/2	1.84	10.63	6.24	05SS14 04/17/97	10.6
TOTAL HPCDF	0/0	-				2/2	0.12	0.921	0.521	05SS14 04/17/97	0.921
TOTAL HXCDD	0/0	-				2/2	0.264	1.01	0.637	05SS14 04/17/97	1.01
TOTAL HXCDF	0/0	-				2/2	0.0893	0.526	0.308	05SS14 04/17/97	0.526
TOTAL PECDD	0/0	-				2/2	0.039	0.112	0.0755	05SS14 04/17/97	0.112
TOTAL PECDF	0/0	-				2/2	0.0539	0.0995	0.0767	05SS14 04/17/97	0.1
total tetrachlorodibenzo-p-dioxin	0/0	-				2/2	0.0101	0.0591	0.0346	05SS14 04/17/97	0.0591
total tetrachlorodibenzofuran	0/0	-				2/2	0.0332	0.0377	0.0355	05SS12 04/17/97	0.0377
2-methylnaphthalene	0/12	-			NA	7/16	50	16000	1170	05SS30 05/28/97	1270
acenaphthene	3/12	55	64	178	04/07/97 BGSS10	13/16	47	36000	2560	05SS30 05/28/97	4370
acenaphthylene	3/12	54	62	178	04/07/97 BGSS12	12/16	73	2300	388	05SS30 05/28/97	643
anthracene	6/12	46	160	155	04/07/97 BGSS12	14/16	140	54000	4330	05SS30 05/28/97	11800
benz(a)anthracene	9/12	33	940	307	04/07/97 BGSS12	14/16	580	48000	7350	05SS30 05/28/97	45400
benzo(a)pyrene	8/12	110	1100	395	04/07/97 BGSS12	14/16	750	36000	5900	05SS30 05/28/97	26700
benzo(b)fluoranthene	8/12	160	1500	508	04/07/97 BGSS12	14/16	1200	35000	7440	05SS30 05/28/97	35000
benzo(g,h,i)perylene	7/12	52	490	225	04/07/97 BGSS12	14/16	400	13000	2340	05SS30 05/28/97	5910
benzo(k)fluoranthene	7/12	98	920	371	04/07/97 BGSS12	13/16	750	29000	4700	05SS30 05/28/97	22800

Table 4-3
Occurrence and Distribution of Organics and Inorganics in Surface Soils, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Background Data					Site-Related Data				
	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Representative Concentration
bis(2-ethylhexyl)phthalate	0/0	-				3/3	210	1200	770	05SS27 04/16/97	1200
carbazole	5/12	80	310	213	04/07/97 BGSS10	13/16	160	19000	1780	05SS30 05/28/97	3200
chrysene	9/12	43	1200	420	04/07/97 BGSS12	14/16	1100	45000	7440	05SS30 05/28/97	37500
di-n-butylphthalate	0/2	-			NA	2/16	85	120	198	05SS22 04/16/97	120
dibenz(a,h)anthracene	5/12	52	160	162	04/07/97 BGSS12	13/16	110	4800	863	05SS30 05/28/97	1710
dibenzofuran	4/12	51	120	173	04/07/97 BGSS08	13/16	71	34000	2380	05SS30 05/28/97	3120
fluoranthene	10/12	49	2600	903	04/07/97 BGSS12	14/16	2400	140000	17800	05SS30 05/28/97	140000
fluorene	4/12	59	160	185	04/07/97 BGSS08	13/16	81	56000	3900	05SS30 05/28/97	5560
indeno(1,2,3-cd)pyrene	8/12	49	640	252	04/07/97 BGSS12	14/16	550	18000	3240	05SS30 05/28/97	9700
naphthalene	0/12	-			NA	5/16	52	22000	1540	05SS30 05/28/97	1610
phenanthrene	8/12	110	1700	668	04/07/97 BGSS12	14/16	1100	200000	18100	05SS30 05/28/97	106000
pyrene	10/12	51	2100	723	04/07/97 BGSS12	14/16	1800	120000	16100	05SS30 05/28/97	120000
acetone	0/0	-				1/5	17	17	7.7	05SB25-0002 04/16/97	16.8
toluene	0/0	-				1/10	1	1	3.2	05SB15-0002 09/04/91	1

Notes:

Units are mg/kg for inorganics, ug/kg for organics.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result.
Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.
The determination of representative concentrations is based on comparison of maximum to the 95 % UCL, which is presented in a separate table.
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.
Number of samples may vary based on the number of usable results.

Table 4-4
Background Comparison Tests - Surface Soil Data for Site 5
NASJRB Willow Grove, Pennsylvania

Name of Test:	Detection Freq: Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:	Site Freq. > Back.Freq.?				Site Maximum > UTL for Background Data ?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation =Background Std.Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back.	Site	P	YN	Back.	Std.Dev.	t	L,N	Back.	Site	YN	r	k	P	YN	P	Test	Used	YN	Back.	Site	t	t	YN	Back.	Site	Std.Dev.	Std.Dev.	F	F	YN
Substance	Freq.	Freq.	Value		Mean@	Back.@	Value	Q	UTL	Max.				Value		Value				Mean@	Mean@	Value	Table		Distrib.	Distrib.	Back.@	Site@	Value	Table	
1,2,3,4,6,7,8-HPCDD	NA	0/0	2/2		NA					5.15	NA				NA				NA		3.06			NA							NA
1,2,3,4,6,7,8-HPCDF	NA	0/0	2/2		NA					0.19	NA				NA				NA		0.118			NA							NA
1,2,3,4,7,8,9-HPCDF	NA	0/0	2/2		NA					0.0128	NA				NA				NA		0.0078			NA							NA
1,2,3,4,7,8-HXCDD	NA	0/0	2/2		NA					0.0271	NA				NA				NA		0.0181			NA							NA
1,2,3,4,7,8-HXCDF	NA	0/0	2/2		NA					0.0116	NA				NA				NA		0.0113			NA							NA
1,2,3,6,7,8-HXCDD	NA	0/0	2/2		NA					0.124	NA				NA				NA		0.0732			NA							NA
1,2,3,6,7,8-HXCDF	NA	0/0	2/2		NA					0.006	NA				NA				NA		0.0046			NA							NA
1,2,3,7,8,9-HXCDD	NA	0/0	2/2		NA					0.0508	NA				NA				NA		0.0316			NA							NA
1,2,3,7,8,9-HXCDF	NA	0/0	2/2		NA					0.0059	NA				NA				NA		0.004			NA							NA
1,2,3,7,8-PECDD	NA	0/0	2/2		NA					0.0146	NA				NA				NA		0.01			NA							NA
1,2,3,7,8-PECDF	NA	0/0	2/2		NA					0.0019	NA				NA				NA		0.0018			NA							NA
2,3,4,6,7,8-HXCDF	NA	0/0	2/2		NA					0.016	NA				NA				NA		0.0102			NA							NA
2,3,4,7,8-PECDF	NA	0/0	2/2		NA					0.0029	NA				NA				NA		0.0025			NA							NA
2,3,7,8-tetrachlorodibenzo-p-d	NA	0/0	2/2		NA					0.0451	NA				NA				NA		0.0243			NA							NA
2,3,7,8-tetrachlorodibenzofura	NA	0/0	2/2		NA					0.0026	NA				NA				NA		0.0026			NA							NA
octachlorodibenzo-p-dioxin	NA	0/0	2/2		NA					45.08	NA				NA				NA		25.1			NA							NA
octachlorodibenzofuran	NA	0/0	2/2		NA					0.0843	NA				NA				NA		0.0803			NA							NA
aluminum	N	12/12	15/15		NA	9.33	0.142	1.7959	L	14700	12400	N	5	2	0.8982	N	0.9860			N	9.33	9.2	-2.4402	1.7081	N	lognor.	lognor.	0.142	0.136	0.0238	3.8453	Y
antimony	N	0/2	2/4	0.4000	N					9.2	NA	2	2	0.4000	N				NA		5.45			NA							NA
arsenic	N	12/12	15/15		NA	1.85	0.283	1.7959	L	10.8	10.5	N	2	1	0.8120	N	0.9665			N	6.61	4.87			NA	lognor.	normal					NA
barium	N	12/12	15/15		NA	4.56	0.129	1.7959	L	121	108	N	17	8	0.9422	N	0.9936			N	96	80.1			NA	lognor.	nonpar.					NA
beryllium	N	12/12	15/15		NA	-0.0287	0.192	1.7959	L	1.39	1.1	N	16	8	0.8632	N	0.9761			N	0.988	0.806			NA	lognor.	normal					NA
cadmium	N	0/12	3/15	0.1556	N					4.7	NA	3	3	0.1556	N				NA		1.17			NA							NA
calcium	Y	12/12	15/15		NA	6.88	0.329	1.7959	L	1790	69400	Y	14	14	<.0001	Y	<.0001			Y	6.88	8.79	6.0898	1.7459	Y	lognor.	lognor.	0.329	1.16	14.2782	3.8453	N
chromium	Y	12/12	15/15		NA	2.73	0.142	1.7959	L	20	56.5	Y	7	6	0.0749	N	0.2709			N	2.73	2.85	1.0052	1.7396	N	lognor.	lognor.	0.142	0.431	11.5553	3.8453	N
cobalt	Y	12/12	15/15		NA	7.9	0.786	1.7959	N	9.37	13	Y	1	1	0.5556	N	0.9467			N	2.06	1.98	-1.1802	1.7291	N	lognor.	lognor.	0.1	0.246	7.9694	3.8453	N
copper	Y	12/12	15/15		NA	10.7	1.55	1.7959	N	13.6	28.4	Y	11	11	0.0001	Y	0.0005			Y	10.7	18.1			NA	normal	normal					NA
iron	Y	12/12	15/15		NA	9.6	0.111	1.7959	L	18200	21600	Y	3	3	0.1556	N	0.5292			N	9.6	9.59	-0.1975	1.7207	N	lognor.	lognor.	0.111	0.223	5.0502	3.8453	N
lead	Y	12/12	15/15		NA	3.34	0.433	1.7959	L	63.3	412	Y	13	11	0.0048	Y	0.0241			Y	3.34	3.98	2.1166	1.7291	Y	lognor.	lognor.	0.433	1.07	8.1898	3.8453	N
magnesium	Y	12/12	15/15		NA	7.31	0.102	1.7959	L	1820	42700	Y	12	12	<.0001	Y	0.0001			Y	7.31	8.39	4.1624	1.7613	Y	lognor.	lognor.	0.102	1	35.0286	3.8453	N
manganese	N	12/12	15/15		NA	6.42	0.277	1.7959	L	1040	873	N	13	7	0.7117	N	0.9379			N	641	507			NA	lognor.	normal					NA
nickel	Y	12/12	15/15		NA	9.78	0.961	1.7959	N	11.6	23.6	Y	5	4	0.2401	N	0.9409			N	9.78	9.49			NA	normal	lognor.					NA
potassium	N	7/12	12/15	0.2116	N	434					2050	NA	4	4	0.0778	N	0.0690	Gehan	Test	N	434	770			NA	normal	lognor.					NA

Table 4-4
Background Comparison Tests - Surface Soil Data for Site 5
NASJRB Willow Grove, Pennsylvania

Name of Test:		Detection Freq: Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:		Site Freq. > Back.Freq ?				Site Maximum > UTL for Background Data ?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation =Background Std.Dev.?						
Assumptions Valid:		#ND & Pos >=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:		P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back?	YN	Back.	Site	P	YN	Back.	Std.Dev.	t	L.N	Back.	Site	YN	r	k	P	YN	P	Test	Used	YN	Back.	Site	t	t	YN	Back.	Site	Std.Dev	Std.Dev.	F	F	YN
Substance		Freq.	Freq.	Value		Mean@	Back.@	Value	Q	UTL	Max.				Value		Value				Mean@	Mean@	Value	Table		Distrib.	Distrib.	Back.@	Site@	Value	Table	
sodium	Y	2/12	9/15	0.0282	Y	63.9					448	NA	7	7	0.0072	Y	0.0058	Gehan	Test	Y	63.9	149			NA	nonpar.	nonpar.					NA
thallium	N	7/12	7/15	0.8390	N	0.226					0.39	NA	1	1	0.5556	N	0.9106	Gehan	Test	N	0.226	0.2			NA	nonpar.	nonpar					NA
vanadium	Y	12/12	15/15		NA	25	2.1	1.7959	N	29	36.3	Y	3	3	0.1556	N	0.8692			N	3.22	3.16	-0.8269	1.7396	N	lognor.	lognor.	0.0852	0.261	11.7231	3.8453	N
zinc	Y	12/12	15/15		NA	90.5					137	NA	9	8	0.0175	Y	0.1707			N	90.5	62.3			NA	nonpar.	lognor.					NA
2-methylnaphthalene	N	0/12	7/16	0.0097	Y						16000	NA	1	1	0.5714	N				NA		1170			NA							NA
acenaphthene	Y	3/12	13/16	0.0043	Y	178					36000	NA	7	7	0.0097	Y	0.0039	Gehan	Test	Y	178	2560			NA	nonpar.	nonpar.					NA
acenaphthylene	Y	3/12	12/16	0.0117	Y	178					2300	NA	3	3	0.1709	N	0.0090	Gehan	Test	Y	178	388			NA	nonpar.	nonpar.					NA
anthracene	Y	6/12	14/16	0.0399	Y	155					54000	NA	12	12	0.0001	Y	0.0001	Gehan	Test	Y	155	4330			NA	normal	nonpar.					NA
benz(a)anthracene	Y	9/12	14/16	0.3573	N	307					48000	NA	13	13	<.0001	Y	0.0002			Y	307	7350			NA	lognor.	lognor.					NA
benzo(a)pyrene	Y	8/12	14/16	0.1938	N	395					36000	NA	13	13	<.0001	Y	0.0003			Y	395	5900			NA	lognor.	lognor.					NA
benzo(b)fluoranthene	Y	8/12	14/16	0.1938	N	508					35000	NA	13	13	<.0001	Y	0.0003			Y	508	7440			NA	lognor.	lognor.					NA
benzo(g,h,i)perylene	Y	7/12	14/16	0.0934	N	225					13000	NA	13	13	<.0001	Y	0.0001	Gehan	Test	Y	225	2340			NA	normal	lognor.					NA
benzo(k)fluoranthene	Y	7/12	13/16	0.1826	N	371					29000	NA	12	12	0.0001	Y	0.0008	Gehan	Test	Y	371	4700			NA	lognor.	lognor.					NA
bis(2-ethylhexyl)phthalate	NA	0/0	3/3		NA						1200	NA				NA				NA		770			NA							NA
carbazole	Y	5/12	13/16	0.0386	Y	213					19000	NA	10	10	0.0006	Y	0.0010	Gehan	Test	Y	213	1780			NA	normal	nonpar.					NA
chrysene	Y	9/12	14/16	0.3573	N	420					45000	NA	13	13	<.0001	Y	0.0002			Y	420	7440			NA	lognor.	lognor.					NA
di-n-butylphthalate	N	0/2	2/16	0.7843	N						120	NA				NA				NA		198			NA							NA
dibenz(a,h)anthracene	Y	5/12	13/16	0.0386	Y	162					4800	NA	12	12	0.0001	Y	0.0001	Gehan	Test	Y	162	863			NA	nonpar.	lognor.					NA
dibenzofuran	Y	4/12	13/16	0.0142	Y	173					34000	NA	8	8	0.0041	Y	0.0017	Gehan	Test	Y	173	2380			NA	nonpar.	nonpar.					NA
fluoranthene	Y	10/12	14/16	0.5829	N	903					140000	NA	13	13	<.0001	Y	0.0003			Y	903	17800			NA	lognor.	lognor.					NA
fluorene	Y	4/12	13/16	0.0142	Y	185					56000	NA	8	8	0.0041	Y	0.0010	Gehan	Test	Y	185	3900			NA	nonpar.	nonpar.					NA
indeno(1,2,3-cd)pyrene	Y	8/12	14/16	0.1938	N	252					18000	NA	13	13	<.0001	Y	0.0002			Y	252	3240			NA	lognor.	lognor.					NA
naphthalene	N	0/12	5/16	0.0444	Y						22000	NA	1	1	0.5714	N				NA		1540			NA							NA
phenanthrene	Y	8/12	14/16	0.1938	N	668					200000	NA	13	13	<.0001	Y	0.0003			Y	668	18100			NA	lognor.	lognor.					NA
pyrene	Y	10/12	14/16	0.5829	N	723					120000	NA	13	13	<.0001	Y	0.0003			Y	723	16100			NA	lognor.	lognor.					NA
acetone	NA	0/0	1/5		NA						17	NA				NA				NA		7.7			NA							NA
toluene	NA	0/0	1/10		NA						1	NA				NA				NA		3.2			NA							NA

Notes: Units are mg/kg for inorganics, ug/kg for organics.

A statistical significance level (P value) of 0.05 is used for all tests that directly compare site to background. A two-sided significance level of 0.1 is used for Bartlett's test for equal variance.

UTL is the expected value for the upper 95 % quantile of the background population; there is an equal chance of the population's true 95 % quantile being either below or above this estimate.

For each test, a YES or NO decision is presented only if all assumptions are met. The overall decision (is site > background) for each chemical appears at the left and is based on four criteria:

(1) Overall decision is YES if any one of the UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is YES, regardless of other test results.

Table 4-4
Background Comparison Tests - Surface Soil Data for Site 5
NASJRB Willow Grove, Pennsylvania

Name of Test:	Detection Freq: Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:	Site Freq. > Back.Freq.?				Site Maximum > UTL for Background Data ?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation =Background Std.Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back. Freq.	Site Freq.	P Value	YN	Back. Mean@	Std.Dev. Back.@	t Value	L,N Q	Back. UTL	Site Max.	YN	r	k	P Value	YN	P Value	Test	Used	YN	Back. Mean@	Site Mean@	t Value	t Table	YN	Back. Distrib.	Site Distrib.	Std.Dev. Back.@	Std.Dev. Site@	F Value	F Table	YN
Substance																															

(2) Overall decision is NO if at least one of UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is NO, and none of the aforementioned tests are YES.
(3) Overall decision is YES/NO if Z/Fisher Test is YES/NO, respectively, and other tests are NA. Z-test is treated as lowest priority since it relies on detection frequency, not magnitude of results.
(4) Overall decision is NA if all tests are NA. (Chemicals assigned NA are still included in human health risk-based screening and/or risk assessment.)

Abbreviations:

# NDs or # Pos.	Number of non-detected (ND) or positive (Pos.) results in data set, not including rejected data or blank-qualified data.
# s or # b	Number of site (s) or background (b) samples, not including rejected data or blank-qualified data.
s = b	Standard deviation of site results must not be different from the standard deviation of background results.
P value	Probability or significance level is defined as the chance of a false positive. *If P <= 0.05 then test determines site > background with 95 % confidence.*
L, N, or Q	UTL is based on 95 % upper limit (using t-value) when data are lognormal (L) or normal (N). Otherwise, an upper 95 % quantile (Q) is used if there are > 18 back. points.
% ND	Mann-Whitney test used if < 40% of data Non-Detected and detect. limits uniformly below the range of positive values. If not, the Gehan Test is used.
@	Mean and standard deviations are shown of log-transformed data when distributions are of this type; ie., if an (L) code appears for the UTL test or if site and background distributions both match lognormal, and both T-test and Bartlett's test are applicable. (Arithmetic mean and normal standard deviation are shown only for illustration in the event that these tests are NA.)
r,k	The upper ranks test calculates the probability that k or more samples from the top r ranks of the combined site and background data set are comprised of site data if both populations are in fact equal.

TABLE 4-5

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SS17	05SS17	05SS18	05SS19	05SS20	ARARS & TBCs			
LOCATION:	05SS17	05SS17	05SS18	05SS19	05SS20	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	04/16/97	04/18/97	04/16/97	04/16/97	04/16/97				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	12100	n/a	8540	7890	9680	78000	1000000	-	-
antimony	5.9 R	n/a	8.3 R	7.7 R	9.2 K	31.0	820	30.0	400
arsenic	3.8 E K	n/a	5.7 E	10.5 E	6.2 E	0.430	3.80	3.00	4.00
barium	108	n/a	86.7	90.8	80.6	5500	140000	5000	70000
beryllium	1.1 E	n/a	0.85 E	0.93 E	0.79 E	0.150	1.30	1.00	1.30
cadmium	1.2 U	n/a	2.8	1.1 U	1.2 U	39.0	1000	20.0	500
calcium	24700	n/a	7110	19500	5950	-	-	-	-
chromium, total	13.4	n/a	17.8	24.1	16.3	390	10000	-	-
cobalt	6.3	n/a	7.1	13	7.8	4700	120000	-	-
copper	14.7	n/a	18.7	23.1	15.4	3100	82000	700	37000
iron	13300	n/a	15300	17300	14700	23000	610000	-	-
lead	157	n/a	115	10.1	50.6 K	400	-	500	1000
magnesium	8690	n/a	3960	12900	3840	-	-	-	-
manganese	567	n/a	550	873	630	1800	47000	-	-
nickel	8.2	n/a	8.9	23.6	8.6	1600	41000	200	20000
potassium	733	n/a	572	2050	688	-	-	-	-
sodium	448	n/a	113	170	98.3 U	-	-	-	-
thallium	0.26	n/a	0.27 U	0.25 L	0.27	6.30	160	6.00	80.0
vanadium	18.6	n/a	23.1	36	27.2	550	14000	-	-
zinc	49.6	n/a	102	57.6	61.1	23000	610000	-	-
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
2-methylnaphthalene	50 J	n/a	190 J	350 UJ	400 UJ	-	-	-	-
acenaphthene	340 J	n/a	690 J	350 UJ	120 J	4700000	120000000	5000000	60000000
acenaphthylene	220 J	n/a	140 J	350 UJ	73 J	-	-	-	-
anthracene	1400 J	n/a	1000 J	350 UJ	660 J	23000000	610000000	23000000	300000000
benzo(a)anthracene	9000 E J	n/a	6100 E J	350 UJ	2600 E J	880	7800	6000	8000
benzo(a)pyrene	7200 E J	n/a	6700 E J	350 UJ	2300 E J	88.0	780	600	800
benzo(b)fluoranthene	11000 E J	n/a	11000 E J	350 UJ	3200 E J	880	7800	6000	8000

TABLE 4-5

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SS17	05SS17	05SS18	05SS19	05SS20	ARARS & TBCs			
LOCATION:	05SS17	05SS17	05SS18	05SS19	05SS20	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	04/16/97	04/18/97	04/16/97	04/16/97	04/16/97				
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
benzo(g,h,i)perylene	3800 J	n/a	2800 J	350 UJ	590 J	-	-	-	-
benzo(k)fluoranthene	5300 J	n/a	4600 J	350 UJ	1500 J	8800	78000	60000	80000
bis(2-ethylhexyl)phthalate	470 B	n/a	390 B	140 B	260 B	46000	410000	300000	400000
carbazole	920 J	n/a	1500 J	350 UJ	250 J	32000	290000	-	-
chrysene	7400 J	n/a	9600 J	350 UJ	2600 J	88000	780000	600000	800000
dibenz(a,h)anthracene	1100 E J	n/a	690 E J	350 UJ	430 E J	88.0	780	600	800
dibenzofuran	250 J	n/a	500 J	350 UJ	81 J	310000	8200000	-	-
fluoranthene	15000 J	n/a	18000 J	350 UJ	4400 J	3100000	82000000	3000000	40000000
fluorene	480 J	n/a	840 J	350 UJ	160 J	3100000	82000000	3000000	40000000
indeno(1,2,3-cd)pyrene	4800 E J	n/a	4700 E J	350 UJ	1000 E J	880	7800	6000	8000
naphthalene	410 UJ	n/a	130 J	350 UJ	400 UJ	3100000	82000000	3000000	40000000
phenanthrene	7800 J	n/a	13000 J	350 UJ	2700 J	-	-	-	-
pyrene	17000 J	n/a	16000 J	350 UJ	5600 J	2300000	61000000	2000000	30000000
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
PCBs (immunoassay)	18000 E	n/a	870 E	n/a	500 U	319	2860	5000	-
PCBs (tot. all)	n/a	42 U	870 E	n/a	500 U	319	2860	5000	-

TABLE 4-5

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SS21	05SS22	05SS23	05SS24	05SS24	ARARS & TBCs			
LOCATION:	05SS21	05SS22	05SS23	05SS24	05SS24	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	04/16/97	04/16/97	04/16/97	04/16/97	04/18/97				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	10200	9460	10200	11100	n/a	78000	1000000	-	-
antimony	6.2 R	8.2 K	6.9 R	9.5 R	n/a	31.0	820	30.0	400
arsenic	5 E	7.8 E J	4.7 E K	6.4 E	n/a	0.430	3.80	3.00	4.00
barium	78.9	81.8	77	89.9	n/a	5500	140000	5000	70000
beryllium	0.92 E	0.88 E	0.68 E	0.94 E	n/a	0.150	1.30	1.00	1.30
cadmium	1.1 U	2.9	1.3 U	1.3 U	n/a	39.0	1000	20.0	500
calcium	8690	3380	5140	2070	n/a	-	-	-	-
chromium, total	18.7	19.1	12.5	15.3	n/a	390	10000	-	-
cobalt	7.8	6.6	7.2	7.8	n/a	4700	120000	-	-
copper	14.2	27.3	11.9	12.8	n/a	3100	82000	700	37000
iron	15300	13500	13500	18000	n/a	23000	610000	-	-
lead	41.7	412 E	22.6	43.3	n/a	400	-	500	1000
magnesium	5180	2470	2920	1850	n/a	-	-	-	-
manganese	577	535	508	558	n/a	1800	47000	-	-
nickel	10.5	7	6.1	8.5	n/a	1600	41000	200	20000
potassium	932	399 U	447	584	n/a	-	-	-	-
sodium	127	106 U	113	124	n/a	-	-	-	-
thallium	0.24	0.27 U	0.26 U	0.3	n/a	6.30	160	6.00	80.0
vanadium	30.3	24.3	23.4	25.8	n/a	550	14000	-	-
zinc	52.4	88	31.5	58.5	n/a	23000	610000	-	-
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
2-methylnaphthalene	75 J	440 UJ	90 J	120 J	n/a	-	-	-	-
acenaphthene	300 J	110 J	690 J	1000 J	n/a	4700000	120000000	5000000	60000000
acenaphthylene	520 J	97 J	150 J	230 J	n/a	-	-	-	-
anthracene	2200 J	210 J	2100 J	2800 J	n/a	23000000	610000000	23000000	300000000
benzo(a)anthracene	12000 E J	1400 E J	7400 E J	11000 E J	n/a	880	7800	6000	8000
benzo(a)pyrene	8200 E J	1200 E J	6100 E J	8600 E J	n/a	88.0	780	600	800
benzo(b)fluoranthene	14000 E J	4400 E J	6500 E J	10000 E J	n/a	880	7800	6000	8000

TABLE 4-5

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SS21	05SS22	05SS23	05SS24	05SS24	ARARS & TBCs			
LOCATION:	05SS21	05SS22	05SS23	05SS24	05SS24	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	04/16/97	04/16/97	04/16/97	04/16/97	04/18/97				
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
benzo(g,h,i)perylene	4200 J	1200 J	1600 J	1800 J	n/a	-	-	-	-
benzo(k)fluoranthene	8100 J	440 UJ	5200 J	7100 J	n/a	8800	78000	60000	80000
bis(2-ethylhexyl)phthalate	230 B	190 B	380 B	310 B	n/a	46000	410000	300000	400000
carbazole	1300 J	450 J	880 J	1500 J	n/a	32000	290000	-	-
chrysene	13000 J	2000 J	7500 J	11000 J	n/a	88000	780000	600000	800000
di-n-butylphthalate	370 UJ	120 J	430 UJ	440 UJ	n/a	7800000	200000000	-	-
dibenz(a,h)anthracene	1400 E J	440 UJ	760 E J	1300 E J	n/a	88.0	780	600	800
dibenzofuran	250 J	230 J	480 J	740 J	n/a	310000	8200000	-	-
fluoranthene	25000 J	5300 J	16000 J	23000 J	n/a	3100000	82000000	3000000	40000000
fluorene	360 J	200 J	930 J	1200 J	n/a	3100000	82000000	3000000	40000000
indeno(1,2,3-cd)pyrene	5500 E J	1500 E J	2300 E J	3200 E J	n/a	880	7800	6000	8000
naphthalene	370 UJ	81 J	430 UJ	62 J	n/a	3100000	82000000	3000000	40000000
phenanthrene	10000 J	4400 J	12000 J	18000 J	n/a	-	-	-	-
pyrene	22000 J	4300 J	14000 J	20000 J	n/a	2300000	61000000	2000000	30000000
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
PCBs (immunoassay)	2000 E	1600 E	500 U	500 U	n/a	319	2860	5000	-
PCBs (tot. all)	2000 E	1600 E	500 U	n/a	43 U	319	2860	5000	-

TABLE 4-5

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SS25	05SS26	05SS27	05SS27	05SS28	ARARS & TBCs			
LOCATION:	05SS25	05SS26	05SS27	05SS27	05SS28	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	04/16/97	04/16/97	04/16/97	04/17/97	04/16/97				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	12400	10300	9280	n/a	9970	78000	1000000	-	-
antimony	5.5 R	6 R	8.1 R	n/a	6.1 R	31.0	820	30.0	400
arsenic	4.3 E K	6.2 E	2.4 E K	n/a	5.9 E	0.430	3.80	3.00	4.00
barium	84.8	88.7	95.1	n/a	88.5	5500	140000	5000	70000
beryllium	0.73 E	0.78 E	0.86 E	n/a	0.98 E	0.150	1.30	1.00	1.30
cadmium	1.3 U	1.3 U	1.2 U	n/a	4.7	39.0	1000	20.0	500
calcium	1690	1150	3710	n/a	4020	-	-	-	-
chromium, total	13	12.6	56.5	n/a	13.9	390	10000	-	-
cobalt	7.3	7.6	9.1	n/a	6.6	4700	120000	-	-
copper	10.4	16.3	22.9	n/a	25.1	3100	82000	700	37000
iron	13900	13700	20800	n/a	13400	23000	610000	-	-
lead	40.1	119	56.4	n/a	51 K	400	-	500	1000
magnesium	1640	1410	2790	n/a	2730	-	-	-	-
manganese	462	491	331	n/a	603	1800	47000	-	-
nickel	6.2	7.5	10.2	n/a	6.6	1600	41000	200	20000
potassium	562	476	1670	n/a	398 U	-	-	-	-
sodium	100 U	101 U	121	n/a	106 U	-	-	-	-
thallium	0.25 U	0.25 U	0.23 UJ	n/a	0.3	6.30	160	6.00	80.0
vanadium	22	22.5	20.8	n/a	23.8	550	14000	-	-
zinc	30.5	42.3	105	n/a	71.9	23000	610000	-	-
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
acenaphthene	550 J	160 J	47 J	n/a	60 J	4700000	120000000	5000000	60000000
acenaphthylene	130 J	110 J	380 UJ	n/a	110 J	-	-	-	-
anthracene	2200 J	350 J	140 J	n/a	380 J	23000000	610000000	23000000	300000000
benzo(a)anthracene	6700 E J	1100 E J	580 J	n/a	1000 E J	880	7800	6000	8000
benzo(a)pyrene	5500 E J	1700 E J	750 E J	n/a	1500 E J	88.0	780	600	800
benzo(b)fluoranthene	5900 E J	3100 E J	1200 E J	n/a	2000 E J	880	7800	6000	8000
benzo(g,h,i)perylene	1500 J	890 J	400 J	n/a	860 J	-	-	-	-

TABLE 4-5

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SS25	05SS26	05SS27	05SS27	05SS28	ARARS & TBCs			
LOCATION:	05SS25	05SS26	05SS27	05SS27	05SS28	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	04/16/97	04/16/97	04/16/97	04/17/97	04/16/97				
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
benzo(k)fluoranthene	5700 J	1600 J	750 J	n/a	1100 J	8800	78000	60000	80000
bis(2-ethylhexyl)phthalate	210 B	180 B	1200 J	n/a	500 B	46000	410000	300000	400000
carbazole	820 J	510 J	160 J	n/a	320 J	32000	290000	-	-
chrysene	7100 J	2300 J	1100 J	n/a	1700 J	88000	780000	600000	800000
di-n-butylphthalate	410 UJ	85 J	380 UJ	n/a	440 UJ	7800000	200000000	-	-
dibenz(a,h)anthracene	710 E J	240 E J	110 E J	n/a	330 E J	88.0	780	600	800
dibenzofuran	340 J	260 J	72 J	n/a	90 J	310000	8200000	-	-
fluoranthene	15000 J	5500 J	2400 J	n/a	3100 J	3100000	82000000	3000000	40000000
fluorene	710 J	310 J	81 J	n/a	100 J	3100000	82000000	3000000	40000000
indeno(1,2,3-cd)pyrene	2300 E J	1200 E J	550 J	n/a	1000 E J	880	7800	6000	8000
naphthalene	410 UJ	52 J	380 UJ	n/a	440 UJ	3100000	82000000	3000000	40000000
phenanthrene	9800 J	4600 J	1800 J	n/a	2000 J	-	-	-	-
pyrene	13000 J	4200 J	1800 J	n/a	3200 J	2300000	61000000	2000000	30000000
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
PCBs (immunoassay)	n/a	n/a	n/a	800 E	n/a	319	2860	5000	-
PCBs (tot. all)	n/a	n/a	n/a	800 E	n/a	319	2860	5000	-

TABLE 4-5

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SS28	05SS29	05SS29	05SS29	05SS29-DUP	ARARS & TBCs			
LOCATION:	05SS28	05SS29	05SS29	05SS29	05SS29	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	04/17/97	04/16/97	04/17/97	04/18/97	04/16/97				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	n/a	8950	n/a	n/a	5500	78000	1000000	-	-
antimony	n/a	9.8 R	n/a	n/a	4.6 U	31.0	820	30.0	400
arsenic	n/a	1.3 E J	n/a	n/a	3.5 E K	0.430	3.80	3.00	4.00
barium	n/a	51.3	n/a	n/a	58.3	5500	140000	5000	70000
beryllium	n/a	0.81 E	n/a	n/a	0.23 E	0.150	1.30	1.00	1.30
calcium	n/a	33800	n/a	n/a	114000	-	-	-	-
chromium, total	n/a	26.9	n/a	n/a	9.8	390	10000	-	-
cobalt	n/a	8.1	n/a	n/a	3.1	4700	120000	-	-
copper	n/a	28.4	n/a	n/a	32.1	3100	82000	700	37000
iron	n/a	21600	n/a	n/a	6230	23000	610000	-	-
lead	n/a	29.6	n/a	n/a	40 K	400	-	500	1000
magnesium	n/a	23000	n/a	n/a	72000	-	-	-	-
manganese	n/a	502	n/a	n/a	117	1800	47000	-	-
nickel	n/a	14.1	n/a	n/a	4.8	1600	41000	200	20000
potassium	n/a	1720	n/a	n/a	416	-	-	-	-
sodium	n/a	274	n/a	n/a	407	-	-	-	-
thallium	n/a	0.39 L	n/a	n/a	0.45 L	6.30	160	6.00	80.0
vanadium	n/a	36.3	n/a	n/a	12.9	550	14000	-	-
zinc	n/a	137	n/a	n/a	55.1	23000	610000	-	-
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
2-methylnaphthalene	n/a	170 J	n/a	n/a	380 UJ	-	-	-	-
acenaphthene	n/a	120 J	n/a	n/a	61 J	4700000	120000000	5000000	60000000
acenaphthylene	n/a	1200 J	n/a	n/a	350 UJ	-	-	-	-
anthracene	n/a	1300 J	n/a	n/a	380 UJ	23000000	610000000	23000000	300000000
benzo(a)anthracene	n/a	9300 E J	n/a	n/a	1800 E J	880	7800	6000	8000
benzo(a)pyrene	n/a	6800 E J	n/a	n/a	2200 E J	88.0	780	600	800
benzo(b)fluoranthene	n/a	8600 E J	n/a	n/a	3000 E J	880	7800	6000	8000
benzo(g,h,i)perylene	n/a	3400 J	n/a	n/a	2000 J	-	-	-	-

TABLE 4-5

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SS28	05SS29	05SS29	05SS29	05SS29-DUP	ARARS & TBCs			
LOCATION:	05SS28	05SS29	05SS29	05SS29	05SS29	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	04/17/97	04/16/97	04/17/97	04/18/97	04/16/97				
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
benzo(k)fluoranthene	n/a	3500 J	n/a	n/a	1100 J	8800	78000	60000	80000
bis(2-ethylhexyl)phthalate	n/a	230 B	n/a	n/a	380 UJ	46000	410000	300000	400000
carbazole	n/a	210 J	n/a	n/a	98 J	32000	290000	-	-
chrysene	n/a	6100 J	n/a	n/a	1600 J	88000	780000	600000	800000
dibenz(a,h)anthracene	n/a	1100 E J	n/a	n/a	470 E J	88.0	780	600	800
dibenzofuran	n/a	71 J	n/a	n/a	380 UJ	310000	8200000	-	-
fluoranthene	n/a	8100 J	n/a	n/a	2600 J	3100000	82000000	3000000	40000000
fluorene	n/a	230 J	n/a	n/a	380 UJ	3100000	82000000	3000000	40000000
indeno(1,2,3-cd)pyrene	n/a	4300 E J	n/a	n/a	2100 E J	880	7800	6000	8000
phenanthrene	n/a	2200 J	n/a	n/a	830 J	-	-	-	-
pyrene	n/a	13000 J	n/a	n/a	3000 J	2300000	61000000	2000000	30000000
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
PCBs (immunoassay)	500 U	n/a	2200 E	n/a	n/a	319	2860	5000	-

TABLE 4-5

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SS30	05SS31	05SS32	---	---	ARARS & TBCs			
LOCATION:	05SS30	05SS31	05SS32	---	---	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil						
SAMPLE DATE:	05/28/97	05/27/97	05/27/97						
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**			**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	8000	n/a	n/a			78000	1000000	-	-
arsenic	1.5 E L	n/a	n/a			0.430	3.80	3.00	4.00
barium	33.1	n/a	n/a			5500	140000	5000	70000
beryllium	0.3 E	n/a	n/a			0.150	1.30	1.00	1.30
calcium	69400	n/a	n/a			-	-	-	-
chromium, total	18	n/a	n/a			390	10000	-	-
cobalt	4.3	n/a	n/a			4700	120000	-	-
copper	23.8	n/a	n/a			3100	82000	700	37000
iron	10600	n/a	n/a			23000	610000	-	-
lead	189	n/a	n/a			400	-	500	1000
magnesium	42700	n/a	n/a			-	-	-	-
manganese	215	n/a	n/a			1800	47000	-	-
nickel	11.2 K	n/a	n/a			1600	41000	200	20000
potassium	554	n/a	n/a			-	-	-	-
sodium	439	n/a	n/a			-	-	-	-
vanadium	15.7	n/a	n/a			550	14000	-	-
zinc	30 L	n/a	n/a			23000	610000	-	-
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**			**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
2-methylnaphthalene	16000 J	n/a	n/a			-	-	-	-
acenaphthene	36000	n/a	n/a			4700000	120000000	5000000	60000000
acenaphthylene	2300	n/a	n/a			-	-	-	-
anthracene	54000	n/a	n/a			23000000	610000000	23000000	300000000
benzo(a)anthracene	48000 E	n/a	n/a			880	7800	6000	8000
benzo(a)pyrene	36000 E	n/a	n/a			88.0	780	600	800
benzo(b)fluoranthene	35000 E J	n/a	n/a			880	7800	6000	8000
benzo(g,h,i)perylene	13000 J	n/a	n/a			-	-	-	-
benzo(k)fluoranthene	29000 E J	n/a	n/a			8800	78000	60000	80000
bis(2-ethylhexyl)phthalate	900 J	n/a	n/a			46000	410000	300000	400000

TABLE 4-5

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SS30	05SS31	05SS32	---	---	ARARS & TBCs			
LOCATION:	05SS30	05SS31	05SS32	---	---	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil						
SAMPLE DATE:	05/28/97	05/27/97	05/27/97						
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**			**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
carbazole	19000 J	n/a	n/a			32000	290000	-	-
chrysene	45000	n/a	n/a			88000	780000	600000	800000
dibenz(a,h)anthracene	4800 E J	n/a	n/a			88.0	780	600	800
dibenzofuran	34000 J	n/a	n/a			310000	8200000	-	-
fluoranthene	140000	n/a	n/a			3100000	82000000	3000000	40000000
fluorene	56000	n/a	n/a			3100000	82000000	3000000	40000000
indeno(1,2,3-cd)pyrene	18000 E J	n/a	n/a			880	7800	6000	8000
naphthalene	22000 J	n/a	n/a			3100000	82000000	3000000	40000000
phenanthrene	200000	n/a	n/a			-	-	-	-
pyrene	120000	n/a	n/a			2300000	61000000	2000000	30000000
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**			**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
PCBs (immunoassay)	6400 E	3900 E	2300 E			319	2860	5000	-
PCBs (tot. all)	6400 E	38 U	2300 E			319	2860	5000	-

Footnotes to sample results:

U - Compound or element was not detected. Value is the detection limit (inorganics) or quantitation limit (organics).

UJ - Not detected. Detection limit or quantitation limit shown is considered estimated due to exceedance of data validation quality control criteria.

UL - Not detected. Detection limit or quantitation limit shown is considered biased low due to exceedance of data validation quality control criteria.

No Value - Constituent was not analyzed for in this sample.

UR - Nondetected result is considered rejected based on exceedance of data validation quality control criteria.

J - Value is estimated because concentration is below the quantitation limit or because of exceedance of data validation quality control criteria.

L - Value is considered biased low because of exceedance of data validation quality control criteria.

K - Value is considered biased high because of exceedance of data validation quality control criteria.

R - Positive result is considered rejected based on exceedance of data validation quality control criteria.

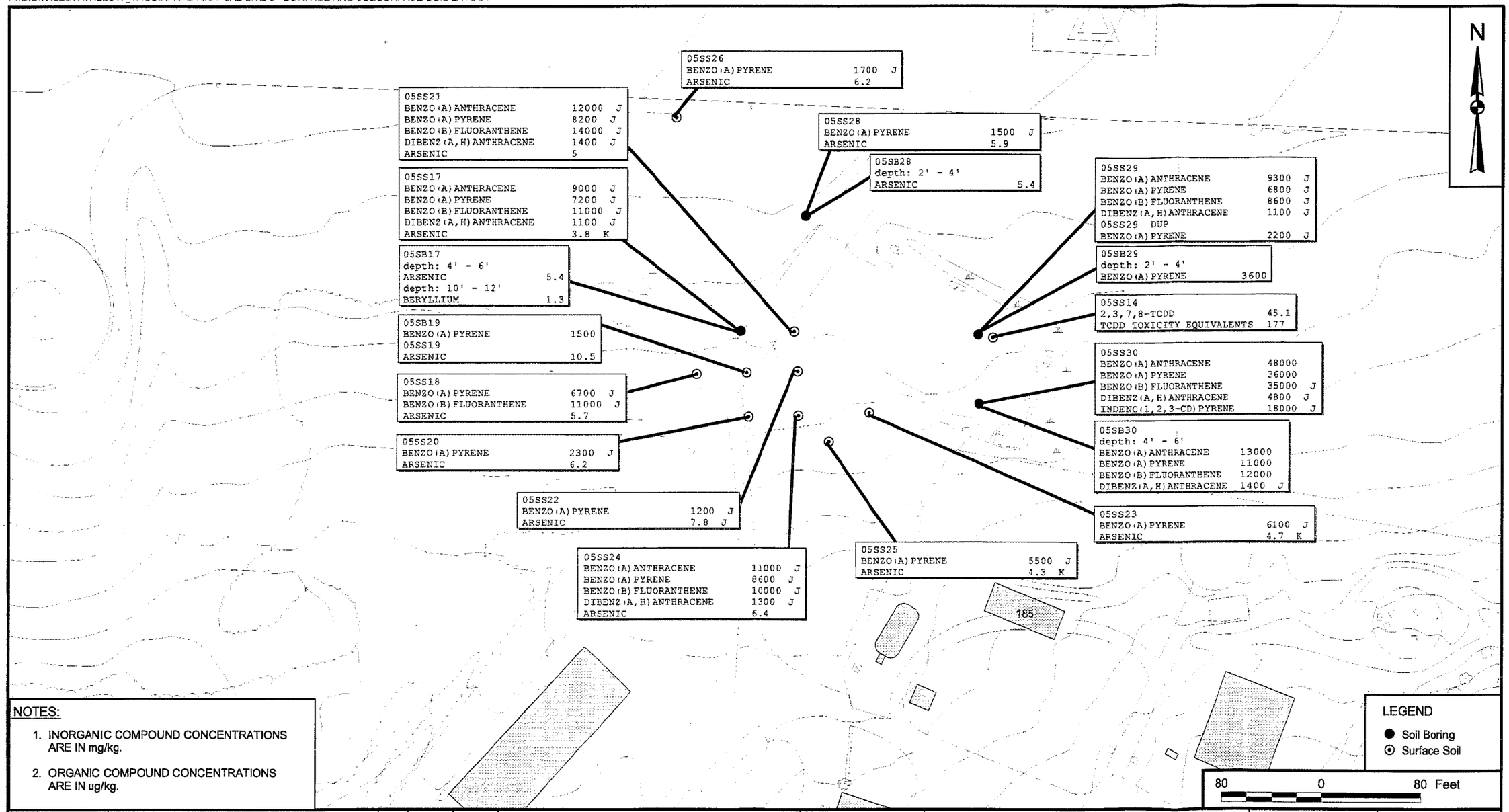
E - Result exceeds one or more of the selected ARARs.

Footnotes to PADEP Criteria:

- - No standard is available for this chemical in this classification.

MSC - Medium-Specific Concentration.

P:\GIS\WILLOW\WILLOW_TAGS.APR 8/14/01 JAL SITE 5 - SURFACE AND SUBSURFACE SOIL LAYOUT



NOTES:

1. INORGANIC COMPOUND CONCENTRATIONS ARE IN mg/kg.
2. ORGANIC COMPOUND CONCENTRATIONS ARE IN ug/kg.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES
1	8/7/01	NOTE ADDED, FIGURE NUMBER & COMPANY NAME REVISED.	LDL			

DRAWN BY S. TABLER DATE 3/25/98
CHECKED BY DATE
COST/SCHEDULE-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

CONCENTRATION ABOVE SCREENING LEVELS
HUMAN HEALTH RISK CRITERIA
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NUMBER 5466
OWNER NUMBER 2207
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4-9A
REV 1

4.5.1.1 Inorganics

Arsenic and beryllium were detected above reference criteria but within background ranges in the samples analyzed for inorganic parameters. Lead was the only metal detected above background and reference criteria (05SS21, 412 mg/kg). Other metals detected at levels above background but below regulatory levels include chromium, cobalt, copper, iron, nickel, and zinc.

4.5.1.2 Organics

PAHs exceeded background levels and reference criteria at the majority of surface soil locations. The location with the highest levels of PAHs was 05SS30.

PCB immunoassay results exceeded reference criteria at seven locations; however, the analytical technique used is considered a field screening method that provides an approximation of detected concentrations.

Low levels of dibenzodioxin and dibenzofuran compounds were detected in Site 5 surface soil samples. No background samples were analyzed for these compounds. The three samples exceeded the most stringent reference criteria for total TCDD equivalents; however, the levels were below the PADEP non-residential soil direct contact standard at two locations and slightly above it for one location.

4.5.2 Subsurface Soil

During the 1991 Phase I RI, 58 samples were obtained from 12 subsurface locations (05SB05 through 05SB16). Four to five samples at various depths were obtained from each boring, with total depths reaching up to 18 feet. Samples were analyzed for VOCs only.

During Phase II RI activities, 16 samples were collected from various depths at 14 locations (05SB17 through 05SB30). Sample analyses were for TAL inorganics, TCL VOCs, and TCL SVOCs. Three samples were also analyzed using PCB immunoassay field screening methodology.

Figure 4-1 presents sampling locations. Table 4-6 presents the occurrence and distribution of inorganic and organic chemicals detected in site-related subsurface soil samples and compares them to background. Table 4-7 presents results from the background comparison tests. Table 4-8 presents a comparison of detected compounds to ARARS and TBCs. Figure 4-9A shows sample locations and concentrations of compounds that exceed ARARS and TBCs.

Table 4-6
Occurrence and Distribution of Organics and Inorganics in Subsurface Soils, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Background Data					Site-Related Data				
	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Representative Concentration
aluminum	12/12	9090	15000	11400	04/07/97 BGSS06	9/9	8420	12200	10500	05SB27-0810 04/18/97	11400
arsenic	12/12	3.7	10.6	6.61	04/07/97 BGSS03	9/9	1.1	5.4	2.7	05SB17-0406 04/17/97	4.73
barium	12/12	77.8	111	96	04/07/97 BGSS04	9/9	39.9	280	134	05SB26-0406 04/18/97	264
beryllium	12/12	0.75	1.3	0.988	04/07/97 BGSS11	9/9	0.47	1.3	0.901	05SB17-1012 04/17/97	1.08
calcium	12/12	614	1600	1020	04/07/97 BGSS12	9/9	416	8340	1880	05SB30-0406 05/28/97	5920
chromium	12/12	12.4	20.8	15.4	04/07/97 BGSS02	9/9	6.1	23.7	15.3	05SB17-0406 04/17/97	18.8
cobalt	12/12	6.8	9.3	7.9	04/07/97 BGSS02	9/9	5.9	14.9	9.88	05SB17-1012 04/17/97	11.6
copper	12/12	8	13.4	10.7	04/07/97 BGSS09	8/9	7.1	25.1	12.4	05SB29-0204 04/17/97	16.6
iron	12/12	12800	17600	14900	04/07/97 BGSS06	9/9	11100	27900	19000	05SB18-0406 04/17/97	23600
lead	12/12	16.3	64.7	31	04/07/97 BGSS04	9/9	5.4	64.8	16.2	05SB30-0406 05/28/97	34.4
magnesium	12/12	1300	1940	1510	04/07/97 BGSS06	9/9	533	5360	2690	05SB30-0406 05/28/97	3640
manganese	12/12	429	1190	641	04/07/97 BGSS04	9/9	134	1550	512	05SB26-0406 04/18/97	1100
nickel	12/12	7.4	11.2	9.78	04/07/97 BGSS04	9/9	6.7	17.4	11.9	05SB27-0810 04/18/97	14.3
potassium	7/12	436	771	434	04/07/97 BGSS05	7/9	418	3130	1080	05SB17-1012 04/17/97	3130
sodium	2/12	112	120	63.9	04/07/97 BGSS09	9/9	101	341	150	05SB17-1012 04/17/97	199
thallium	7/12	0.25	0.34	0.226	04/07/97 BGSS07	3/9	0.24	0.27	0.163	05SB28-0204 04/18/97	0.218
vanadium	12/12	20.9	28.2	25	04/07/97 BGSS02	9/9	12.4	36.8	23.5	05SB17-0406 04/17/97	32.2
zinc	12/12	21.7	597	90.5	04/07/97 BGSS04	9/9	12.4	57.4	30.4	05SB27-0810 04/18/97	46.7
2-methylnaphthalene	0/12	-			NA	7/14	120	5500	975	05SB21-0204 04/17/97	2520
acenaphthene	3/12	55	64	178	04/07/97 BGSS10	2/14	1400	5700	691	05SB30-0406 05/28/97	1090
acenaphthylene	3/12	54	62	178	04/07/97 BGSS12	2/14	160	890	259	05SB30-0406 05/28/97	321
anthracene	6/12	46	160	155	04/07/97 BGSS12	3/14	36	11000	1170	05SB30-0406 05/28/97	2860
benz(a)anthracene	9/12	33	940	307	04/07/97 BGSS12	4/14	55	13000	1380	05SB30-0406 05/28/97	3400
benzo(a)pyrene	8/12	110	1100	395	04/07/97 BGSS12	4/14	45	11000	1200	05SB30-0406 05/28/97	2860
benzo(b)fluoranthene	8/12	160	1500	508	04/07/97 BGSS12	4/14	64	12000	1310	05SB30-0406 05/28/97	2930
benzo(g,h,i)perylene	7/12	52	490	225	04/07/97 BGSS12	3/14	250	4400	603	05SB30-0406 05/28/97	953
benzo(k)fluoranthene	7/12	98	920	371	04/07/97 BGSS12	2/14	2000	6900	820	05SB30-0406 05/28/97	1380

Table 4-6
Occurrence and Distribution of Organics and Inorganics in Subsurface Soils, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Background Data					Site-Related Data					
	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Representative Concentration
bis(2-ethylhexyl)phthalate	0/0	-				6/6	160	790	340	05SB30-0406 05/28/97	688
carbazole	5/12	80	310	213	04/07/97 BGSS10	2/14	1600	5300	677	05SB30-0406 05/28/97	1090
chrysene	9/12	43	1200	420	04/07/97 BGSS12	5/14	41	12000	1310	05SB30-0406 05/28/97	3620
dibenz(a,h)anthracene	5/12	52	160	162	04/07/97 BGSS12	2/14	510	1400	320	05SB30-0406 05/28/97	426
dibenzofuran	4/12	51	120	173	04/07/97 BGSS08	4/14	120	5200	646	05SB30-0406 05/28/97	1070
fluoranthene	10/12	49	2600	903	04/07/97 BGSS12	5/14	84	34000	3310	05SB30-0406 05/28/97	10700
fluorene	4/12	59	160	185	04/07/97 BGSS08	4/14	93	10000	1030	05SB30-0406 05/28/97	1950
indeno(1,2,3-cd)pyrene	8/12	49	640	252	04/07/97 BGSS12	3/14	170	5700	726	05SB30-0406 05/28/97	1220
N-nitrosodiphenylamine (1)	0/12	-			NA	1/14	75	75	204	05SB30-0406 05/28/97	75
naphthalene	0/12	-			NA	6/14	99	2300	580	05SB21-0204 04/17/97	1220
phenanthrene	8/12	110	1700	668	04/07/97 BGSS12	5/14	46	43000	4090	05SB30-0406 05/28/97	16700
pyrene	10/12	51	2100	723	04/07/97 BGSS12	5/14	76	30000	2890	05SB30-0406 05/28/97	8690
1,1,1-trichloroethane	0/0	-				1/56	140	140	19.4	05SB22-0406 04/16/97	9.01
1,1,2-trichloroethane	0/0	-				2/61	5	15	16.2	05SB22-0406 04/16/97	6.53
1,1-dichloroethane	0/0	-				3/61	8	160	18.7	05SB22-0406 04/16/97	9.92
1,1-dichloroethene	0/0	-				1/59	5	5	16.5	05SB22-0406 04/16/97	5
2-butanone	0/0	-				3/61	9	54	19.8	05SB22-0406 04/16/97	11.3
2-hexanone	0/0	-				1/61	1	1	18.7	05SB05-0608 09/05/91	1
4-methyl-2-pentanone	0/0	-				1/61	2	2	18.8	05SB13-0204 09/04/91	2
acetone	0/0	-				6/24	14	140	49.7	05SB22-0406 04/16/97	62.8
benzene	0/0	-				5/61	1	20	16.5	05SB17-1012 04/17/97	6.83
carbon disulfide	0/0	-				1/61	2	2	16	05SB15-0406 09/04/91	2
chloroform	0/0	-				1/61	8	8	16.1	05SB22-1416 04/16/97	6.4
chloromethane	0/0	-				2/61	3	6	18.8	05SB13-1214 09/04/91	6
ethylbenzene	0/0	-				5/61	5	3400	65.4	05SB21-0204 04/17/97	3400
methylene chloride	0/0	-				1/35	10	10	25.4	05SB30-0406 05/28/97	10
tetrachloroethene	0/0	-				1/61	10	10	16.1	05SB22-0406 04/16/97	6.45

Table 4-6
Occurrence and Distribution of Organics and Inorganics in Subsurface Soils, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Background Data					Site-Related Data					
	Freq. of Detection	Range of Positive Detection		Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection		Mean of All Data	Sampling Round and Location of Maximum	Representative Concentration
		Min.	Max.				Min.	Max.			
toluene	0/0	-				3/61	2	14	16.1	05SB22-0406 04/16/97	6.48
trichloroethene	0/0	-				2/61	2	8	16	05SB17-1012 04/17/97	6.3
xylene (total)	0/0	-				5/61	22	16000	294	05SB21-0204 04/17/97	28.9

Notes:

Units are mg/kg for inorganics, ug/kg for organics.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result.
Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.
The determination of representative concentrations is based on comparison of maximum to the 95 % UCL, which is presented in a separate table.
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.
Number of samples may vary based on the number of usable results.

TABLE 4-7

Background Comparison Tests - Subsurface Soil Data for Site 5

NASJRB Willow Grove, Pennsylvania

Name of Test:	Detection Freq: Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:	Site Freq. > Back Freq.?				Site Maximum > UTL for Background Data ?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation =Background Std.Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back. Freq.	Site Freq.	P Value	YN	Back. Mean@	Std.Dev. Back.@	t Value	L,N Q	Back. UTL	Site Max.	YN	r	k	P Value	YN	P Value	Test	Used	YN	Back. Mean@	Site Mean@	t Value	t Table	YN	Back. Distrib.	Site Distrib.	Std.Dev. Back.@	Std.Dev. Site@	F Value	F Table	YN
Substance																															
aluminum	N	12/12	9/9		NA	9.33	0.142	1.7959	L	14700	12200	N	10	4	0.7551	N	0.9062			N	11400	10500			NA	lognor.	normal					NA
arsenic	N	12/12	9/9		NA	1.85	0.283	1.7959	L	10.8	5.4	N	12	2	0.9996	N	0.9998			N	1.85	0.817	-4.6476	1.8125	N	lognor.	lognor.	0.283	0.622	5.3709	3.8495	N
barium	Y	12/12	9/9		NA	4.56	0.129	1.7959	L	121	280	Y	5	5	0.0062	Y	0.3478			N	4.56	4.7	0.6181	1.8595	N	lognor.	lognor.	0.129	0.691	20.611	3.8495	N
beryllium	N	12/12	9/9		NA	-0.0287	0.192	1.7959	L	1.39	1.3	N	8	4	0.4721	N	0.7941			N	0.988	0.901			NA	lognor.	normal					NA
calcium	Y	12/12	9/9		NA	6.88	0.329	1.7959	L	1790	8340	Y	2	2	0.1714	N	0.7931			N	6.88	6.98	0.2945	1.8331	N	lognor.	lognor.	0.329	1.02	10.549	3.8495	N
chromium	Y	12/12	9/9		NA	2.73	0.142	1.7959	L	20	23.7	Y	6	4	0.1827	N	0.5142			N	15.4	15.3			NA	lognor.	normal					NA
cobalt	Y	12/12	9/9		NA	7.9	0.786	1.7959	N	9.37	14.9	Y	6	6	0.0015	Y	0.0509			N	7.9	9.88			NA	normal	normal					NA
copper	Y	12/12	8/9	1.0000	N	10.7	1.55	1.7959	N	13.6	25.1	Y	3	3	0.0632	N	0.2610			N	10.7	12.4			NA	normal	normal					NA
iron	Y	12/12	9/9		NA	9.6	0.111	1.7959	L	18200	27900	Y	5	5	0.0062	Y	0.0295			Y	9.6	9.81	2.0092	1.8331	Y	lognor.	lognor.	0.111	0.298	8.2036	3.8495	N
lead	Y	12/12	9/9		NA	3.34	0.433	1.7959	L	63.3	64.8	Y	1	1	0.4286	N	0.9962			N	31	16.2			NA	lognor.	nonpar.					NA
magnesium	Y	12/12	9/9		NA	7.31	0.102	1.7959	L	1820	5360	Y	6	6	0.0015	Y	0.0214			Y	7.31	7.71	1.6777	1.8595	N	lognor.	lognor.	0.102	0.708	25.883	3.8495	N
manganese	Y	12/12	9/9		NA	6.42	0.277	1.7959	L	1040	1550	Y	1	1	0.4286	N	0.9593			N	6.42	5.97	-1.7050	1.8331	N	lognor.	lognor.	0.277	0.763	8.5907	3.8495	N
nickel	Y	12/12	9/9		NA	9.78	0.961	1.7959	N	11.6	17.4	Y	5	5	0.0062	Y	0.2383			N	9.78	11.9			NA	normal	normal					NA
potassium	N	7/12	7/9	0.3235	N	434					3130	NA	3	3	0.0632	N	0.1332	Gehan	Test	N	434	1080			NA	normal	lognor.					NA
sodium	Y	2/12	9/9	0.0002	Y	63.9					341	NA	5	5	0.0062	Y	0.0039	Gehan	Test	Y	63.9	150			NA	nonpar.	nonpar.					NA
thallium	N	7/12	3/9	0.9437	N	0.226					0.27	NA	3		1.0000	N	0.9978	Gehan	Test	N	0.226	0.163			NA	nonpar.	nonpar.					NA
vanadium	Y	12/12	9/9		NA	25	2.1	1.7959	N	29	36.8	Y	3	3	0.0632	N	0.7272			N	3.22	3.09	-0.9506	1.8595	N	lognor.	lognor.	0.0852	0.401	18.117	3.8495	N
zinc	N	12/12	9/9		NA	90.5					57.4	NA	2	1	0.6857	N	0.9820			N	90.5	30.4			NA	nonpar.	lognor.					NA
2-methylnaphthalene	Y	0/12	7/14	0.0052	Y						5500	NA	6	6	0.0130	Y				NA		975			NA							NA
acenaphthene	N	3/12	2/14	0.8826	N	178					5700	NA	2	2	0.2800	N	0.1011	Gehan	Test	N	178	691			NA	nonpar.	nonpar.					NA
acenaphthylene	N	3/12	2/14	0.8826	N	178					890	NA	1	1	0.5385	N	0.2381	Gehan	Test	N	178	259			NA	nonpar.	nonpar.					NA
anthracene	N	6/12	3/14	0.9746	N	155					11000	NA	2	2	0.2800	N	0.3219	Gehan	Test	N	155	1170			NA	normal	nonpar.					NA
benz(a)anthracene	N	9/12	4/14	0.9976	N	307					13000	NA	2	2	0.2800	N	0.9335	Gehan	Test	N	307	1380			NA	lognor.	nonpar.					NA
benzo(a)pyrene	N	8/12	4/14	0.9911	N	395					11000	NA	2	2	0.2800	N	0.9405	Gehan	Test	N	395	1200			NA	lognor.	nonpar.					NA
benzo(b)fluoranthene	N	8/12	4/14	0.9911	N	508					12000	NA	2	2	0.2800	N	0.9686	Gehan	Test	N	508	1310			NA	lognor.	nonpar.					NA
benzo(g,h,i)perylene	N	7/12	3/14	0.9909	N	225					4400	NA	2	2	0.2800	N	0.7932	Gehan	Test	N	225	603			NA	normal	nonpar.					NA
benzo(k)fluoranthene	N	7/12	2/14	0.9977	N	371					6900	NA	2	2	0.2800	N	0.9384	Gehan	Test	N	371	820			NA	lognor.	nonpar.					NA
bis(2-ethylhexyl)phthalate	NA	0/0	6/6		NA						790	NA				NA				NA		340			NA							NA
carbazole	N	5/12	2/14	0.9791	N	213					5300	NA	2	2	0.2800	N	0.8075	Gehan	Test	N	213	677			NA	normal	nonpar.					NA
chrysene	N	9/12	5/14	0.9927	N	420					12000	NA	2	2	0.2800	N	0.9100	Gehan	Test	N	420	1310			NA	lognor.	nonpar.					NA
dibenz(a,h)anthracene	N	5/12	2/14	0.9791	N	162					1400	NA	2	2	0.2800	N	0.2876	Gehan	Test	N	162	320			NA	nonpar.	nonpar.					NA
dibenzofuran	N	4/12	4/14	0.7542	N	173					5200	NA	2	2	0.2800	N	0.0629	Gehan	Test	N	173	646			NA	nonpar.	nonpar.					NA
fluoranthene	N	10/12	5/14	0.9984	N	903					34000	NA	2	2	0.2800	N	0.9505	Gehan	Test	N	903	3310			NA	lognor.	nonpar.					NA

TABLE 4-7
Background Comparison Tests - Subsurface Soil Data for Site 5
NASJRB Willow Grove, Pennsylvania

Name of Test:	Detection Freq, Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:	Site Freq. > Back.Freq.?				Site Maximum > UTL for Background Data ?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation =Background Std.Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back.	Site	P	YN	Back.	Std.Dev.	t	L,N	Back.	Site	YN	r	k	P	YN	P	Test	Used	YN	Back.	Site	t	t	YN	Back.	Site	Std.Dev.	Std.Dev.	F	F	YN
Substance	Freq.	Freq.	Value		Mean@	Back.@	Value	Q	UTL	Max.				Value		Value				Mean@	Mean@	Value	Table		Distrib.	Distrib.	Back.@	Site@	Value	Table	
fluorene	N	4/12	4/14	0.7542	N	185					10000	NA	2	2	0.2800	N	0.5163	Gehan	Test	N	185	1030			NA	nonpar.	nonpar.					NA
indeno(1,2,3-cd)pyrene	N	8/12	3/14	0.9973	N	252					5700	NA	2	2	0.2800	N	0.8954	Gehan	Test	N	252	726			NA	lognor.	nonpar.					NA
N-nitrosodiphenylamine (1)	N	0/12	1/14	0.5385	N						75	NA				NA				NA		204			NA							NA
naphthalene	N	0/12	6/14	0.0130	Y						2300	NA	4	4	0.0670	N				NA		580			NA							NA
phenanthrene	N	8/12	5/14	0.9764	N	668					43000	NA	2	2	0.2800	N	0.8737	Gehan	Test	N	668	4090			NA	lognor.	nonpar.					NA
pyrene	N	10/12	5/14	0.9984	N	723					30000	NA	2	2	0.2800	N	0.9538	Gehan	Test	N	723	2890			NA	lognor.	nonpar.					NA
1,1,1-trichloroethane	NA	0/0	1/56		NA						140	NA				NA				NA		19.4			NA							NA
1,1,2-trichloroethane	NA	0/0	2/61		NA						15	NA				NA				NA		16.2			NA							NA
1,1-dichloroethane	NA	0/0	3/61		NA						160	NA				NA				NA		18.7			NA							NA
1,1-dichloroethene	NA	0/0	1/59		NA						5	NA				NA				NA		16.5			NA							NA
2-butanone	NA	0/0	3/61		NA						54	NA				NA				NA		19.8			NA							NA
2-hexanone	NA	0/0	1/61		NA						1	NA				NA				NA		18.7			NA							NA
4-methyl-2-pentanone	NA	0/0	1/61		NA						2	NA				NA				NA		18.8			NA							NA
acetone	NA	0/0	6/24		NA						140	NA				NA				NA		49.7			NA							NA
benzene	NA	0/0	5/61		NA						20	NA				NA				NA		16.5			NA							NA
carbon disulfide	NA	0/0	1/61		NA						2	NA				NA				NA		16			NA							NA
chloroform	NA	0/0	1/61		NA						8	NA				NA				NA		16.1			NA							NA
chloromethane	NA	0/0	2/61		NA						6	NA				NA				NA		18.8			NA							NA
ethylbenzene	NA	0/0	5/61		NA						3400	NA				NA				NA		65.4			NA							NA
methylene chloride	NA	0/0	1/35		NA						10	NA				NA				NA		25.4			NA							NA
tetrachloroethene	NA	0/0	1/61		NA						10	NA				NA				NA		16.1			NA							NA
toluene	NA	0/0	3/61		NA						14	NA				NA				NA		16.1			NA							NA
trichloroethene	NA	0/0	2/61		NA						8	NA				NA				NA		16			NA							NA
xylene (total)	NA	0/0	5/61		NA						16000	NA				NA				NA		294			NA							NA

Notes: Units are mg/kg for inorganics, ug/kg for organics.

A statistical significance level (P value) of 0.05 is used for all tests that directly compare site to background. A two-sided significance level of 0.1 is used for Bartlett's test for equal variance.

UTL is the expected value for the upper 95 % quantile of the background population; there is an equal chance of the population's true 95 % quantile being either below or above this estimate.

For each test, a YES or NO decision is presented only if all assumptions are met. The overall decision (is site > background) for each chemical appears at the left and is based on four criteria:

(1) Overall decision is YES if any one of the UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is YES, regardless of other test results.

(2) Overall decision is NO if at least one of UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is NO, and none of the aforementioned tests are YES.

(3) Overall decision is YES/NO if Z/Fisher Test is YES/NO, respectively, and other tests are NA. Z-test is treated as lowest priority since it relies on detection frequency, not magnitude of results.

(4) Overall decision is NA if all tests are NA. (Chemicals assigned NA are still included in human health risk-based screening and/or risk assessment.)

TABLE 4-7
Background Comparison Tests - Subsurface Soil Data for Site 5
NASJRB Willow Grove, Pennsylvania

Name of Test:	Detection Freq: Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:	Site Freq. > Back.Freq.?				Site Maximum > UTL for Background Data ?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation =Background Std.Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back.	Site	P	YN	Back.	Std.Dev.	t	L,N	Back.	Site	YN	r	k	P	YN	P	Test	Used	YN	Back.	Site	t	t	YN	Back.	Site	Std.Dev.	Std.Dev.	F	F	YN
Substance	Freq.	Freq.	Value		Mean@	Back.@	Value	Q	UTL	Max.				Value		Value				Mean@	Mean@	Value	Table		Distrib.	Distrib.	Back.@	Site@	Value	Table	

Abbreviations:

# NDs or # Pos.	Number of non-detected (ND) or positive (Pos.) results in data set, not including rejected data or blank-qualified data.
# s or # b	Number of site (s) or background (b) samples, not including rejected data or blank-qualified data.
s = b	Standard deviation of site results must not be different from the standard deviation of background results.
P value	Probability or significance level is defined as the chance of a false positive. If P <= 0.05 then test determines site > background with 95 % confidence.
L, N, or Q	UTL is based on 95 % upper limit (using t-value) when data are lognormal (L) or normal (N). Otherwise, an upper 95 % quantile (Q) is used if there are > 18 back. points.
% ND	Mann-Whitney test used if < 40% of data Non-Detected and detect. limits uniformly below the range of positive values. If not, the Gehan Test is used.
@	Mean and standard deviations are shown of log-transformed data when distributions are of this type; ie., if an (L) code appears for the UTL test or if site and background distributions both match lognormal, and both T-test and Bartlett's test are applicable. (Arithmetic mean and normal standard deviation are shown only for illustration in the event that these tests are NA.)
r,k	The upper ranks test calculates the probability that k or more samples from the top r ranks of the combined site and background data set are comprised of site data if both populations are in fact equal.

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB05-0002		05SB05-0204		05SB05-0406		05SB05-0406-DU		05SB05-0608		ARARS & TBCs			
LOCATION:	05SB05		05SB05		05SB05		05SB05		05SB05		Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil					
SAMPLE DATE:	09/05/91		09/05/91		09/05/91		09/05/91		09/05/91					
VOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
2-hexanone	11	U	12	U	12	U	12	U	1	J	-	-	-	-
acetone	5	B	6	B	5	B	9	B	6	B	7800000	200000000	8000000	100000000
methylene chloride	2	B	6	U	6	U	6	U	4	B	85000	760000	600000	800000

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB05-1012		05SB06-0002		05SB06-0204		05SB06-0406		05SB06-0608		ARARS & TBCs			
LOCATION:	05SB05		05SB06		05SB06		05SB06		05SB06		Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil					
SAMPLE DATE:	09/05/91		09/05/91		09/05/91		09/05/91		09/05/91					
VOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,1,1-trichloroethane	1	B	5	U	6	U	6	U	5	U	2700000	72000000	7000000	90000000
acetone	4	B	8	B	6	B	5	B	4	B	7800000	200000000	8000000	100000000
chloromethane	11	U	11	U	11	U	3	J	11	U	49000	440000	-	-

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB06-1012		05SB07-0002		05SB07-0204		05SB07-0406		05SB07-0608		ARARS & TBCs			
LOCATION:	05SB06		05SB07		05SB07		05SB07		05SB07		Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil					
SAMPLE DATE:	09/05/91		09/05/91		09/05/91		09/05/91		09/05/91					
VOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
acetone	5	B	3	B	3	B	4	B	11	U	7800000	200000000	8000000	100000000
methylene chloride	5	UJ	2	B	3	B	6	U	2	B	85000	760000	600000	800000

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB07-0608-DU		05SB07-1011		05SB08-0002		05SB08-0406		05SB08-0608		ARARS & TBCs			
LOCATION:	05SB07		05SB07		05SB08		05SB08		05SB08		Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil					
SAMPLE DATE:	09/05/91		09/05/91		09/05/91		09/05/91		09/05/91					
VOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
acetone	5	B	3	B	6	B	6	B	12	U	7800000	200000000	8000000	100000000
methylene chloride	3	B	3	B	6	U	2	B	3	B	85000	760000	600000	800000

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB08-1012		05SB08-1416		05SB09-0002		05SB09-0204		05SB09-0608		ARARS & TBCs			
LOCATION:	05SB08		05SB08		05SB09		05SB09		05SB09		Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil					
SAMPLE DATE:	09/05/91		09/04/91		09/04/91		09/04/91		09/04/91					
VOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
acetone	12	B	11	U	3	B	11	B	8	B	7800000	200000000	8000000	100000000
methylene chloride	2	B	2	B	2	B	5	B	6	U	85000	760000	600000	800000

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB09-1012	05SB09-1618	05SB10-0204	05SB10-0204-DU	05SB10-0406	ARARS & TBCs			
LOCATION:	05SB09	05SB09	05SB10	05SB10	05SB10	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	09/04/91	09/04/91	09/05/91	09/05/91	09/05/91				
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
acetone	12 U	5 B	17 B	4 B	200 B	7800000	200000000	8000000	100000000

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB10-0810		05SB10-1012		05SB10-1618		05SB11-0002		05SB11-0406		ARARS & TBCs			
LOCATION:	05SB10		05SB10		05SB10		05SB11		05SB11		Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil					
SAMPLE DATE:	09/05/91		09/05/91		09/05/91		09/04/91		09/04/91					
VOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,1,1-trichloroethane	7	B	6	U	6	U	6	U	6	U	2700000	72000000	7000000	90000000
acetone	690	B	250	B	11	U	11	U	5	B	7800000	200000000	8000000	100000000

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB11-0406-DU	05SB11-0608	05SB11-1012	05SB11-1416	05SB12-0002	ARARS & TBCs			
LOCATION:	05SB11	05SB11	05SB11	05SB11	05SB12	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	09/04/91	09/04/91	09/04/91	09/04/91	09/05/91				
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
acetone	6 B	5 B	5 B	11 U	11 U	7800000	200000000	8000000	100000000

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB12-0406		05SB12-0810		05SB12-1214		05SB12-1618		05SB13-0204		ARARS & TBCs			
LOCATION:	05SB12		05SB12		05SB12		05SB12		05SB13		Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil					
SAMPLE DATE:	09/05/91		09/05/91		09/05/91		09/05/91		09/04/91					
VOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,1-dichloroethene	6	U	6	U	6	U	6	U	2	B	1100	9500	700000	9000000
4-methyl-2-pentanone	13	U	12	U	12	U	12	U	2	J	6300000	160000000	6000000	80000000
acetone	3	B	12	U	4	B	5	B	11	U	7800000	200000000	8000000	100000000
methylene chloride	3	B	6	U	6	U	3	B	9	B	85000	760000	600000	800000
toluene	6	U	6	U	6	U	6	U	5	J	16000000	410000000	16000000	200000000

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB13-0204-DU		05SB13-0608		05SB13-1012		05SB13-1214		05SB14-0406		ARARS & TBCs			
LOCATION:	05SB13		05SB13		05SB13		05SB13		05SB14		Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil					
SAMPLE DATE:	09/04/91		09/04/91		09/04/91		09/04/91		09/04/91					
VOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,1,1-trichloroethane	6	U	6	U	6	U	1	B	6	U	2700000	72000000	7000000	90000000
1,1-dichloroethene	6	U	2	B	6	U	6	U	6	U	1100	9500	700000	9000000
acetone	15	B	12	U	11	U	12	B	20	B	7800000	200000000	8000000	100000000
chloromethane	12	U	12	U	11	U	6	J	12	U	49000	440000	-	-
methylene chloride	6	U	6	U	4	B	3	B	6	U	85000	760000	600000	800000

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB14-0608		05SB14-0810		05SB14-1012		05SB14-1209		05SB14-1209-DU		ARARS & TBCs			
LOCATION:	05SB14		05SB14		05SB14		05SB14		05SB14		Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil					
SAMPLE DATE:	09/04/91		09/04/91		09/04/91		09/04/91		09/04/91					
VOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,1,1-trichloroethane	1	B	6	U	6	U	1	B	6	U	2700000	72000000	7000000	90000000
2-butanone	12	U	9	J	11	U	12	U	11	U	47000000	1000000000	40000000	600000000
acetone	8	B	52	B	5	B	12	U	7	B	7800000	200000000	8000000	100000000
methylene chloride	4	B	3	B	2	B	3	B	2	B	85000	760000	600000	800000

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB15-0002		05SB15-0406		05SB15-0406-DU		05SB15-0810		05SB15-1214		ARARS & TBCs			
LOCATION:	05SB15		05SB15		05SB15		05SB15		05SB15		Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil					
SAMPLE DATE:	09/04/91		09/04/91		09/04/91		09/04/91		09/04/91					
VOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,1-dichloroethene	1	B	6	U	6	U	6	U	7	U	1100	9500	700000	9000000
acetone	10	U	52	B	49	B	6	B	13	U	7800000	200000000	8000000	100000000
benzene	5	U	1	J	6	U	6	U	7	U	22000	200000	100000	200000
carbon disulfide	5	U	2	J	1	J	6	U	7	U	7800000	200000000	7000000	100000000
methylene chloride	2	B	5	B	4	B	1	B	7	U	85000	760000	600000	800000
toluene	1	J	6	U	6	U	6	U	7	U	16000000	410000000	16000000	200000000

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB15-1618	05SB16-0406	05SB16-0608	05SB16-1012	05SB16-1214	ARARS & TBCs			
LOCATION:	05SB15	05SB16	05SB16	05SB16	05SB16	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	09/04/91	09/04/91	09/04/91	09/04/91	09/04/91				
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
acetone	6 B	93 B	11 U	11 U	8 B	7800000	200000000	8000000	100000000

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB16-1416	05SB17-0406	05SB17-0406	05SB17-1012	05SB18-0406	ARARS & TBCs			
LOCATION:	05SB16	05SB17	05SB17	05SB17	05SB18	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	09/04/91	04/17/97	04/18/97	04/17/97	04/17/97				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	n/a	11400	n/a	10500	12000	78000	1000000	-	-
antimony	n/a	8.1 R	n/a	6.8 R	9.6 R	31.0	820	30.0	400
arsenic	n/a	5.4 E	n/a	1.3 E K	3.5 E K	0.430	3.80	3.00	4.00
barium	n/a	56.1	n/a	250	73.1	5500	140000	5000	70000
beryllium	n/a	0.71 E	n/a	1.3 E	0.76 E	0.150	1.30	1.00	1.30
calcium	n/a	589	n/a	1360	430	-	-	-	-
chromium, total	n/a	23.7	n/a	14.9	20.3	390	10000	-	-
cobalt	n/a	6.7	n/a	14.9	10.2	4700	120000	-	-
copper	n/a	10	n/a	2.4 U	12.8	3100	82000	700	37000
iron	n/a	26000 E	n/a	19500	27900 E	23000	610000	-	-
lead	n/a	8.5	n/a	12.4	6.1	400	-	500	1000
magnesium	n/a	2090	n/a	3460	2590	-	-	-	-
manganese	n/a	260	n/a	645	266	1800	47000	-	-
nickel	n/a	9.3 K	n/a	15.8 K	12.6 K	1600	41000	200	20000
potassium	n/a	611	n/a	3130	702	-	-	-	-
sodium	n/a	133	n/a	341	131	-	-	-	-
thallium	n/a	0.24 UL	n/a	0.25 L	0.24 L	6.30	160	6.00	80.0
vanadium	n/a	36.8	n/a	15.7	34.8	550	14000	-	-
zinc	n/a	27.8 L	n/a	51.2	35.7	23000	610000	-	-
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
2-methylnaphthalene	n/a	560	n/a	2900	390 U	-	-	-	-
anthracene	n/a	400 U	n/a	36 J	390 U	23000000	610000000	23000000	300000000
benzo(a)anthracene	n/a	400 U	n/a	55 J	390 U	880	7800	6000	8000
benzo(a)pyrene	n/a	400 U	n/a	45 J	390 U	88.0	780	600	800
benzo(b)fluoranthene	n/a	400 U	n/a	64 J	390 U	880	7800	6000	8000
bis(2-ethylhexyl)phthalate	n/a	240 J	n/a	310 J	160 J	46000	410000	300000	400000
chrysene	n/a	41 J	n/a	74 J	390 U	88000	780000	600000	800000
dibenzofuran	n/a	400 U	n/a	120 J	390 U	310000	8200000	-	-

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB16-1416	05SB17-0406	05SB17-0406	05SB17-1012	05SB18-0406	ARARS & TBCs			
LOCATION:	05SB16	05SB17	05SB17	05SB17	05SB18	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	09/04/91	04/17/97	04/18/97	04/17/97	04/17/97				
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
fluoranthene	n/a	84 J	n/a	170 J	390 U	3100000	82000000	3000000	40000000
fluorene	n/a	400 U	n/a	93 J	390 U	3100000	82000000	3000000	40000000
naphthalene	n/a	99 J	n/a	940	390 U	3100000	82000000	3000000	40000000
phenanthrene	n/a	46 J	n/a	170 J	390 U	-	-	-	-
pyrene	n/a	76 J	n/a	140 J	390 U	2300000	61000000	2000000	30000000
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,1-dichloroethane	6 U	12 U	n/a	11 J	12 U	7800000	200000000	7000000	100000000
acetone	15 B	70	n/a	12 U	14 J	7800000	200000000	8000000	100000000
benzene	6 U	15	n/a	20 J	12 U	22000	200000	100000	200000
ethylbenzene	6 U	180	n/a	150 J	12 U	7800000	200000000	7000000	100000000
methylene chloride	1 B	12 U	n/a	12 U	12 U	85000	760000	600000	800000
trichloroethene	6 U	12 U	n/a	8 J	12 U	58000	520000	400000	500000
xylene (total)	6 U	410	n/a	1100	12 U	160000000	1000000000	-	-

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB19-0002	05SB20-0406	05SB21-0204	05SB22-0406	05SB22-0406	ARARS & TBCs			
LOCATION:	05SB19	05SB20	05SB21	05SB22	05SB22	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	04/17/97	04/16/97	04/17/97	04/16/97	04/17/97				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	11200	n/a	8420	n/a	n/a	78000	1000000	-	-
arsenic	1.4 E J	n/a	3 E K	n/a	n/a	0.430	3.80	3.00	4.00
barium	66.6	n/a	62	n/a	n/a	5500	140000	5000	70000
beryllium	0.54 E	n/a	0.56 E	n/a	n/a	0.150	1.30	1.00	1.30
calcium	4080	n/a	649	n/a	n/a	-	-	-	-
chromium, total	8.8	n/a	8.2	n/a	n/a	390	10000	-	-
cobalt	5.2	n/a	8.1	n/a	n/a	4700	120000	-	-
copper	6.5	n/a	11.9	n/a	n/a	3100	82000	700	37000
iron	9320	n/a	11100	n/a	n/a	23000	610000	-	-
lead	7.4	n/a	6.1	n/a	n/a	400	-	500	1000
magnesium	2340	n/a	1210	n/a	n/a	-	-	-	-
manganese	202	n/a	414	n/a	n/a	1800	47000	-	-
nickel	5.2 K	n/a	7.8 K	n/a	n/a	1600	41000	200	20000
potassium	335 U	n/a	418	n/a	n/a	-	-	-	-
sodium	89.3 U	n/a	101	n/a	n/a	-	-	-	-
vanadium	14.3	n/a	15.9	n/a	n/a	550	14000	-	-
zinc	17	n/a	15	n/a	n/a	23000	610000	-	-
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
2-methylnaphthalene	740 U	410 UJ	5500	630 J	n/a	-	-	-	-
anthracene	140 J	410 UJ	770 U	410 UJ	n/a	23000000	610000000	23000000	300000000
benzo(a)anthracene	1000 E	410 UJ	100 J	410 UJ	n/a	880	7800	6000	8000
benzo(a)pyrene	1500 E	410 UJ	130 E J	410 UJ	n/a	88.0	780	600	800
benzo(b)fluoranthene	2700 E	410 UJ	220 J	410 UJ	n/a	880	7800	6000	8000
benzo(g,h,i)perylene	960	410 UJ	250 J	410 UJ	n/a	-	-	-	-
benzo(k)fluoranthene	1200	410 UJ	770 U	410 UJ	n/a	8800	78000	60000	80000
bis(2-ethylhexyl)phthalate	210 J	270 B	340 J	160 B	n/a	46000	410000	300000	400000
chrysene	2200	410 UJ	190 J	410 UJ	n/a	88000	780000	600000	800000
dibenz(a,h)anthracene	250 E J	410 UJ	770 U	410 UJ	n/a	88.0	780	600	800

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB19-0002		05SB20-0406		05SB21-0204		05SB22-0406		05SB22-0406	ARARS & TBCs			
LOCATION:	05SB19		05SB20		05SB21		05SB22		05SB22	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil				
SAMPLE DATE:	04/17/97		04/16/97		04/17/97		04/16/97		04/17/97				
SEMIVOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
dibenzofuran	740	U	410	UJ	130	J	410	UJ	n/a	310000	8200000	-	-
fluoranthene	3300		410	UJ	340	J	410	UJ	n/a	3100000	82000000	3000000	40000000
fluorene	740	U	410	UJ	100	J	410	UJ	n/a	3100000	82000000	3000000	40000000
indeno(1,2,3-cd)pyrene	1200	E	410	UJ	170	J	410	UJ	n/a	880	7800	6000	8000
naphthalene	740	U	410	UJ	2300		130	J	n/a	3100000	82000000	3000000	40000000
phenanthrene	1100		410	UJ	210	J	410	UJ	n/a	-	-	-	-
pyrene	3100		410	UJ	280	J	410	UJ	n/a	2300000	61000000	2000000	30000000
VOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,1,1-trichloroethane	11	U	12	U	1500	U	140		n/a	2700000	72000000	7000000	90000000
1,1,2-trichloroethane	11	U	12	U	1500	U	15		n/a	11000	100000	300000	4000000
1,1-dichloroethane	11	U	12	U	1500	U	160		n/a	7800000	200000000	7000000	100000000
1,1-dichloroethene	11	U	12	U	1500	U	5	J	n/a	1100	9500	700000	9000000
1,2-dichloroethene (total)	11	U	12	U	1500	U	120		n/a	700000	18000000	800000	10000000
2-butanone	11	U	12	U	1500	U	54		n/a	47000000	1000000000	40000000	600000000
acetone	11	UJ	12	UJ	1500	UJ	140	J	n/a	7800000	200000000	8000000	100000000
benzene	11	U	12	U	1500	U	19		n/a	22000	200000	100000	200000
ethylbenzene	11	U	12	U	3400		50		n/a	7800000	200000000	7000000	100000000
methylene chloride	11	U	10	B	1500	U	10	B	n/a	85000	760000	600000	800000
tetrachloroethene	11	U	12	U	1500	U	10	J	n/a	12000	110000	700000	10000000
toluene	11	U	12	U	1500	U	14		n/a	16000000	410000000	16000000	200000000
trichloroethene	11	U	12	U	1500	U	2	J	n/a	58000	520000	400000	500000
xylene (total)	11	U	12	U	16000		220		n/a	160000000	1000000000	-	-

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB22-0406-DU		05SB22-1416		05SB23-0204		05SB24-0406		05SB24-0406		ARARS & TBCs			
LOCATION:	05SB22		05SB22		05SB23		05SB24		05SB24		Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil					
SAMPLE DATE:	04/16/97		04/16/97		04/16/97		04/16/97		04/18/97					
SEMIVOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
2-methylnaphthalene	98	J	390	UJ	380	UJ	120	J	n/a		-	-	-	-
bis(2-ethylhexyl)phthalate	170	B	150	B	180	B	180	B	n/a		46000	410000	300000	400000
VOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,1,1-trichloroethane	29		12	U	12	U	12	U	n/a		2700000	72000000	7000000	90000000
1,1,2-trichloroethane	11	J	5	J	12	U	12	U	n/a		11000	100000	300000	4000000
1,1-dichloroethane	55		8	J	12	U	12	U	n/a		7800000	200000000	7000000	100000000
1,2-dichloroethene (total)	58		8	J	12	U	12	U	n/a		700000	18000000	800000	10000000
2-butanone	55		12	U	12	U	14		n/a		47000000	1000000000	40000000	600000000
acetone	140	J	12	UJ	31	J	48	J	n/a		7800000	200000000	8000000	100000000
benzene	9	J	2	J	12	U	12	U	n/a		22000	200000	100000	200000
chloroform	12	U	8	J	12	U	12	U	n/a		100000	940000	700000	900000
ethylbenzene	17		12	U	12	U	12	U	n/a		7800000	200000000	7000000	100000000
methylene chloride	8	B	6	B	4	B	6	B	n/a		85000	760000	600000	800000
tetrachloroethene	3	J	12	U	12	U	12	U	n/a		12000	110000	700000	10000000
toluene	6	J	12	U	12	U	12	U	n/a		16000000	410000000	16000000	200000000
xylene (total)	76		12	U	12	U	12	U	n/a		160000000	1000000000	-	-

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB25-0002	05SB26-0406	05SB27-0810	05SB28-0204	05SB29-0204	ARARS & TBCs			
LOCATION:	05SB25	05SB26	05SB27	05SB28	05SB29	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	04/16/97	04/18/97	04/18/97	04/18/97	04/17/97				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	n/a	8980	12200	10300	8890	78000	1000000	-	-
antimony	n/a	4.8 U	5.6 R	7.2 R	5.6 R	31.0	820	30.0	400
arsenic	n/a	1.1 E J	1.7 E J	5.4 E	1.5 E J	0.430	3.80	3.00	4.00
barium	n/a	280	163	39.9	137	5500	140000	5000	70000
beryllium	n/a	1.1 E	1.2 E	0.47 E	0.91 E	0.150	1.30	1.00	1.30
calcium	n/a	416	1400	553	3220	-	-	-	-
chromium, total	n/a	6.1	15.2	19.4	12.1	390	10000	-	-
cobalt	n/a	11.3	12.5	5.9	9.5	4700	120000	-	-
copper	n/a	15.5	7.1	9.4	25.1	3100	82000	700	37000
iron	n/a	13200	15700	21100	17100	23000	610000	-	-
lead	n/a	24.7	8.6	9.2	5.4	400	-	500	1000
magnesium	n/a	533	4370	1700	2930	-	-	-	-
manganese	n/a	1550	172	134	474	1800	47000	-	-
nickel	n/a	14.2 L	17.4 L	6.7 L	8.9 K	1600	41000	200	20000
potassium	n/a	359 U	3070	373 U	822	-	-	-	-
sodium	n/a	108	157	109	105	-	-	-	-
thallium	n/a	0.24 UL	0.24 UL	0.27 L	0.24 UL	6.30	160	6.00	80.0
vanadium	n/a	12.4	17.2	32.6	19.8	550	14000	-	-
zinc	n/a	12.4 L	57.4	23.4 L	22	23000	610000	-	-
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
2-methylnaphthalene	380 UJ	390 UJ	390 UJ	410 UJ	460	-	-	-	-
acenaphthene	380 UJ	390 UJ	390 UJ	410 UJ	1400	4700000	120000000	5000000	60000000
acenaphthylene	380 UJ	390 UJ	390 UJ	410 UJ	160 J	-	-	-	-
anthracene	380 UJ	390 UJ	390 UJ	410 UJ	3000	23000000	610000000	23000000	300000000
benzo(a)anthracene	380 UJ	390 UJ	390 UJ	410 UJ	4200 E	880	7800	6000	8000
benzo(a)pyrene	380 UJ	390 UJ	390 UJ	410 UJ	3600 E	88.0	780	600	800
benzo(b)fluoranthene	380 UJ	390 UJ	390 UJ	410 UJ	4000 E	880	7800	6000	8000
benzo(g,h,i)perylene	380 UJ	390 UJ	390 UJ	410 UJ	1600 J	-	-	-	-

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB25-0002		05SB26-0406		05SB27-0810		05SB28-0204		05SB29-0204		ARARS & TBCs			
LOCATION:	05SB25		05SB26		05SB27		05SB28		05SB29		Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil					
SAMPLE DATE:	04/16/97		04/18/97		04/18/97		04/18/97		04/17/97					
SEMIVOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
benzo(k)fluoranthene	380	UJ	390	UJ	390	UJ	410	UJ	2000		8800	78000	60000	80000
bis(2-ethylhexyl)phthalate	210	B	200	B	440	B	220	B	200	J	46000	410000	300000	400000
carbazole	380	UJ	390	UJ	390	UJ	410	UJ	1600		32000	290000	-	-
chrysene	380	UJ	390	UJ	390	UJ	410	UJ	4300		88000	780000	600000	800000
dibenz(a,h)anthracene	380	UJ	390	UJ	390	UJ	410	UJ	510	E J	88.0	780	600	800
dibenzofuran	380	UJ	390	UJ	390	UJ	410	UJ	1600		310000	8200000	-	-
fluoranthene	380	UJ	390	UJ	390	UJ	410	UJ	10000		3100000	82000000	3000000	40000000
fluorene	380	UJ	390	UJ	390	UJ	410	UJ	2300		3100000	82000000	3000000	40000000
indeno(1,2,3-cd)pyrene	380	UJ	390	UJ	390	UJ	410	UJ	2100	E	880	7800	6000	8000
naphthalene	380	UJ	390	UJ	390	UJ	410	UJ	760		3100000	82000000	3000000	40000000
phenanthrene	380	UJ	390	UJ	390	UJ	410	UJ	12000		-	-	-	-
pyrene	380	UJ	390	UJ	390	UJ	410	UJ	8200		2300000	61000000	2000000	30000000
VOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
acetone	17	J	n/a		n/a		n/a		n/a		7800000	200000000	8000000	100000000
PESTICIDES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
PCBs (immunoassay)	n/a		500	U	n/a		550	E	500	U	319	2860	5000	-
PCBs (tot. all)	n/a		500	U	n/a		550	E	n/a		319	2860	5000	-

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB29-0204	05SB29-0204-DU	05SB30-0406	---	---	ARARS & TBCs			
LOCATION:	05SB29	05SB29	05SB30	---	---	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil						
SAMPLE DATE:	04/18/97	04/18/97	05/28/97						
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**			**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	n/a	n/a	11600			78000	1000000	-	-
arsenic	n/a	n/a	1.4 E L			0.430	3.80	3.00	4.00
barium	n/a	n/a	149			5500	140000	5000	70000
beryllium	n/a	n/a	1.1 E			0.150	1.30	1.00	1.30
calcium	n/a	n/a	8340			-	-	-	-
chromium, total	n/a	n/a	17.5			390	10000	-	-
cobalt	n/a	n/a	9.8			4700	120000	-	-
copper	n/a	n/a	18.2			3100	82000	700	37000
iron	n/a	n/a	19200			23000	610000	-	-
lead	n/a	n/a	64.8			400	-	500	1000
magnesium	n/a	n/a	5360			-	-	-	-
manganese	n/a	n/a	694			1800	47000	-	-
nickel	n/a	n/a	14.7 K			1600	41000	200	20000
potassium	n/a	n/a	566			-	-	-	-
sodium	n/a	n/a	167			-	-	-	-
vanadium	n/a	n/a	26.7			550	14000	-	-
zinc	n/a	n/a	28.6 L			23000	610000	-	-
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**			**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
2-methylnaphthalene	n/a	n/a	2100			-	-	-	-
N-nitrosodiphenylamine (1)	n/a	n/a	75 J			130000	1200000	-	-
acenaphthene	n/a	n/a	5700 J			4700000	120000000	5000000	60000000
acenaphthylene	n/a	n/a	890			-	-	-	-
anthracene	n/a	n/a	11000			23000000	610000000	23000000	300000000
benzo(a)anthracene	n/a	n/a	13000 E			880	7800	6000	8000
benzo(a)pyrene	n/a	n/a	11000 E			88.0	780	600	800
benzo(b)fluoranthene	n/a	n/a	12000 E			880	7800	6000	8000
benzo(g,h,i)perylene	n/a	n/a	4400 J			-	-	-	-
benzo(k)fluoranthene	n/a	n/a	6900 J			8800	78000	60000	80000

TABLE 4-8

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SB29-0204	05SB29-0204-DU	05SB30-0406	---	---	ARARS & TBCs			
LOCATION:	05SB29	05SB29	05SB30	---	---	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil						
SAMPLE DATE:	04/18/97	04/18/97	05/28/97						
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**			**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
bis(2-ethylhexyl)phthalate	n/a	n/a	790			46000	410000	300000	400000
carbazole	n/a	n/a	5300 J			32000	290000	-	-
chrysene	n/a	n/a	12000			88000	780000	600000	800000
dibenz(a,h)anthracene	n/a	n/a	1400 E J			88.0	780	600	800
dibenzofuran	n/a	n/a	5200 J			310000	8200000	-	-
fluoranthene	n/a	n/a	34000			3100000	82000000	3000000	40000000
fluorene	n/a	n/a	10000			3100000	82000000	3000000	40000000
indeno(1,2,3-cd)pyrene	n/a	n/a	5700 E J			880	7800	6000	8000
naphthalene	n/a	n/a	2300			3100000	82000000	3000000	40000000
phenanthrene	n/a	n/a	43000			-	-	-	-
pyrene	n/a	n/a	30000			2300000	61000000	2000000	30000000
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**			**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
acetone	n/a	n/a	41 J			7800000	200000000	8000000	100000000
ethylbenzene	n/a	n/a	5 J			7800000	200000000	7000000	100000000
methylene chloride	n/a	n/a	10 J			85000	760000	600000	800000
toluene	n/a	n/a	2 J			16000000	410000000	16000000	200000000
xylene (total)	n/a	n/a	22			160000000	1000000000	-	-

Footnotes to sample results:

U - Compound or element was not detected. Value is the detection limit (inorganics) or quantitation limit (organics).

UJ - Not detected. Detection limit or quantitation limit shown is considered estimated due to exceedance of data validation quality control criteria.

UL - Not detected. Detection limit or quantitation limit shown is considered biased low due to exceedance of data validation quality control criteria.

No Value - Constituent was not analyzed for in this sample.

UR - Nondetected result is considered rejected based on exceedance of data validation quality control criteria.

J - Value is estimated because concentration is below the quantitation limit or because of exceedance of data validation quality control criteria.

L - Value is considered biased low because of exceedance of data validation quality control criteria.

K - Value is considered biased high because of exceedance of data validation quality control criteria.

R - Positive result is considered rejected based on exceedance of data validation quality control criteria.

E - Result exceeds one or more of the selected ARARs.

Footnotes to PADEP Criteria:

MSC - Medium-Specific Concentration.

4.5.2.1 Inorganics

Arsenic and beryllium exceeded reference criteria in all Phase II subsurface soil samples; however, levels were within background. Iron was the only metal exceeding reference criteria and background (05SB17-0406, 26,000 mg/kg; 05SB18-0406, 27,900 mg/kg). Other metals detected at levels above background but below reference criteria include barium, chromium, cobalt, copper, lead, manganese, nickel, and vanadium.

4.5.2.2 Organics

VOCs were detected in borings (05SB05, 05SB13 through 05SB15, 05SB17, 05SB18, 05SB22, 05SB24, 05SB25, and 05SB30). The highest levels were detected at 05SB22 at a depth of 4 to 6 feet; however, VOCs were detected to depths of 16 feet. No VOCs were present over ARARs. A comparison against EPA soil screening levels (SSLs) indicates that the soil to groundwater pathway, historically the presumed route for groundwater contamination, is no longer a significant source of VOCs in groundwater. BTEX compounds were detected at 05SB17, 05SB21, 05SB22, and 05SB30; the highest concentrations were detected at 05SB21. BTEX compounds were detected at depths to 12 feet.

PAHs were detected above reference criteria but within background levels at several locations. Locations where PAHs exceeded background as well as regulatory criteria were 05SB17, 05SB29, and 05SB30.

The highest level of PAH contamination was at 05SB30. PCBs (immunoassay result) exceeded reference criteria at 05SB28-0204.

4.5.3 Surface Water

Two surface water samples (05SW01 and 05SW02) were collected during Phase II RI activities from Site 5 (Figure 4-1). Table 4-9 presents the occurrence and distribution of inorganic and organic chemicals detected in site-related surface water samples and compares them to background. Table 4-10 presents results from the background comparison tests. Table 4-11 presents a comparison of detected compounds to ARARS and TBCs. Figure 4-9B shows sample locations and concentrations of compounds that exceed ARARS and TBCs.

4.5.3.1 Inorganics

Based on these results, sample location 05SW01 showed levels within background range while exceedences were detected in sample 05SW02. Iron, lead, and zinc were detected in surface water

Table 4-9
Occurrence and Distribution of Organics and Inorganics in Surface Water, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Background Data					Site-Related Data				
	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Representative Concentration
aluminum	0/0	-				1/1	926	926	926	03/18/97 05SW02	926
arsenic	0/8	-			NA	1/2	1.4	1.4	0.95	03/18/97 05SW02	1.4
barium	8/8	87.3	112	101	03/13/97 BGSW05	2/2	23.3	44.8	34.1	03/18/97 05SW02	44.8
calcium	8/8	15800	34900	24600	03/13/97 BGSW01	2/2	19900	24500	22200	03/18/97 05SW01	24500
iron	8/8	85.3	519	307	03/13/97 BGSW03	2/2	261	1170	716	03/18/97 05SW02	1170
lead	0/8	-			NA	2/2	1.3	3	2.15	03/18/97 05SW02	3
magnesium	8/8	6250	12100	8890	03/13/97 BGSW01	2/2	4350	5420	4890	03/18/97 05SW02	5420
manganese	8/8	26.7	98.5	65.6	03/13/97 BGSW03	2/2	12.6	55.9	34.3	03/18/97 05SW02	55.9
potassium	6/8	1750	2860	1820	03/13/97 BGSW01	2/2	2180	2840	2510	03/18/97 05SW01	2840
sodium	8/8	10700	36200	20400	03/13/97 BGSW02	2/2	2060	11200	6630	03/18/97 05SW01	11200
zinc	3/8	6.8	9.1	4.53	03/13/97 BGSW04	2/2	19	32.1	25.6	03/18/97 05SW02	32.1
dieldrin	0/8	-			NA	1/2	0.06	0.06	0.055	03/18/97 05SW02	0.06

Notes:

Units are ug/L.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result.
Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.
The determination of representative concentrations is based on comparison of maximum to the 95 % UCL, which is presented in a separate table.
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.
Number of samples may vary based on the number of usable results.

TABLE 4-10
Background Comparison Tests - Surface Water Data for Site 5
NASJRB Willow Grove, Pennsylvania

Name of Test:		Detection Freq: Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:		Site Freq. > Back.Freq.?				Site Maximum > UTL for Background Data ?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation =Background Std.Dev.?						
Assumptions Valid:		#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:		P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back?	YN	Back.	Site	P	YN	Back.	Std.Dev.	t	L,N	Back.	Site	YN	r	k	P	YN	P	Test	Used	YN	Back.	Site	t	t	YN	Back.	Site	Std.Dev.	Std.Dev.	F	F	YN
Substance		Freq.	Freq.	Value		Mean@	Back.@	Value	Q	UTL	Max.				Value		Value				Mean@	Mean@	Value	Table		Distrib.	Distrib.	Back.@	Site@	Value	Table	
aluminum	NA	0/0	1/1		NA						926	NA				NA				NA		926			NA							NA
arsenic	N	0/8	1/2	0.2000	N						1.4	NA	1	1	0.2000	N				NA		0.95			NA							NA
barium	N	8/8	2/2		NA	4.61	0.0937	1.8946	L	121	44.8	N	9	1	1.0000	N	1.0000			N	101	34.1			NA	lognor.	unknow.					NA
calcium	N	8/8	2/2		NA	10.1	0.322	1.8946	L	44900	24500	N	7	2	0.4667	N	0.6222			N	24600	22200			NA	lognor.	unknow.					NA
iron	Y	8/8	2/2		NA	307	124	1.8946	N	557	1170	Y	1	1	0.2000	N	0.1556			N	307	716			NA	normal	unknow.					NA
lead	Y	0/8	2/2	0.0222	Y						3	NA	2	2	0.0222	Y				NA		2.15			NA							NA
magnesium	N	8/8	2/2		NA	9.06	0.266	1.8946	L	14700	5420	N	9	1	1.0000	N	1.0000			N	8890	4890			NA	lognor.	unknow.					NA
manganese	N	8/8	2/2		NA	65.6	23.6	1.8946	N	113	55.9	N	7	1	0.9333	N	0.9556			N	65.6	34.3			NA	normal	unknow.					NA
potassium	N	6/8	2/2	0.6222	N	1820					2840	NA	4	2	0.1333	N	0.1111			N	1820	2510			NA	normal	unknow.					NA
sodium	N	8/8	2/2		NA	9.61	0.501	1.8946	L	50000	11200	N	7	1	0.9333	N	0.9556			N	20400	6630			NA	lognor.	unknow.					NA
zinc	Y	3/8	2/2	0.2222	N	4.53					32.1	NA	2	2	0.0222	Y	0.0222	Gehan	Test	Y	4.53	25.6			NA	nonpar.	unknow.					NA
dieldrin	N	0/8	1/2	0.2000	N						0.06	NA	1	1	0.2000	N				NA		0.055			NA							NA

Notes: Units are ug/L.
A statistical significance level (P value) of 0.05 is used for all tests that directly compare site to background. A two-sided significance level of 0.1 is used for Bartlett's test for equal variance.
UTL is the expected value for the upper 95 % quantile of the background population; there is an equal chance of the population's true 95 % quantile being either below or above this estimate.
For each test, a YES or NO decision is presented only if all assumptions are met. The overall decision (is site > background) for each chemical appears at the left and is based on four criteria:
(1) Overall decision is YES if any one of the UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is YES, regardless of other test results.
(2) Overall decision is NO if at least one of UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is NO, and none of the aforementioned tests are YES.
(3) Overall decision is YES/NO if Z/Fisher Test is YES/NO, respectively, and other tests are NA. Z-test is treated as lowest priority since it relies on detection frequency, not magnitude of results.
(4) Overall decision is NA if all tests are NA. (Chemicals assigned NA are still included in human health risk-based screening and/or risk assessment.)

Abbreviations:

# NDs or # Pos.	Number of non-detected (ND) or positive (Pos.) results in data set, not including rejected data or blank-qualified data.
# s or # b	Number of site (s) or background (b) samples, not including rejected data or blank-qualified data.
s = b	Standard deviation of site results must not be different from the standard deviation of background results.
P value	Probability or significance level is defined as the chance of a false positive. If P <= 0.05 then test determines site > background with 95 % confidence.
L, N, or Q	UTL is based on 95 % upper limit (using t-value) when data are lognormal (L) or normal (N). Otherwise, an upper 95 % quantile (Q) is used if there are > 18 back. points.
% ND	Mann-Whitney test used if < 40% of data Non-Detected and detect. limits uniformly below the range of positive values. If not, the Gehan Test is used.
@	Mean and standard deviations are shown of log-transformed data when distributions are of this type; ie., if an (L) code appears for the UTL test or if site and background distributions both match lognormal, and both T-test and Bartlett's test are applicable. (Arithmetic mean and normal standard deviation are shown only for illustration in the event that these tests are NA.)
r,k	The upper ranks test calculates the probability that k or more samples from the top r ranks of the combined site and background data set are comprised of site data if both populations are in fact equal.

TABLE 4-11

COMPARISON OF SURFACE WATER ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SW01 03/18/97	05SW01-DUP	05SW02 03/18/97	---	ARARS & TBCs				
LOCATION:	05SW01	05SW01	05SW02	---	AWQC Freshwater Chronic Aquatic Life	AWQC Ingestion of Water and Fish	AWQC Ingestion of Fish Only	PADEP WQC Criteria Continuous Concentrations	PADEP WQC Human Health Criteria
DATA SOURCE:	Surface Water	Surface Water	Surface Water						
SAMPLE DATE:	03/18/97	03/18/97	03/18/97						
INORGANICS	ug/L	ug/L	ug/L		ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	231 B	229 B	926		-	-	-	-	-
arsenic	1 U	1 U	1.4 E		189	0.0180	0.140	190 *	50.0
barium	23.3	23.3	44.8		-	-	-	4100	1000.
calcium	24500	24600	19900		-	-	-	-	-
iron	261	259	1170		-	-	-	-	-
lead	1.3 K	1 U	3 E K		3.20 +	-	-	2.50 +	50.0
magnesium	4350	4370	5420		-	-	-	-	-
manganese	12.6	11.9	55.9		-	-	-	-	-
potassium	2840	2530	2180		-	-	-	-	-
sodium	11200	9900	2060		-	-	-	-	-
zinc	19	7.1	32.1		101 +	-	-	100 +	5000
PESTICIDES	ug/L	ug/L	ug/L		ug/L	ug/L	ug/L	ug/L	ug/L
dieldrin	0.1 U	0.1 U	0.06 E J		-	-	-	0.00190	

TABLE 4-11

COMPARISON OF SURFACE WATER ANALYTICAL DATA TO ARARS AND TBCS - SITE 05
NASJRB, WILLOW GROVE, PENNSYLVANIA

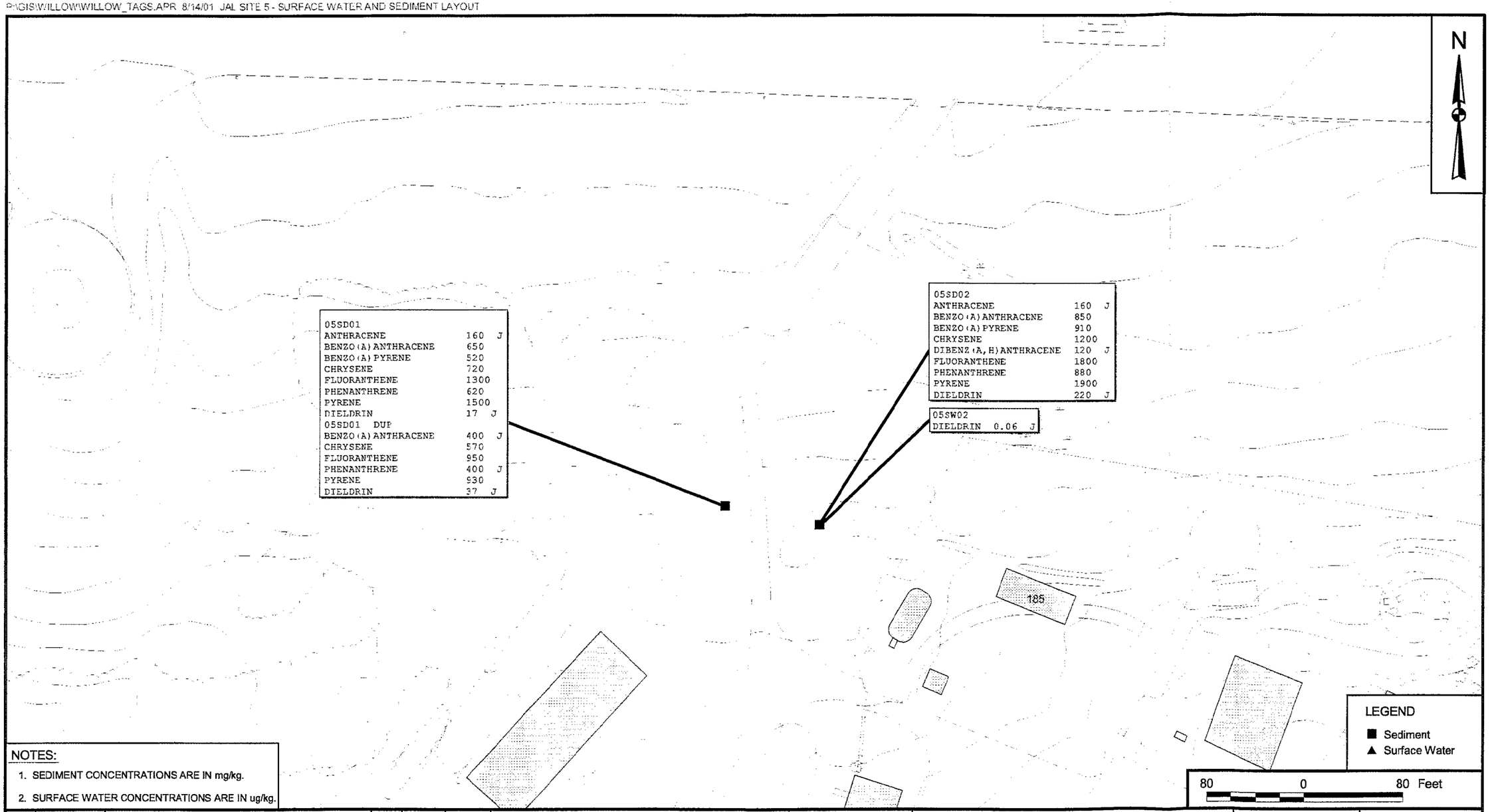
Footnotes to sample results:

U - Compound or element was not detected. Value is the detection limit (inorganics) or quantitation limit (organics).
UJ - Not detected. Detection limit or quantitation limit shown is considered estimated due to exceedance of data validation quality control criteria.
UL - Not detected. Detection limit or quantitation limit shown is considered biased low due to exceedance of data validation quality control criteria.
No Value - Constituent was not analyzed for in this sample.
UR - Nondetected result is considered rejected based on exceedance of data validation quality control criteria.
J - Value is estimated because concentration is below the quantitation limit or because of exceedance of data validation quality control criteria.
L - Value is considered biased low because of exceedance of data validation quality control criteria.
K - Value is considered biased high because of exceedance of data validation quality control criteria.
R - Positive result is considered rejected based on exceedance of data validation quality control criteria.
E - Result exceeds one or more of the selected ARARs.

Footnotes to Ambient Water Quality Criteria:

- - No standard is available for this chemical in this classification.
+ - Criterion is hardness dependent and is generated based upon an assumed hardness of 100 mg/L.

P:\GIS\WILLOW\WILLOW_TAGS.APR 8/14/01 JAL SITE 5 - SURFACE WATER AND SEDIMENT LAYOUT



NOTES:

1. SEDIMENT CONCENTRATIONS ARE IN mg/kg.
2. SURFACE WATER CONCENTRATIONS ARE IN ug/kg.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES
1	8/7/01	NOTES ADDED, FIGURE NUMBER & COMPANY NAME REVISED.	LDL			

DRAWN BY S. TABLER	DATE 3/25/98
CHECKED BY	DATE
COST/SCHEDULE-AREA	
SCALE AS NOTED	

Tetra Tech NUS, Inc.

CONCENTRATION ABOVE SCREENING LEVELS
ECOLOGICAL RISK CRITERIA
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NUMBER 5466	OWNER NUMBER 2207
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO. FIGURE 4-9B	REV 1

samples at levels exceeding background. Aluminum and arsenic were detected in surface water but not in background. Aluminum (926 ug/l), arsenic (1.4 ug/l), iron (1,170 ug/l), lead (3 ug/l), and zinc (32.1 ug/l) were detected at 05SW02. Arsenic and lead levels present in 05SW02 exceed reference criteria.

4.5.3.2 Organics

Dieldrin was detected at a level exceeding reference criteria but within background levels in 05SW02 (0.06 ug/l). No other organic compounds were detected in surface water samples.

4.5.4 Sediment

Two sediment samples (05SD01 and 05SD02) were collected during Phase II RI activities from Site 5 (Figure 4-1). Table 4-12 presents the occurrence and distribution of inorganic and organic chemicals detected in site-related sediment samples and compares them to background. Table 4-13 presents results from the background comparison tests. Table 4-14 presents a comparison of detected compounds to ARARS and TBCs. Figure 4-9B shows sample locations and concentrations of compounds that exceed ARARS and TBCs.

4.5.4.1 Inorganics

Antimony, which was not detected in background samples, was detected at 4.1 mg/kg and 6.1 mg/kg at samples 05SD01 and 05SD02, respectively. The concentration of antimony in 05SD02 exceeds reference criteria. Aluminum was the only other inorganic compound detected at significant levels above background. Barium was detected at levels greater than reference criteria but within background range.

4.5.4.2 Organics

For all organics detected in Site 5 sediment samples, the highest levels were recorded at location 05SD02. Two VOCs were detected in sample 05SD02. Toluene and 2-butanone were detected at 4 ug/kg and 22 ug/kg, respectively. No VOCs were detected in 05SD01 or background sediment samples. The pesticides aldrin (2.3 ug/kg to 11 ug/kg) and dieldrin (27 ug/kg to 220 ug/kg) were detected at 05SD01 and 05SD02. Dieldrin levels exceeded background, and aldrin was not detected in background samples. Elevated levels of PAHs were also detected in 05SD02 and, to a lesser extent, in 05SD01. The levels exceeded reference criteria and background for several PAH compounds in 05SD01 and to a greater degree in 05SD02.

Table 4-12
Occurrence and Distribution of Organics and Inorganics in Sediments, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Background Data					Site-Related Data				
	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Representative Concentration
aluminum	8/8	3610	8950	6300	03/13/97 BGSD01	2/2	11200	12000	11600	03/18/97 05SD01	12000
antimony	0/5	-			NA	2/2	5.6	6.1	5.85	03/18/97 05SD02	6.1
arsenic	8/8	3.2	7.2	4.51	03/13/97 BGSD01	2/2	4	4.5	4.25	03/18/97 05SD02	4.5
barium	8/8	54.6	142	95.9	03/13/97 BGSD03	2/2	69.8	74.3	72.1	03/18/97 05SD02	74.3
beryllium	8/8	0.52	1.2	0.865	03/13/97 BGSD01	2/2	0.58	0.77	0.675	03/18/97 05SD02	0.77
calcium	8/8	744	18200	4970	03/13/97 BGSD06	2/2	1420	12200	6810	03/18/97 05SD01	12200
chromium	8/8	6.8	34.5	15.3	03/13/97 BGSD01	2/2	8.8	12.9	10.9	03/18/97 05SD02	12.9
cobalt	8/8	4.5	12.4	7.08	03/13/97 BGSD01	2/2	7.1	7.1	7.1	03/18/97 05SD02	7.1
copper	8/8	5.8	27.8	13.3	03/13/97 BGSD01	2/2	12.3	13.5	12.9	03/18/97 05SD01	13.5
iron	8/8	9540	35400	16200	03/13/97 BGSD01	2/2	11000	11900	11500	03/18/97 05SD02	11900
lead	8/8	6.4	26.8	15.2	03/13/97 BGSD03	2/2	7.9	31.7	19.8	03/18/97 05SD02	31.7
magnesium	8/8	999	10600	3400	03/13/97 BGSD06	2/2	1610	7650	4630	03/18/97 05SD01	7650
manganese	8/8	376	759	505	03/13/97 BGSD01	2/2	107	222	165	03/18/97 05SD02	222
nickel	8/8	6.8	22.7	12.2	03/13/97 BGSD01	2/2	9.4	11	10.2	03/18/97 05SD02	11
potassium	6/8	514	2330	1010	03/13/97 BGSD01	2/2	664	691	678	03/18/97 05SD01	691
vanadium	8/8	7.9	52.6	22.3	03/13/97 BGSD01	2/2	15.6	21.2	18.4	03/18/97 05SD02	21.2
zinc	8/8	25.4	97.6	50.2	03/13/97 BGSD01	2/2	14.8	40.1	27.5	03/18/97 05SD02	40.1
aldrin	0/8	-			NA	1/2	11	11	6.05	03/18/97 05SD02	11
dieldrin	1/8	3.1	3.1	2.26	03/13/97 BGSD03	2/2	17	220	119	03/18/97 05SD02	220
anthracene	0/8	-			NA	2/2	160	160	160	03/18/97 05SD02	160
benz(a)anthracene	1/8	580	580	275	03/13/97 BGSD01	2/2	650	850	750	03/18/97 05SD02	850
benzo(a)pyrene	1/8	530	530	269	03/13/97 BGSD01	2/2	520	910	715	03/18/97 05SD02	910
benzo(b)fluoranthene	1/8	670	670	286	03/13/97 BGSD01	2/2	720	1400	1060	03/18/97 05SD02	1400
benzo(g,h,i)perylene	0/8	-			NA	2/2	200	400	300	03/18/97 05SD02	400
benzo(k)fluoranthene	1/8	300	300	240	03/13/97 BGSD01	2/2	430	700	565	03/18/97 05SD02	700
chrysene	3/8	110	640	240	03/13/97 BGSD01	2/2	720	1200	960	03/18/97 05SD02	1200
dibenz(a,h)anthracene	0/8	-			NA	1/2	120	120	170	03/18/97 05SD02	120

Table 4-12
Occurrence and Distribution of Organics and Inorganics in Sediments, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Background Data					Site-Related Data				
	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Representative Concentration
fluoranthene	4/8	100	510	226	03/13/97 BGSD01	2/2	1300	1800	1550	03/18/97 05SD02	1800
indeno(1,2,3-cd)pyrene	0/8	-			NA	2/2	290	560	425	03/18/97 05SD02	560
phenanthrene	1/8	260	260	235	03/13/97 BGSD01	2/2	620	880	750	03/18/97 05SD02	880
pyrene	4/8	100	1300	319	03/13/97 BGSD01	2/2	1500	1900	1700	03/18/97 05SD02	1900
2-butanone	0/8	-			NA	1/2	22	22	14.3	03/18/97 05SD02	22
toluene	0/8	-			NA	1/2	4	4	5.25	03/18/97 05SD02	4

Notes:

Units are mg/kg for inorganics, ug/kg for organics.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result.
Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.
The determination of representative concentrations is based on comparison of maximum to the 95 % UCL, which is presented in a separate table.
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.
Number of samples may vary based on the number of usable results.

TABLE 4-13
Background Comparison Tests - Sediment Data for Site 5
NASJRB Willow Grove, Pennsylvania

Name of Test:	Detection Freq. Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:	Site Freq. > Back.Freq.?				Site Maximum > UTL for Background Data ?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation =Background Std.Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back.	Site	P	YN	Back.	Std.Dev.	t	L,N	Back.	Site	YN	r	k	P	YN	P	Test	Used	YN	Back	Site	t	t	YN	Back.	Site	Std.Dev.	Std.Dev.	F	F	YN
Substance	Freq.	Freq.	Value		Mean@	Back.@	Value	Q	UTL	Max.				Value		Value				Mean@	Mean@	Value	Table		Distrib.	Distrib.	Back.@	Site@	Value	Table	
aluminum Y	8/8	2/2		NA	8.71	0.304	1.8946	L	11200	12000	Y	2	2	0.0222	Y	0.0222			Y	6300	11600			NA	lognor.	unknow.					NA
antimony Y	0/5	2/2	0.0476	Y						6.1	NA				NA				NA		5.85			NA							NA
arsenic N	8/8	2/2		NA	1.48	0.246	1.8946	L	7.2	4.5	N	8	2	0.6222	N	0.5778			N	4.51	4.25			NA	lognor.	unknow.					NA
barium N	8/8	2/2		NA	95.9	27.7	1.8946	N	152	74.3	N	9	2	0.8000	N	0.8889			N	95.9	72.1			NA	normal	unknow.					NA
beryllium N	8/8	2/2		NA	0.865	0.265	1.8946	N	1.4	0.77	N	9	2	0.8000	N	0.8222			N	0.865	0.675			NA	normal	unknow.					NA
calcium N	8/8	2/2		NA	4970					12200	NA	5	2	0.2222	N	0.4222			N	4970	6810			NA	nonpar.	unknow.					NA
chromium N	8/8	2/2		NA	2.56	0.589	1.8946	L	42.3	12.9	N	8	2	0.6222	N	0.6000			N	15.3	10.9			NA	lognor.	unknow.					NA
cobalt N	8/8	2/2		NA	1.9	0.347	1.8946	L	13.4	7.1	N	4	2	0.1333	N	0.4000			N	7.08	7.1			NA	lognor.	unknow.					NA
copper N	8/8	2/2		NA	2.46	0.527	1.8946	L	33.6	13.5	N	4	2	0.1333	N	0.4000			N	13.3	12.9			NA	lognor.	unknow.					NA
iron N	8/8	2/2		NA	9.58	0.481	1.8946	L	38100	11900	N	7	2	0.4667	N	0.7111			N	16200	11500			NA	lognor.	unknow.					NA
lead N	8/8	2/2		NA	2.61	0.503	1.8946	L	37.6	31.7	N	1	1	0.2000	N	0.2667			N	15.2	19.8			NA	lognor.	unknow.					NA
magnesium N	8/8	2/2		NA	3400					7650	NA	4	2	0.1333	N	0.4000			N	3400	4630			NA	nonpar.	unknow.					NA
manganese N	8/8	2/2		NA	6.19	0.264	1.8946	L	832	222	N	9	1	1.0000	N	1.0000			N	505	165			NA	lognor.	unknow.					NA
nickel N	8/8	2/2		NA	2.42	0.423	1.8946	L	26.3	11	N	7	2	0.4667	N	0.5556			N	12.2	10.2			NA	lognor.	unknow.					NA
potassium N	6/8	2/2	0.6222	N	1010					691	NA	7	2	0.4667	N	0.6222			N	1010	678			NA	lognor.	unknow.					NA
vanadium N	8/8	2/2		NA	2.9	0.664	1.8946	L	68.9	21.2	N	6	2	0.3333	N	0.4667			N	22.3	18.4			NA	lognor.	unknow.					NA
zinc N	8/8	2/2		NA	3.81	0.475	1.8946	L	117	40.1	N	5	1	0.7778	N	0.8889			N	50.2	27.5			NA	lognor.	unknow.					NA
aldrin N	0/8	1/2	0.2000	N						11	NA	1	1	0.2000	N				NA		6.05			NA							NA
dieldrin Y	1/8	2/2	0.0667	N	2.26					220	NA	2	2	0.0222	Y	0.0222	Gehan	Test	Y	2.26	119			NA	lognor.	unknow.					NA
anthracene Y	0/8	2/2	0.0222	Y						160	NA				NA				NA		160			NA							NA
benz(a)anthracene Y	1/8	2/2	0.0667	N	275					850	NA	2	2	0.0222	Y	0.0222	Gehan	Test	Y	275	750			NA	nonpar.	unknow.					NA
benzo(a)pyrene Y	1/8	2/2	0.0667	N	269					910	NA	3	2	0.0667	N	0.0444	Gehan	Test	Y	269	715			NA	nonpar.	unknow.					NA
benzo(b)fluoranthene Y	1/8	2/2	0.0667	N	286					1400	NA	2	2	0.0222	Y	0.0222	Gehan	Test	Y	286	1060			NA	nonpar.	unknow.					NA
benzo(g,h,i)perylene N	0/8	2/2	0.0222	Y						400	NA	1	1	0.2000	N				NA		300			NA							NA
benzo(k)fluoranthene Y	1/8	2/2	0.0667	N	240					700	NA	2	2	0.0222	Y	0.0222	Gehan	Test	Y	240	565			NA	lognor.	unknow.					NA
chrysene Y	3/8	2/2	0.2222	N	240					1200	NA	2	2	0.0222	Y	0.0222	Gehan	Test	Y	240	960			NA	lognor.	unknow.					NA
dibenz(a,h)anthracene N	0/8	1/2	0.2000	N						120	NA				NA				NA		170			NA							NA
fluoranthene Y	4/8	2/2	0.3333	N	226					1800	NA	2	2	0.0222	Y	0.0222	Gehan	Test	Y	226	1550			NA	lognor.	unknow.					NA
indeno(1,2,3-cd)pyrene Y	0/8	2/2	0.0222	Y						560	NA	2	2	0.0222	Y				NA		425			NA							NA
phenanthrene Y	1/8	2/2	0.0667	N	235					880	NA	2	2	0.0222	Y	0.0222	Gehan	Test	Y	235	750			NA	lognor.	unknow.					NA
pyrene Y	4/8	2/2	0.3333	N	319					1900	NA	2	2	0.0222	Y	0.0222	Gehan	Test	Y	319	1700			NA	nonpar.	unknow.					NA
2-butanone N	0/8	1/2	0.2000	N						22	NA	1	1	0.2000	N				NA		14.3			NA							NA
toluene N	0/8	1/2	0.2000	N						4	NA				NA				NA		5.25			NA							NA

TABLE 4-13
Background Comparison Tests - Sediment Data for Site 5
NASJRB Willow Grove, Pennsylvania

Name of Test:	Detection Freq: Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:	Site Freq. > Back Freq.?				Site Maximum > UTL for Background Data ?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation =Background Std.Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back.	Site	P	YN	Back.	Std.Dev.	t	L,N	Back.	Site	YN	r	k	P	YN	P	Test	Used	YN	Back.	Site	t	t	YN	Back.	Site	Std.Dev.	Std.Dev.	F	F	YN
Substance	Freq.	Freq.	Value		Mean@	Back.@	Value	Q	UTL	Max.				Value		Value				Mean@	Mean@	Value	Table		Distrib.	Distrib.	Back.@	Site@	Value	Table	

Notes: Units are mg/kg for inorganics, ug/kg for organics.
A statistical significance level (P value) of 0.05 is used for all tests that directly compare site to background. A two-sided significance level of 0.1 is used for Bartlett's test for equal variance.
UTL is the expected value for the upper 95 % quantile of the background population; there is an equal chance of the population's true 95 % quantile being either below or above this estimate.
For each test, a YES or NO decision is presented only if all assumptions are met. The overall decision (is site > background) for each chemical appears at the left and is based on four criteria:
(1) Overall decision is YES if any one of the UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is YES, regardless of other test results.
(2) Overall decision is NO if at least one of UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is NO, and none of the aforementioned tests are YES.
(3) Overall decision is YES/NO if Z/Fisher Test is YES/NO, respectively, and other tests are NA. Z-test is treated as lowest priority since it relies on detection frequency, not magnitude of results.
(4) Overall decision is NA if all tests are NA. (Chemicals assigned NA are still included in human health risk-based screening and/or risk assessment.)

Abbreviations:

# NDs or # Pos.	Number of non-detected (ND) or positive (Pos.) results in data set, not including rejected data or blank-qualified data.
# s or # b	Number of site (s) or background (b) samples, not including rejected data or blank-qualified data.
s = b	Standard deviation of site results must not be different from the standard deviation of background results.
P value	Probability or significance level is defined as the chance of a false positive. If P <= 0.05 then test determines site > background with 95 % confidence.
L, N, or Q	UTL is based on 95 % upper limit (using t-value) when data are lognormal (L) or normal (N). Otherwise, an upper 95 % quantile (Q) is used if there are > 18 back. points.
% ND	Mann-Whitney test used if < 40% of data Non-Detected and detect. limits uniformly below the range of positive values. If not, the Gehan Test is used.
@	Mean and standard deviations are shown of log-transformed data when distributions are of this type; ie., if an (L) code appears for the UTL test or if site and background distributions both match lognormal, and both T-test and Bartlett's test are applicable. (Arithmetic mean and normal standard deviation are shown only for illustration in the event that these tests are NA.)
r,k	The upper ranks test calculates the probability that k or more samples from the top r ranks of the combined site and background data set are comprised of site data if both populations are in fact equal.

TABLE 4-14

COMPARISON OF SEDIMENT ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SD01 03/18/97	05SD01-DUP	05SD02 03/18/97	---	---	---	---	Sediment Ecological Toxicity Threshold Values
LOCATION:	05SD01	05SD01	05SD02	---	---	---	---	
DATA SOURCE:	Sediment	Sediment	Sediment					
SAMPLE DATE:	03/18/97	03/18/97	03/18/97					
MISCELLANEOUS	**mg/kg**	**mg/kg**	**mg/kg**					**mg/kg**
total organic carbon	14400	8950	31900					-
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**					**mg/kg**
aluminum	12000	12900	11200					-
antimony	5.6	5.2 U	6.1					150 A
arsenic	4 J	2	4.5 J					8.20 L
barium	69.8	76.2	74.3					-
beryllium	0.58	0.6	0.77					-
calcium	12200	977	1420					-
chromium, total	8.8	9.2	12.9					81.0 L
cobalt	7.1	8.3	7.1					-
copper	13.5	12.5	12.3					34.0 L
iron	11000	11100	11900					-
lead	7.9	8.4	31.7					47.0 L
magnesium	7650	931	1610					-
manganese	107	90.1	222					1110 O
nickel	9.4 K	9.6 K	11 K					21.0 L
potassium	691	518	664					-
vanadium	15.6	16	21.2					-
zinc	14.8	16	40.1					150 L
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**					**ug/kg**
anthracene	160 E J	430 U	160 E J					85.3 L
benzo(a)anthracene	650 E	400 E J	850 E					261 L
benzo(a)pyrene	520 E	400 J	910 E					430 L
benzo(b)fluoranthene	720	570	1400					3200 A
benzo(g,h,i)perylene	200 J	160 J	400 J					670 A
benzo(k)fluoranthene	430 J	390 J	700					-
chrysene	720 E	570 E	1200 E					384 L
dibenz(a,h)anthracene	440 U	430 U	120 E J					63.4 L

TABLE 4-14

COMPARISON OF SEDIMENT ANALYTICAL DATA TO ARARS AND TBCs - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05SD01 03/18/97	05SD01-DUP	05SD02 03/18/97	---	---	---	---	Sediment Ecological Toxicity Threshold Values
LOCATION:	05SD01	05SD01	05SD02	---	---	---	---	
DATA SOURCE:	Sediment	Sediment	Sediment					
SAMPLE DATE:	03/18/97	03/18/97	03/18/97					
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**					**ug/kg**
fluoranthene	1300 E	950 E	1800 E					600 L
indeno(1,2,3-cd)pyrene	290 J	240 J	560					600 A
phenanthrene	620 E	400 E J	880 E					240 L
pyrene	1500 E	930 E	1900 E					660 L
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**					**ug/kg**
2-butanone	13 U	13 U	22					-
acetone	13 U	120 B	180 B					-
methylene chloride	13 U	33 B	37 B					427 S
toluene	13 U	13 U	4 J					670 P
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**					**ug/kg**
aldrin	2.2 U	3.5	11 J					80.0 O
dieldrin	17 E J	37 E J	220 E J					8.00 M

Footnotes to sample results:

U - Compound or element was not detected. Value is the detection limit (inorganics) or quantitation limit (organics).

UJ - Not detected. Detection limit or quantitation limit shown is considered estimated due to exceedance of data validation quality control criteria.

UL - Not detected. Detection limit or quantitation limit shown is considered biased low due to exceedance of data validation quality control criteria.

No Value - Constituent was not analyzed for in this sample.

UR - Nondetected result is considered rejected based on exceedance of data validation quality control criteria.

J - Value is estimated because concentration is below the quantitation limit or because of exceedance of data validation quality control criteria.

L - Value is considered biased low because of exceedance of data validation quality control criteria.

K - Value is considered biased high because of exceedance of data validation quality control criteria.

R - Positive result is considered rejected based on exceedance of data validation quality control criteria.

E - Result exceeds one or more of the selected ARARs.

Footnotes to Sediment Criteria:

- No standard is available for this chemical in this classification.

A - EPA Region III BTAG Screening Level (EPA, 1995).

L - Effects Range-Low. Source: Long E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Environmental Management. 19:81-97.

M - Effects Range-Medium. Source: Long, E. R. and L. G. Morgan. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52, National Oceanic and Atmospheric Administration, Seattle, WA.

O - Ontario screening level. Source: Ontario Ministry of the Environment (OME). 1992. Guidelines for the Protection and Management of the Aquatic Sediment Quality in Ontario. Log 92-2309-067, PIBS 1962.

P - Sediment quality benchmark using equipartition. Source: USEPA. 1996. ECO Update. Volume 3: Number 2. EPA 540/F-95/038.

S - Sediment screening benchmark. Source: Suter, G. W., and J. B. Mabrey. 1994. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota. Oak Ridge National Laboratory, Oak Ridge, TN.

4.5.5 Groundwater

Ten monitoring wells (shallow zone wells 05MW01S through 05MW07S, shallow intermediate zone wells 05MW01SI and 05MW06SI, and intermediate zone well 05MW07I) were sampled for TCL VOCs during the Phase I RI. During Phase II initial field activities, 21 monitoring wells (shallow zone wells 05MW01S through 05MW10S, shallow intermediate zone wells 05MW06SI, and 05MW08 through 05MW10SI, intermediate zone wells 05MW01I, 05MW03I, 05MW06I, and 05MW08 through 05MW10I, and deep well 05MW01D) were sampled for TAL metals and full TCL organic parameters. During the Phase II follow-on field activities, 26 monitoring wells (shallow zone wells 05MW01S through 05MW11S, shallow intermediate zone wells 05MW01SI, 05MW09SI, and 05MW11SI, and intermediate zone wells 05MW01I 05MW03I, 05MW04I, 05MW05I, 05MW06I, 05MW07I, 05MW08I, 05MW09I, 05MW10I, 05MW11I, and 05MW12I) were samples for TCL VOCs and MNA parameters.

Figure 4-1 presents sampling locations. Table 4-15 presents the occurrence and distribution of inorganic and organic chemicals detected in groundwater samples and compares them to background. Table 4-16 presents results from the background comparison tests. Table 4-17 presents a comparison of detected compounds to ARARS and TBCs. Table 4-17A presents NA parameter results for data acquired during field activities IN September 2000. Figure 4-10A shows sample locations and concentrations of compounds that exceed ARAR/TBC screening levels from the September 2000 groundwater samples. Figure 4-10B shows sample locations and concentrations of compounds that exceed ARAR/TBC screening levels from the initial field activities.

4.5.5.1 Inorganics

Lead (05MW07I), arsenic (05MW10S), and beryllium (05MW10S) were the only inorganics detected at levels above reference criteria. Statistical tests indicate these inorganics are not site related.

4.5.5.2 Organics

No SVOCs were detected in groundwater samples. The pesticide dieldrin exceeded screening levels in 05MW07S (0.3 ug/l) and 05MW10S (0.09J ug/l). VOCs were detected in the groundwater throughout Site 5. In general, the VOC occurrences and concentrations formed a somewhat predictable pattern (plume geometry) that was consistent with the interpreted groundwater flow patterns and the conceptual model of a groundwater plume migrating advectively with the groundwater flow. The areal distributions of VOCs for the most recent sampling round (September 2000) are illustrated in isoconcentration contour maps constructed for the shallow (Fig. 4-11) and intermediate (Fig 4-12) groundwater zones.

Table 4-15
Occurrence and Distribution of Organics and Inorganics in Groundwater, Site 5
NASJRB Willow Grove, Pennsylvania

	Background Data					Site-Related Data				
Substance	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Representative Concentration
aluminum		-				7/16	59.9	6970	540	05MW10S 06/24/97	1310
arsenic		-				1/21	2	2	0.571	05MW10S 06/24/97	0.633
barium		-				21/21	43.8	1430	317	05MW10S 06/24/97	575
beryllium		-				1/21	2.8	2.8	0.61	05MW10S 06/24/97	0.683
calcium		-				21/21	5740	39000	22300	05MW08SI 06/23/97	33100
chromium		-				7/21	6	40.8	5.72	05MW10S 06/24/97	7.32
cobalt		-				3/21	5.1	18.8	3.67	05MW09SI 06/23/97	4.31
iron		-				18/21	61.4	7440	533	05MW10S 06/24/97	858
lead		-				1/8	18.1	18.1	2.7	05MW07I 06/23/97	12.6
magnesium		-				21/21	1820	12000	6260	05MW01D 07/07/97	7430
manganese		-				19/21	5	397	81.5	05MW01S 06/23/97	356
nickel		-				1/21	74.3	74.3	13.1	05MW10S 06/24/97	14.6
potassium		-				9/21	1630	26000	3360	05MW06I 06/25/97	5400
sodium		-				21/21	7680	29100	14700	05MW10S 06/24/97	17200
vanadium		-				1/21	5	5	2.62	05MW10S 06/24/97	2.77
zinc		-				5/9	27.7	457	68.5	05MW10S 06/24/97	457
dieldrin		-				2/21	0.09	0.3	0.0638	05MW07S 06/23/97	0.0723
1,1,1-trichloroethane		-				10/21	2	960	66	05MW01S 06/23/97	114
1,1,2-trichloroethane		-				1/21	10	10	5.24	05MW01S 06/23/97	5.55
1,1-dichloroethane		-				9/21	4	350	30	05MW01S 06/23/97	45.9
1,1-dichloroethene		-				9/21	6	300	31.2	05MW01S 06/23/97	52.9
1,2-dichloroethane		-				2/21	3	4	4.86	05MW01S 06/23/97	4
1,2-dichloroethene (total)						7/21	1	99	8.95	05MW01S 06/23/97	11
benzene		-				2/21	3	28	6	05MW01S 06/23/97	6.79
tetrachloroethene		-				8/21	1	35	6.86	05MW01D 07/07/97	9.48
trichloroethene		-				9/21	5	300	25.7	05MW01S 06/23/97	33.9

Table 4-15
Occurrence and Distribution of Organics and Inorganics in Groundwater, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Background Data					Site-Related Data				
	Freq. of Detection	Range of Positive Detection		Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection		Mean of All Data	Sampling Round and Location of Maximum	Representative Concentration
		Min.	Max.				Min.	Max.			

Notes:

Units are ug/L.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result.
Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.
The determination of representative concentrations is based on comparison of maximum to the 95 % UCL, which is presented in a separate table.
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.
Number of samples may vary based on the number of usable results.

TABLE 4-16
Background Comparison Tests - Groundwater Data for Site 5
NASJRB Willow Grove, Pennsylvania

Name of Test:	Detection Freq: Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:	Site Freq. > Back.Freq.?				Site Maximum > UTL for Background Data ?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation =Background Std.Dev.?						
Assumptions Valid:	#ND & Pos >=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back.	Site	P	YN	Back.	Std.Dev.	t	L,N	Back.	Site	YN	r	k	P	YN	P	Test	Used	YN	Back.	Site	t	t	YN	Back.	Site	Std.Dev.	Std.Dev.	F	F	YN
Substance	Freq.	Freq.	Value		Mean@	Back.@	Value	Q	UTL	Max.				Value		Value				Mean@	Mean@	Value	Table		Distrib.	Distrib.	Back.@	Site@	Value	Table	
aluminum	N	0/0	7/16		NA						6970	NA				NA				NA		540			NA		nonpar.					NA
arsenic	N	0/0	1/21		NA						2	NA				NA				NA		0.571			NA		nonpar.					NA
barium	Y	0/0	21/21		NA						1430	NA				NA				NA		5.35			NA		lognor.		0.961			NA
beryllium	N	0/0	1/21		NA						2.8	NA				NA				NA		0.61			NA		nonpar.					NA
calcium	N	0/0	21/21		NA						39000	NA				NA				NA		22300			NA		nonpar.					NA
chromium	N	0/0	7/21		NA						40.8	NA				NA				NA		5.72			NA		nonpar.					NA
cobalt	N	0/0	3/21		NA						18.8	NA				NA				NA		3.67			NA		nonpar.					NA
iron	N	0/0	18/21		NA						7440	NA				NA				NA		533			NA		nonpar.					NA
lead	N	0/0	1/8		NA						18.1	NA				NA				NA		2.7			NA		nonpar.					NA
magnesium	N	0/0	21/21		NA						12000	NA				NA				NA		6260			NA		normal					NA
manganese	N	0/0	19/21		NA						397	NA				NA				NA		3.35			NA		lognor.		1.6			NA
nickel	N	0/0	1/21		NA						74.3	NA				NA				NA		13.1			NA		nonpar.					NA
potassium	N	0/0	9/21		NA						26000	NA				NA				NA		3360			NA		nonpar.					NA
sodium	Y	0/0	21/21		NA						29100	NA				NA				NA		9.52			NA		lognor.		0.377			NA
vanadium	N	0/0	1/21		NA						5	NA				NA				NA		2.62			NA							NA
zinc	Y	0/0	5/9		NA						457	NA				NA				NA		68.5			NA		lognor.					NA
dieldrin	N	0/0	2/21		NA						0.3	NA				NA				NA		0.0638			NA							NA
1,1,1-trichloroethane	Y	0/0	10/21		NA						960	NA				NA				NA		66			NA		nonpar.					NA
1,1,2-trichloroethane	N	0/0	1/21		NA						10	NA				NA				NA		5.24			NA							NA
1,1-dichloroethane	Y	0/0	9/21		NA						350	NA				NA				NA		30			NA		nonpar.					NA
1,1-dichloroethene	Y	0/0	9/21		NA						300	NA				NA				NA		31.2			NA							NA
1,2-dichloroethane	N	0/0	2/21		NA						4	NA				NA				NA		4.86			NA							NA
benzene	N	0/0	2/21		NA						28	NA				NA				NA		6			NA							NA
tetrachloroethene	N	0/0	8/21		NA						35	NA				NA				NA		6.86			NA		nonpar.					NA
trichloroethene	Y	0/0	9/21		NA						300	NA				NA				NA		25.7			NA		nonpar.					NA

Notes: Units are ug/L.

A statistical significance level (P value) of 0.05 is used for all tests that directly compare site to background. A two-sided significance level of 0.1 is used for Bartlett's test for equal variance.

UTL is the expected value for the upper 95 % quantile of the background population; there is an equal chance of the population's true 95 % quantile being either below or above this estimate.

For each test, a YES or NO decision is presented only if all assumptions are met. The overall decision (is site > background) for each chemical appears at the left and is based on four criteria:

(1) Overall decision is YES if any one of the UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is YES, regardless of other test results.

(2) Overall decision is NO if at least one of UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is NO, and none of the aforementioned tests are YES.

(3) Overall decision is YES/NO if Z/Fisher Test is YES/NO, respectively, and other tests are NA. Z-test is treated as lowest priority since it relies on detection frequency, not magnitude of results.

TABLE 4-16

Background Comparison Tests - Groundwater Data for Site 5
NASJRB Willow Grove, Pennsylvania

Name of Test:	Detection Freq: Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:	Site Freq. > Back.Freq.?				Site Maximum > UTL for Background Data ?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation =Background Std.Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back.	Site	P	YN	Back.	Std.Dev.	t	L,N	Back.	Site	YN	r	k	P	YN	P	Test	Used	YN	Back.	Site	t	t	YN	Back.	Site	Std.Dev.	Std.Dev.	F	F	YN
Substance	Freq.	Freq.	Value		Mean@	Back.@	Value	Q	UTL	Max.				Value		Value				Mean@	Mean@	Value	Table		Distrib.	Distrib.	Back.@	Site@	Value	Table	

(4) Overall decision is NA if all tests are NA. (Chemicals assigned NA are still included in human health risk-based screening and/or risk assessment.)

Abbreviations:

# NDs or # Pos.	Number of non-detected (ND) or positive (Pos.) results in data set, not including rejected data or blank-qualified data.
# s or # b	Number of site (s) or background (b) samples, not including rejected data or blank-qualified data.
s = b	Standard deviation of site results must not be different from the standard deviation of background results.
P value	Probability or significance level is defined as the chance of a false positive. If P <= 0.05 then test determines site > background with 95 % confidence.
L, N, or Q	UTL is based on 95 % upper limit (using t-value) when data are lognormal (L) or normal (N). Otherwise, an upper 95 % quantile (Q) is used if there are > 18 back. points.
% ND	Mann-Whitney test used if < 40% of data Non-Detected and detect. limits uniformly below the range of positive values. If not, the Gehan Test is used.
@	Mean and standard deviations are shown of log-transformed data when distributions are of this type; ie., if an (L) code appears for the UTL test or if site and background distributions both match lognormal, and both T-test and Bartlett's test are applicable. (Arithmetic mean and normal standard deviation are shown only for illustration in the event that these tests are NA.)
r,k	The upper ranks test calculates the probability that k or more samples from the top r ranks of the combined site and background data set are comprised of site data if both populations are in fact equal.

TABLE 4-17

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW01D	05MW01I	05MW01I	05MW01S	05MW01S	SCREENING VALUES			
LOCATION:	05MW01I	05MW01I	05MW01I	05MW01S	05MW01S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	07/07/97	06/23/97	09/25/00	06/23/97	09/18/91				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	89.4	50 U	n/a	50 U	n/a	-	-	-	37000
barium	363	502	n/a	266	n/a	2000	700	2000	2600
calcium	30100	31000	n/a	13100	n/a	-	-	-	-
chromium, total	10.7	5 U	n/a	5 U	n/a	100 *	1000	100	110
iron	220 J	142	n/a	71	n/a	-	-	-	11000
lead	1.2 B	2.5 B	n/a	7 B	n/a	15.0	-	5.00	15.0
magnesium	12000	8610	n/a	5750	n/a	-	-	-	-
manganese	81.5	55.1	n/a	397	n/a	-	-	-	730
potassium	9420	10700	n/a	1500 U	n/a	-	-	-	-
sodium	23400	15600	n/a	15800	n/a	-	-	-	-
zinc	6.2 B	18.1 B	n/a	21.8 B	n/a	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10 U	54	10 U	960 E	2800 E	200	200 a	200	3200
1,1,2-trichloroethane	10 U	10 U	10 U	10 E J	250 U	5.00	3.00 a	5.00	0.190
1,1-dichloroethane	10 U	50 E	10 U	350 E	420 E	-	-	27.0	800
1,1-dichloroethene	10 U	35 E J	10 U	300 E J	840 E	7.00	7.00 a	7.00	0.0440
1,2-dichloroethane	10 U	3 E J	10 U	4 E J	250 U	5.00	700	5.00	0.120
1,2-dichloroethene (total)	10 U	6 J	n/a	99 E	180 E J	70.0 a	70.0 a	70.0	55.0
acetone	10 U	10 U	2.8 J	10 U	500 U	-	-	3700	610
benzene	10 U	10 U	10 U	28 E	250 U	5.00	200	5.00	0.320
methylene chloride	5 B	7 B	10 U	7 B	250 U	5.00	2000 d	5.00	4.10
tetrachloroethene	35 E	3 E J	10 U	24 E	500 U	5.00	10.0 a	5.00	1.10
trichloroethene	10 U	23 E	10 U	300 E	590 E	5.00	-	5.00	1.60

TABLE 4-17

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW01S-RE-D	05MW01S-RE	05MW01SI	05MW01SI	05MW02S	SCREENING VALUES			
LOCATION:	05MW01S	05MW01S	05MW01SI	05MW01SI	05MW02S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	09/25/00	09/25/00	09/20/91	09/25/00	06/24/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
barium	n/a	n/a	n/a	n/a	43.8	2000	700	2000	2600
calcium	n/a	n/a	n/a	n/a	7200	-	-	-	-
magnesium	n/a	n/a	n/a	n/a	2230	-	-	-	-
sodium	n/a	n/a	n/a	n/a	9410	-	-	-	-
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	2700 E	2400 E J	260 E	73	10 U	200	200 a	200	3200
1,1,2-trichloroethane	38 E J	42 E	5 U	10 U	10 U	5.00	3.00 a	5.00	0.190
1,1-dichloroethane	590 E	620 E J	84 E	54 E	10 U	-	-	27.0	800
1,1-dichloroethene	530 E	600 E J	120 E J	43 E	10 U	7.00	7.00 a	7.00	0.0440
1,2-dichlorobenzene	200 U	4.5 J	n/a	10 U	10 U	600	600 a	600	550
1,2-dichlorobenzene	200 U	4.5 J	n/a	10 U	10 U	600	600 a	600	550
1,2-dichloroethane	200 U	13 E	5 U	10 U	10 U	5.00	700	5.00	0.120
1,2-dichloroethene (total)	n/a	n/a	11 J	n/a	1 J	70.0 a	70.0 a	70.0	55.0
1,4-dichlorobenzene	200 U	21 E	n/a	10 U	10 U	75.0	75.0 a	75.0	0.470
1,4-dichlorobenzene	200 U	21 E	n/a	10 U	10 U	75.0	75.0 a	75.0	0.470
acetone	74 J	10 U	10 U	10 U	10 U	-	-	3700	610
benzene	53 E J	58 E	16 E J	10 U	10 U	5.00	200	5.00	0.320
chloroform	200 U	1.1 E J	5 U	10 U	10 U	80.0	4000	100	0.150
cis-1,2-dichloroethene	450 E	460 E J	n/a	9.8 J	n/a	70.0	70.0 a	70.0	61.0
methylcyclohexane	200 U	18	n/a	10 U	n/a				6300
methylene chloride	200 U	5.9 E J	6 B	10 U	5 B	5.00	2000 d	5.00	4.10
tetrachloroethene	79 E J	87 E	8 E	4.2 E J	1 J	5.00	10.0 a	5.00	1.10
toluene	200 U	10 U	3 B	10 U	10 U	1000	1000 a	1000	750
trans-1,2-dichloroethene	200 U	3.5 J	n/a	10 U	n/a	100	100 a	100	120
trichloroethene	890 E	740 E J	69 E J	29 E	10 U	5.00	-	5.00	1.60

TABLE 4-17

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW02S	05MW02S	05MW02S-DUP	05MW02S	05MW03I	SCREENING VALUES			
LOCATION:	05MW02S	05MW02S	05MW02S	05MW02S	05MW03I	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	08/07/97	09/18/91	06/24/97	09/18/00	06/24/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	n/a	n/a	50 U	n/a	282	-	-	-	37000
barium	n/a	n/a	45.6	n/a	77.5	2000	700	2000	2600
calcium	n/a	n/a	7120	n/a	32700	-	-	-	-
chromium, total	n/a	n/a	5 U	n/a	7.2 K	100 *	1000	100	110
iron	n/a	n/a	50 U	n/a	357	-	-	-	11000
lead	n/a	n/a	2.1 B	n/a	1.2 B	15.0	-	5.00	15.0
magnesium	n/a	n/a	2220	n/a	3620	-	-	-	-
manganese	n/a	n/a	5 U	n/a	14 K	-	-	-	730
potassium	n/a	n/a	1500 U	n/a	3300	-	-	-	-
sodium	n/a	n/a	9320	n/a	17500	-	-	-	-
zinc	n/a	n/a	5 U	n/a	7.5 B	-	2000 a	2000	11000
SEMIVOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
di-n-butyl phthalate	2 B	n/a	10 U	n/a	10 U	-	-	3700	3700
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	n/a	5 U	10 U	10 U	13	200	200 a	200	3200
1,1-dichloroethane	n/a	5 U	10 U	10 U	18	-	-	27.0	800
1,1-dichloroethene	n/a	5 U	10 U	10 U	7 E J	7.00	7.00 a	7.00	0.0440
1,2-dichloroethene (total)	n/a	5 U	1 J	n/a	2 J	70.0 a	70.0 a	70.0	55.0
acetone	n/a	10 U	10 U	2.1 J	10 U	-	-	3700	610
cis-1,2-dichloroethene	n/a	n/a	n/a	2.7 J	n/a	70.0	70.0 a	70.0	61.0
methylene chloride	n/a	8 B	6 B	10 U	6 B	5.00	2000 d	5.00	4.10
tetrachloroethene	n/a	2 E J	2 E J	5.6 E J	2 E J	5.00	10.0 a	5.00	1.10
trichloroethene	n/a	5 U	10 U	10 U	5 E J	5.00	-	5.00	1.60

TABLE 4-17

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW03I	05MW03S	05MW03S	05MW03S	05MW04I	SCREENING VALUES			
LOCATION:	05MW03I	05MW03S	05MW03S	05MW03S	05MW04I	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	09/18/00	06/24/97	09/18/91	09/18/00	09/21/00				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
barium	n/a	44.5	n/a	n/a	136 B	2000	700	2000	2600
calcium	n/a	7300	n/a	n/a	n/a	-	-	-	-
chromium, total	n/a	6.3 K	n/a	n/a	1 U	100 *	1000	100	110
iron	n/a	124	n/a	n/a	n/a	-	-	-	11000
lead	n/a	2.1 B	n/a	n/a	1.9 U	15.0	-	5.00	15.0
magnesium	n/a	2110	n/a	n/a	n/a	-	-	-	-
manganese	n/a	7.5 K	n/a	n/a	n/a	-	-	-	730
sodium	n/a	7680	n/a	n/a	n/a	-	-	-	-
zinc	n/a	19.6 B	n/a	n/a	n/a	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	3.7 J	10 U	1 B	10 U	50	200	200 a	200	3200
1,1-dichloroethane	5.5 J	10 U	5 U	10 U	29 E	-	-	27.0	800
1,1-dichloroethene	3.5 E J	10 U	5 U	10 U	25 E	7.00	7.00 a	7.00	0.0440
acetone	2.1 J	10 U	10 U	2.2 J	3 J	-	-	3700	610
cis-1,2-dichloroethene	1.6 J	n/a	n/a	10 U	5 J	70.0	70.0 a	70.0	61.0
methylene chloride	10 U	6 B	4 B	10 U	10 U	5.00	2000 d	5.00	4.10
tetrachloroethene	2 E J	10 U	5 U	10 U	2.2 E J	5.00	10.0 a	5.00	1.10
trichloroethene	2.5 E J	10 U	5 U	10 U	18 E	5.00	-	5.00	1.60

TABLE 4-17

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW04S	05MW04S	05MW04S	05MW05I	05MW05I-F	SCREENING VALUES			
LOCATION:	05MW04S	05MW04S	05MW04S	05MW05I	05MW05I	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Filt. Mon. Well				
SAMPLE DATE:	06/25/97	09/18/91	09/21/00	09/21/00	09/21/00				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	82.9 B	n/a	n/a	n/a	n/a	-	-	-	37000
arsenic	1 UL	n/a	n/a	8.3 B	6.8 B	5.00	-	50.0	0.0450
barium	56.8	n/a	n/a	164 B	132 B	2000	700	2000	2600
calcium	5740	n/a	n/a	n/a	n/a	-	-	-	-
chromium, total	5 U	n/a	n/a	10.2	n/a	100 *	1000	100	110
iron	61.4	n/a	n/a	n/a	n/a	-	-	-	11000
lead	2.9 B	n/a	n/a	3.8	1.9 U	15.0	-	5.00	15.0
magnesium	2240	n/a	n/a	n/a	n/a	-	-	-	-
manganese	5 K	n/a	n/a	n/a	n/a	-	-	-	730
sodium	9200	n/a	n/a	n/a	n/a	-	-	-	-
zinc	39.2 B	n/a	n/a	n/a	n/a	-	2000 a	2000	11000
SEMIVOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
bis(2-ethylhexyl)phthalate	1 B	n/a	n/a	n/a	n/a	6.00	-	6.00	4.80
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10 U	3 B	10 U	7.3 J	n/a	200	200 a	200	3200
1,1-dichloroethane	10 U	5 U	10 U	2.9 J	n/a	-	-	27.0	800
1,1-dichloroethene	10 U	5 U	10 U	9.2 E J	n/a	7.00	7.00 a	7.00	0.0440
acetone	10 U	10 U	10 U	3.5 J	n/a	-	-	3700	610
methylene chloride	17 B	5 U	10 U	10 U	n/a	5.00	2000 d	5.00	4.10
trichloroethene	10 U	5 U	10 U	2.9 E J	n/a	5.00	-	5.00	1.60

TABLE 4-17

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW05S	05MW05S	05MW05S-DUP	05MW05S	05MW06I	SCREENING VALUES			
LOCATION:	05MW05S	05MW05S	05MW05S	05MW05S	05MW06I	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	06/24/97	09/20/91	09/20/91	09/12/00	06/25/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	50 U	n/a	n/a	n/a	59.5 B	-	-	-	37000
barium	190	n/a	n/a	n/a	178	2000	700	2000	2600
calcium	6860	n/a	n/a	n/a	7640	-	-	-	-
chromium, total	6 K	n/a	n/a	n/a	5 U	100 *	1000	100	110
iron	85.9	n/a	n/a	n/a	50 U	-	-	-	11000
lead	3.4 B	n/a	n/a	n/a	1 U	15.0	-	5.00	15.0
magnesium	1820	n/a	n/a	n/a	5790	-	-	-	-
manganese	5.5 K	n/a	n/a	n/a	5 U	-	-	-	730
potassium	1500 U	n/a	n/a	n/a	26000	-	-	-	-
sodium	12300	n/a	n/a	n/a	25200	-	-	-	-
zinc	9 B	n/a	n/a	n/a	5 U	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
acetone	10 U	10 U	10 U	1.8 J	10 U	-	-	3700	610
methylene chloride	5 B	5 U	3 B	10 U	17 B	5.00	2000 d	5.00	4.10

TABLE 4-17

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW06I		05MW06I		05MW06S		05MW06S		05MW06S		SCREENING VALUES			
LOCATION:	05MW06I		05MW06I		05MW06S		05MW06S		05MW06S		Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well		Monitoring Well		Monitoring Well		Monitoring Well		Monitoring Well					
SAMPLE DATE:	09/13/00		09/20/91		06/25/97		09/20/91		09/13/00					
INORGANICS	**ug/L**		**ug/L**		**ug/L**		**ug/L**		**ug/L**		**ug/L**	**ug/L**	**ug/L**	**ug/L**
aluminum	n/a		n/a		68.3	B	n/a		n/a		-	-	-	37000
barium	n/a		n/a		111		n/a		n/a		2000	700	2000	2600
calcium	n/a		n/a		7320		n/a		n/a		-	-	-	-
lead	n/a		n/a		2.8	B	n/a		n/a		15.0	-	5.00	15.0
magnesium	n/a		n/a		3410		n/a		n/a		-	-	-	-
manganese	n/a		n/a		14.2	K	n/a		n/a		-	-	-	730
sodium	n/a		n/a		8510		n/a		n/a		-	-	-	-
VOLATILES	**ug/L**		**ug/L**		**ug/L**		**ug/L**		**ug/L**		**ug/L**	**ug/L**	**ug/L**	**ug/L**
acetone	2.2	J	10	U	10	U	10	U	2	J	-	-	3700	610
methylene chloride	10	U	5	U	16	B	5	U	10	U	5.00	2000 d	5.00	4.10
toluene	10	U	1	B	10	U	5	U	10	U	1000	1000 a	1000	750

TABLE 4-17

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW07I	05MW07I	05MW07I	05MW07S	05MW07S	SCREENING VALUES			
LOCATION:	05MW07I	05MW07I	05MW07I	05MW07S	05MW07S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	06/23/97	09/14/00	09/20/91	06/23/97	09/20/91				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
barium	460	n/a	n/a	95.1	n/a	2000	700	2000	2600
calcium	35600	n/a	n/a	24300	n/a	-	-	-	-
iron	90.3	n/a	n/a	71.8	n/a	-	-	-	11000
lead	18.1 E	n/a	n/a	1 U	n/a	15.0	-	5.00	15.0
magnesium	6980	n/a	n/a	9850	n/a	-	-	-	-
manganese	142	n/a	n/a	6.4 K	n/a	-	-	-	730
potassium	2330	n/a	n/a	1500 U	n/a	-	-	-	-
sodium	10000	n/a	n/a	10700	n/a	-	-	-	-
zinc	5 U	n/a	n/a	24.1 B	n/a	-	2000 a	2000	11000
SEMIVOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
bis(2-ethylhexyl)phthalate	10 U	n/a	n/a	6 B	n/a	6.00	-	6.00	4.80
di-n-butyl phthalate	3 B	n/a	n/a	3 B	n/a	-	-	3700	3700
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10 U	3.3 J	6	10 U	2 J	200	200 a	200	3200
1,1-dichloroethane	10 U	2.9 J	2 J	10 U	1 J	-	-	27.0	800
1,1-dichloroethene	10 U	5.4 E J	4 E J	10 U	5 U	7.00	7.00 a	7.00	0.0440
acetone	10 U	2.1 J	10 U	10 U	10 U	-	-	3700	610
methylene chloride	6 B	10 U	3 B	6 B	5 U	5.00	2000 d	5.00	4.10
toluene	10 U	10 U	2 B	10 U	1 B	1000	1000 a	1000	750
trichloroethene	10 U	2.4 E J	2 E J	10 U	5 U	5.00	-	5.00	1.60
PESTICIDES/PCBS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
dieldrin	0.1 U	n/a	n/a	0.3 E	n/a	-	0.500	0.0410	0.00420

TABLE 4-17

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW07S	05MW08I	05MW08I-DUP	05MW08I	05MW08S	SCREENING VALUES			
LOCATION:	05MW07S	05MW08I	05MW08I	05MW08I	05MW08S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	09/14/00	06/23/97	06/23/97	09/15/00	06/25/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	n/a	230	213	n/a	173 B	-	-	-	37000
barium	n/a	372	378	n/a	75.9	2000	700	2000	2600
calcium	n/a	35100	35700	n/a	27300	-	-	-	-
iron	n/a	300	269	n/a	256	-	-	-	11000
lead	n/a	1 B	1.2 B	n/a	1 U	15.0	-	5.00	15.0
magnesium	n/a	8560	8710	n/a	6650	-	-	-	-
manganese	n/a	6.5 K	6.5 K	n/a	57.1	-	-	-	730
potassium	n/a	1500 U	1500 U	n/a	2770	-	-	-	-
sodium	n/a	10100	10100	n/a	15100	-	-	-	-
zinc	n/a	34.8 K	24.9 B	n/a	49.1	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10 U	2 J	10 U	10 U	10 U	200	200 a	200	3200
acetone	2.1 J	10 U	10 U	3 J	10 U	-	-	3700	610
methylene chloride	10 U	7 B	6 B	10 U	16 B	5.00	2000 d	5.00	4.10

TABLE 4-17

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW08S-DUP	05MW08S	05MW08SI	05MW08SI	05MW09I	SCREENING VALUES			
LOCATION:	05MW08S	05MW08S	05MW08S	05MW08SI	05MW09I	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	09/15/00	09/15/00	09/15/00	06/23/97	06/23/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	n/a	n/a	n/a	679	162 B	-	-	-	37000
barium	n/a	n/a	n/a	487	594	2000	700	2000	2600
calcium	n/a	n/a	n/a	39000	38400	-	-	-	-
chromium, total	n/a	n/a	n/a	5 U	7.3 K	100 *	1000	100	110
cobalt	n/a	n/a	n/a	5 U	8.1 K	-	-	2200	2200
iron	n/a	n/a	n/a	765	450	-	-	-	11000
lead	n/a	n/a	n/a	1.5 B	2.2 B	15.0	-	5.00	15.0
magnesium	n/a	n/a	n/a	8450	10100	-	-	-	-
manganese	n/a	n/a	n/a	46.3	21.4 K	-	-	-	730
sodium	n/a	n/a	n/a	12400	10300	-	-	-	-
zinc	n/a	n/a	n/a	24.9 B	27.7 K	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10 U	10 U	1.9 J	10 U	38	200	200 a	200	3200
1,1-dichloroethane	10 U	10 U	1.2 J	10 U	26	-	-	27.0	800
1,1-dichloroethene	10 U	10 U	3.7 E J	10 U	37 E J	7.00	7.00 a	7.00	0.0440
1,2-dichloroethene (total)	n/a	n/a	n/a	10 U	1 J	70.0 a	70.0 a	70.0	55.0
acetone	2 J	2 J	1.6 J	10 U	10 U	-	-	3700	610
methylene chloride	10 U	10 U	10 U	7 B	6 B	5.00	2000 d	5.00	4.10
trichloroethene	10 U	10 U	1.5 J	10 U	15 E	5.00	-	5.00	1.60

TABLE 4-17

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW09I	05MW09S	05MW09S	05MW09SI	05MW09SI	SCREENING VALUES			
LOCATION:	05MW09I	05MW09S	05MW09S	05MW09SI	05MW09SI	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	09/21/00	06/24/97	09/26/00	06/23/97	09/21/00				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	n/a	50 U	n/a	59.9	n/a	-	-	-	37000
barium	n/a	143	n/a	401	n/a	2000	700	2000	2600
calcium	n/a	9650	n/a	26700	n/a	-	-	-	-
chromium, total	n/a	5 U	n/a	6.9 K	n/a	100 *	1000	100	110
cobalt	n/a	5 U	n/a	18.8 K	n/a	-	-	2200	2200
iron	n/a	62.1	n/a	267	n/a	-	-	-	11000
lead	n/a	2.6 B	n/a	1 U	n/a	15.0	-	5.00	15.0
magnesium	n/a	3100	n/a	5460	n/a	-	-	-	-
manganese	n/a	148	n/a	244	n/a	-	-	-	730
potassium	n/a	1680	n/a	1500 U	n/a	-	-	-	-
sodium	n/a	20700	n/a	16100	n/a	-	-	-	-
zinc	n/a	13.7 B	n/a	37.6 K	n/a	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	11	28	11	64	41	200	200 a	200	3200
1,1-dichloroethane	12	27	12	42 E	35 E	-	-	27.0	800
1,1-dichloroethene	13 E	25 E J	20 E	53 E J	57 E	7.00	7.00 a	7.00	0.0440
1,2-dichloroethane	10 U	10 U	10 U	10 U	1.1 E J	5.00	700	5.00	0.120
1,2-dichloroethene (total)	n/a	10 U	n/a	3 J	n/a	70.0 a	70.0 a	70.0	55.0
benzene	10 U	10 U	1.2 E J	3 E J	10 U	5.00	200	5.00	0.320
cis-1,2-dichloroethene	10 U	n/a	10 U	n/a	2.1 J	70.0	70.0 a	70.0	61.0
methylene chloride	10 U	4 B	10 U	7 B	10 U	5.00	2000 d	5.00	4.10
tetrachloroethene	10 U	2 E J	1.6 E J	4 E J	2.9 E J	5.00	10.0 a	5.00	1.10
trichloroethene	5.5 E J	17 E	8.2 E J	32 E	26 E	5.00	-	5.00	1.60

TABLE 4-17

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW10I	05MW10I	05MW10S	05MW10S	05MW10SI	SCREENING VALUES			
LOCATION:	05MW10I	05MW10I	05MW10S	05MW10S	05MW10S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	06/24/97	09/18/00	06/24/97	09/15/00	09/18/00				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	50 U	n/a	6970	n/a	n/a	-	-	-	37000
arsenic	1 U	n/a	2 E L	n/a	n/a	5.00	-	50.0	0.0450
barium	403	n/a	1430 E	n/a	n/a	2000	700	2000	2600
beryllium	1 U	n/a	2.8	n/a	n/a	4.00	30000	4.00	73.0
calcium	34500	n/a	16300	n/a	n/a	-	-	-	-
chromium, total	5 U	n/a	40.8	n/a	n/a	100 *	1000	100	110
cobalt	5 U	n/a	5.1	n/a	n/a	-	-	2200	2200
copper	10 U	n/a	20.8 B	n/a	n/a	1300	-	1000	1500
iron	87.5	n/a	7440	n/a	n/a	-	-	-	11000
lead	1 U	n/a	19.9 B	n/a	n/a	15.0	-	5.00	15.0
magnesium	10900	n/a	7220	n/a	n/a	-	-	-	-
manganese	22.4 K	n/a	356	n/a	n/a	-	-	-	730
nickel	20 U	n/a	74.3	n/a	n/a	-	100 a	100	730
potassium	1630	n/a	3770	n/a	n/a	-	-	-	-
sodium	11600	n/a	29100	n/a	n/a	-	-	-	-
vanadium	5 U	n/a	5 E	n/a	n/a	-	-	2.10	260
zinc	14.1 B	n/a	457	n/a	n/a	-	2000 a	2000	11000
SEMIVOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
bis(2-ethylhexyl)phthalate	10 U	n/a	1 B	n/a	n/a	6.00	-	6.00	4.80
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	18	5.5 J	13	4.8 J	120	200	200 a	200	3200
1,1,2-trichloroethane	10 U	10 U	10 U	10 U	2.5 E J	5.00	3.00 a	5.00	0.190
1,1-dichloroethane	9 J	4.3 J	4 J	3 J	52 E	-	-	27.0	800
1,1-dichloroethene	12 E J	7.6 E J	6 E J	7.3 E J	120 E	7.00	7.00 a	7.00	0.0440
1,2-dichloroethane	10 U	10 U	10 U	10 U	2 E J	5.00	700	5.00	0.120
acetone	10 U	2.3 J	10 U	1.8 J	2.5 J	-	-	3700	610
carbon tetrachloride	10 U	10 U	10 U	10 U	19 E	5.00	200 d	5.00	0.160
cis-1,2-dichloroethene	n/a	10 U	n/a	10 U	8.8 J	70.0	70.0 a	70.0	61.0

TABLE 4-17

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW10I	05MW10I	05MW10S	05MW10S	05MW10SI	SCREENING VALUES			
LOCATION:	05MW10I	05MW10I	05MW10S	05MW10S	05MW10S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	06/24/97	09/18/00	06/24/97	09/15/00	09/18/00				
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
methylene chloride	4 B	10 U	17 B	10 U	10 U	5.00	2000 d	5.00	4.10
tetrachloroethene	10 U	10 U	10 U	10 U	8.7 E J	5.00	10.0 a	5.00	1.10
trichloroethene	8 E J	2.5 E J	5 E J	2.8 E J	68 E	5.00	-	5.00	1.60
PESTICIDES/PCBS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
dieldrin	0.1 U	n/a	0.09 E J	n/a	n/a	-	0.500	0.0410	0.00420

TABLE 4-17

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW10SI	05MW11I	05MW11I	05MW11S	05MW11S	SCREENING VALUES			
LOCATION:	05MW10SI	05MW11I	05MW11I	05MW11S	05MW11S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	06/24/97	05/28/98	09/13/00	05/28/98	09/12/00				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	101	387	n/a	50.2	n/a	-	-	-	37000
antimony	20 U	1.9 B	n/a	1.9 B	n/a	6.00	6.00 a	6.00	15.0
arsenic	1 U	2.3 U	n/a	3.3 E	n/a	5.00	-	50.0	0.0450
barium	354	201	n/a	98.3	n/a	2000	700	2000	2600
beryllium	1 U	0.47 K	n/a	0.62 K	n/a	4.00	30000	4.00	73.0
cadmium	5 U	0.21 L	n/a	0.31 L	n/a	5.00	5.00 a	5.00	18.0
calcium	32100	64100	n/a	14200	n/a	-	-	-	-
chromium, total	5 U	8.4 K	n/a	1.8 K	n/a	100 *	1000	100	110
cobalt	5 U	3	n/a	0.87 K	n/a	-	-	2200	2200
copper	10 U	4.4	n/a	1.8 K	n/a	1300	-	1000	1500
cyanide	5 U	10.3	n/a	10 U	n/a	200	200	200	730
iron	263	769	n/a	83.5	n/a	-	-	-	11000
magnesium	6550	13300	n/a	3030	n/a	-	-	-	-
manganese	75.7	185	n/a	5 K	n/a	-	-	-	730
mercury	0.2 U	0.1	n/a	0.1 U	n/a	2.00	2.00	2.00	3.70
nickel	20 U	6.5	n/a	4	n/a	-	100 a	100	730
potassium	1500 U	7640	n/a	842	n/a	-	-	-	-
sodium	17700	19000	n/a	10100	n/a	-	-	-	-
vanadium	5 U	0.5 B	n/a	0.5 B	n/a	-	-	2.10	260
zinc	17.6 B	34.3	n/a	28.7	n/a	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	140	10 U	10 U	10 U	10 U	200	200 a	200	3200
1,1-dichloroethane	45 E	10 U	10 U	10 U	10 U	-	-	27.0	800
1,1-dichloroethene	120 E J	10 U	10 U	10 U	10 U	7.00	7.00 a	7.00	0.0440
1,2-dichloroethene (total)	6 J	10 U	n/a	10 U	n/a	70.0 a	70.0 a	70.0	55.0
acetone	10 U	6 B	2.5 J	6 B	14	-	-	3700	610
benzene	10 U	10 U	1.2 E J	10 U	10 U	5.00	200	5.00	0.320
chlorobenzene	10 U	10 U	1.3 J	10 U	10 U	-	-	100	110

TABLE 4-17

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW10SI		05MW11I		05MW11I		05MW11S		05MW11S		SCREENING VALUES			
LOCATION:	05MW10SI		05MW11I		05MW11I		05MW11S		05MW11S		Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well		Monitoring Well		Monitoring Well		Monitoring Well		Monitoring Well					
SAMPLE DATE:	06/24/97		05/28/98		09/13/00		05/28/98		09/12/00					
VOLATILES	ug/L		ug/L		ug/L		ug/L		ug/L		ug/L	ug/L	ug/L	ug/L
chloroform	10	U	10	U	1	E J	10	U	10	U	80.0	4000	100	0.150
methylene chloride	20	B	2	B	1.3	J	3	B	10	U	5.00	2000 d	5.00	4.10
tetrachloroethene	8	E J	10	U	10	U	10	U	10	U	5.00	10.0 a	5.00	1.10
toluene	10	U	10	U	1.2	J	10	U	10	U	1000	1000 a	1000	750
trichloroethene	75	E	10	U	1.2	J	10	U	10	U	5.00	-	5.00	1.60
xylenes, total	10	U	10	U	1.4	J	10	U	10	U	10000	10000 a	10000	12000
PESTICIDES/PCBS	ug/L		ug/L		ug/L		ug/L		ug/L		ug/L	ug/L	ug/L	ug/L
Aroclor-1221	2	UJ	2	U	n/a		0.98	B	n/a		0.500	-	1.30	0.0330
dieldrin	0.1	UJ	0.1	U	n/a		0.0051 E	J	n/a		-	0.500	0.0410	0.00420
endrin aldehyde	0.1	UJ	0.021	B	n/a		0.054	B	n/a					11.0
gamma-chlordane	0.05	UJ	0.0049	J	n/a		0.05	U	n/a		2.00	60.0	2.00	0.190
heptachlor	0.05	UJ	0.014	B	n/a		0.02	B	n/a		0.400	10.0	0.400	0.0150

TABLE 4-17

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW11SI	05MW11SI-DUP	05MW11SI	05MW12I	05MW12I-DUP	SCREENING VALUES			
LOCATION:	05MW11SI	05MW11SI	05MW11SI	05MW12I	05MW12I-DUP	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	05/28/98	05/28/98	09/12/00	09/21/00	09/21/00				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	105	73.9	n/a	n/a	n/a	-	-	-	37000
antimony	1.9 B	1.9 B	n/a	n/a	n/a	6.00	6.00 a	6.00	15.0
barium	170	166	n/a	125 B	125 B	2000	700	2000	2600
beryllium	0.51 K	0.59 K	n/a	n/a	n/a	4.00	30000	4.00	73.0
cadmium	0.22 L	0.25 L	n/a	0.49 U	0.49 U	5.00	5.00 a	5.00	18.0
calcium	15300	15000	n/a	n/a	n/a	-	-	-	-
chromium, total	0.9 U	0.9 U	n/a	1.3 B	1.4 B	100 *	1000	100	110
cobalt	0.93 K	0.6 B	n/a	n/a	n/a	-	-	2200	2200
copper	1.6 K	1.5 K	n/a	n/a	n/a	1300	-	1000	1500
cyanide	10 UJ	160 J	n/a	n/a	n/a	200	200	200	730
iron	320 J	253 J	n/a	n/a	n/a	-	-	-	11000
lead	1.2 U	1.2 U	n/a	2.3 B	2.7 B	15.0	-	5.00	15.0
magnesium	3010	2930	n/a	n/a	n/a	-	-	-	-
manganese	15.3	13.9	n/a	n/a	n/a	-	-	-	730
nickel	3	2.2	n/a	n/a	n/a	-	100 a	100	730
potassium	869	837	n/a	n/a	n/a	-	-	-	-
selenium	3.5 UL	3.5 UL	n/a	2.9 B	2.1 U	50.0	50.0 a	50.0	180
sodium	10600	10400	n/a	n/a	n/a	-	-	-	-
vanadium	0.5 B	0.5 B	n/a	n/a	n/a	-	-	2.10	260
zinc	24.4	21	n/a	n/a	n/a	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10 U	10 U	10 U	5.4 J	5.3 J	200	200 a	200	3200
1,1-dichloroethane	10 U	10 U	10 U	9.5 J	12	-	-	27.0	800
1,1-dichloroethene	10 U	10 U	10 U	4.5 E J	4.2 E J	7.00	7.00 a	7.00	0.0440
acetone	10 U	6 B	10 U	10 U	3.1 J	-	-	3700	610
cis-1,2-dichloroethene	n/a	n/a	10 U	2.4 J	2.2 J	70.0	70.0 a	70.0	61.0
methylene chloride	2 B	2 B	10 U	10 U	10 U	5.00	2000 d	5.00	4.10
tetrachloroethene	10 U	10 U	10 U	2.9 E J	2.8 E J	5.00	10.0 a	5.00	1.10

TABLE 4-17

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW11SI	05MW11SI-DUP	05MW11SI	05MW12I	05MW12I-DUP	SCREENING VALUES			
LOCATION:	05MW11SI	05MW11SI	05MW11SI	05MW12I	05MW12I-DUP	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	05/28/98	05/28/98	09/12/00	09/21/00	09/21/00				
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
trichloroethene	10 U	10 U	10 U	2.9 E J	2.8 E J	5.00	-	5.00	1.60
PESTICIDES/PCBS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Aroclor-1221	2 U	1.2 B	n/a	n/a	n/a	0.500	-	1.30	0.0330
dieldrin	0.1 U	0.004 J	n/a	n/a	n/a	-	0.500	0.0410	0.00420
endrin aldehyde	0.1 U	0.11 B	n/a	n/a	n/a				11.0
heptachlor	0.0046 B	0.058 B	n/a	n/a	n/a	0.400	10.0	0.400	0.0150

Footnotes to sample results:

U - Compound or element was not detected. Value is the detection limit (inorganics) or quantitation limit (organics).
UJ - Not detected. Detection limit or quantitation limit shown is considered estimated due to exceedance of data validation quality control criteria.
UL - Not detected. Detection limit or quantitation limit shown is considered biased low due to exceedance of data validation quality control criteria.
n/a - Constituent was not analyzed for in this sample.
B - (Organic Data). Value is considered a nondetected result due to blank contamination.
B - (Inorganic Data). Value is greater than the Instrument Detection Limit (IDL), but less than the Contract Required Detection Limit (CRDL).
J - Value is estimated because concentration is below the quantitation limit or because of exceedance of data validation quality control criteria.
L - Value is considered biased low because of exceedance of data validation quality control criteria.
K - Value is considered biased high because of exceedance of data validation quality control criteria.
E - Result exceeds one or more of the selected ARARs.

Footnotes to MCLs:

- - No standard is available for this chemical in this classification.
a - Where applicable, value(s) represent the more stringent of criteria for total, cis-, and trans- isomers.
* - Criteria are for total chromium.
** - Copper action level 1300 ug/L for water treatment technology for public water supply systems.
*** - Lead action level 15 ug/L for water treatment technology for public water supply systems.

Footnotes to Health Advisories:

- - No standard is available for this chemical in this classification.
a - The listed health advisory criterion, lifetime adult, is equal to the most stringent of the EPA health advisories for this chemical.
b - The listed health advisory criterion, long-term adult, is equal to the most stringent of the EPA health advisories for this chemical.
c - The listed health advisory criterion, one-day child, is equal to the most stringent of the EPA health advisories for this chemical.
d - The listed health advisory criterion, ten-day child, is equal to the most stringent of the EPA health advisories for this chemical.
e - The listed health advisory criterion, long-term child, is equal to the most stringent of the EPA health advisories for this chemical.

Footnotes to PADEP Criteria:

MSC - Medium-Specific Concentration.

TABLE 4-17A
NATURAL ATTENUATION PARAMETER RESULTS
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE

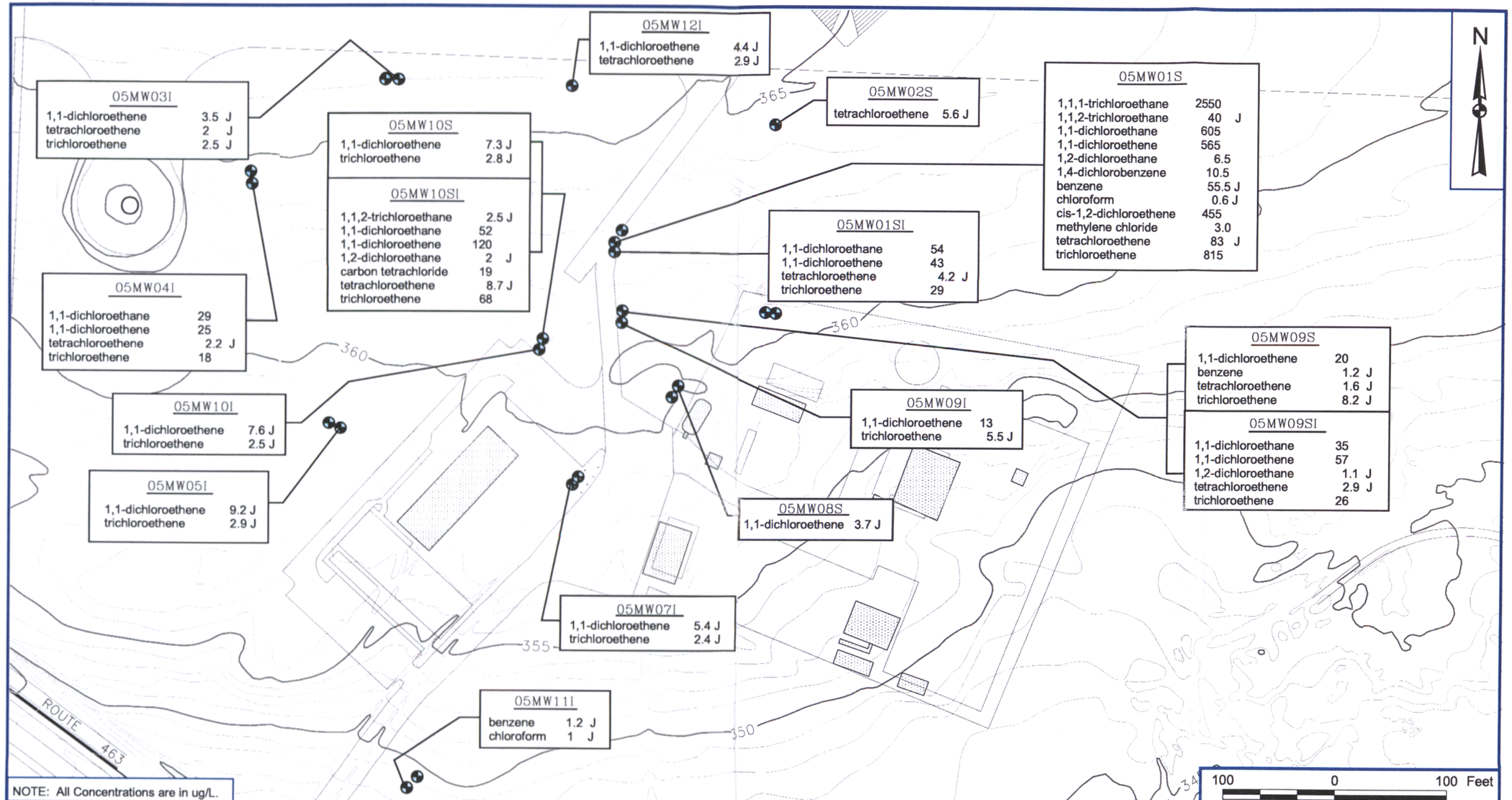
	H	CO2	O	Nitratrogen	Methane	Ethane	Ethene	pH*
Well	(nM/L)	(mg/L	mg/L	(mg/L)	(u/L)	(ug/L)	(ug/L)	
05MW01S	6.4	128.4	1.09	10.4	15.8	0.03	0.05	5.8
05MW01SI	8.8	71.9	0.75	13.6	0.3	nd	0.02	6.2
05MW01I	8.0	6.3	3.15	14.0	nd	nd	nd	7.3
05MW03S	4.1	23.2	5.3	8.0	nd	nd	nd	5.5
05MW03I	3.4	45.6	2.92	11.5	nd	0.01	0.01	6.1
05MW04S	7.1	38.2	5.07	10.5	nd	nd	nd	5.2
05MW04I	7.0	55.1	4.00	14.4	nd	nd	nd	6.0
05MW05S	S**	76.2	2.31	11.1	nd	nd	nd	5.9
05MW06S	S	95.6	2.46	11.7	nd	nd	nd	5.4
05MW06I	S	8.8	2.12	11.4	161.9	nd	nd	7.6
05MW07S	S	119.1	0.64	9.4	nd	nd	0.01	5.7
05MW07I	S	21.8	1.95	13.3	1.5	nd	nd	6.8
05MW08S	S	122	0.86	10.8	nd	nd	nd	5.7
05MW08SI	S	67.2	0.82	11.7	nd	nd	nd	6.4
05MW08I	S	16.1	2.33	10.9	nd	nd	nd	6.8
05MW09S	11.1	174.9	0.36	11.5	0.8	0.01	0.05	5.4
05MW09SI	6.6	90.5	0.73	12.5	nd	nd	0.02	6.2
05MW09I	7.0	21.8	1.92	12.8	nd	0.01	0.01	6.9
05MW10S	S	192.9	0.52	9.7	2.8	nd	0.01	5.5
05MW10SI	S	58.2	1.06	11.4	nd	0.01	0.01	6.5
05MW10I	S	6.5	3.89	16.8	nd	0.01	0.02	7.3
05MW11S	1.8	100.4	0.21	11.3	nd	nd	0.01	5.5
05MW11SI	2.5	83.5	3.05	8.5	nd	nd	nd	5.5
05MW11I	S	1.7	1.09	13	1.3	nd	nd	7.7
05MW12I	9.9	55.0	3.30	12.7	nd	nd	nd	5.7

Criteria (US EPA, 1998)

Tolerated	> 1	> 2 x backgr	< 0.5	< 1	> 0.5	> 0.1	> 0.01	5<pH<9
Score	3	1	3	2	3	3	2	0
not tolerated	< 1		> 5	> 1	< 0.5			5>pH>9
Score	VC oxid.		-3	0	VC oxid.			-2

*pH data from Groundwater Sample Log Sheet (September 2000)
**S Compound saturated detector, actual result > 50 nM/L
nd - not detected

D:\GIS\5466kt01.apr-FIG4-10A 9/7/01 LDL



NOTE: All Concentrations are in ug/L.

NO	DATE	REVISIONS	BY	CHKD	APP'D	REFERENCES

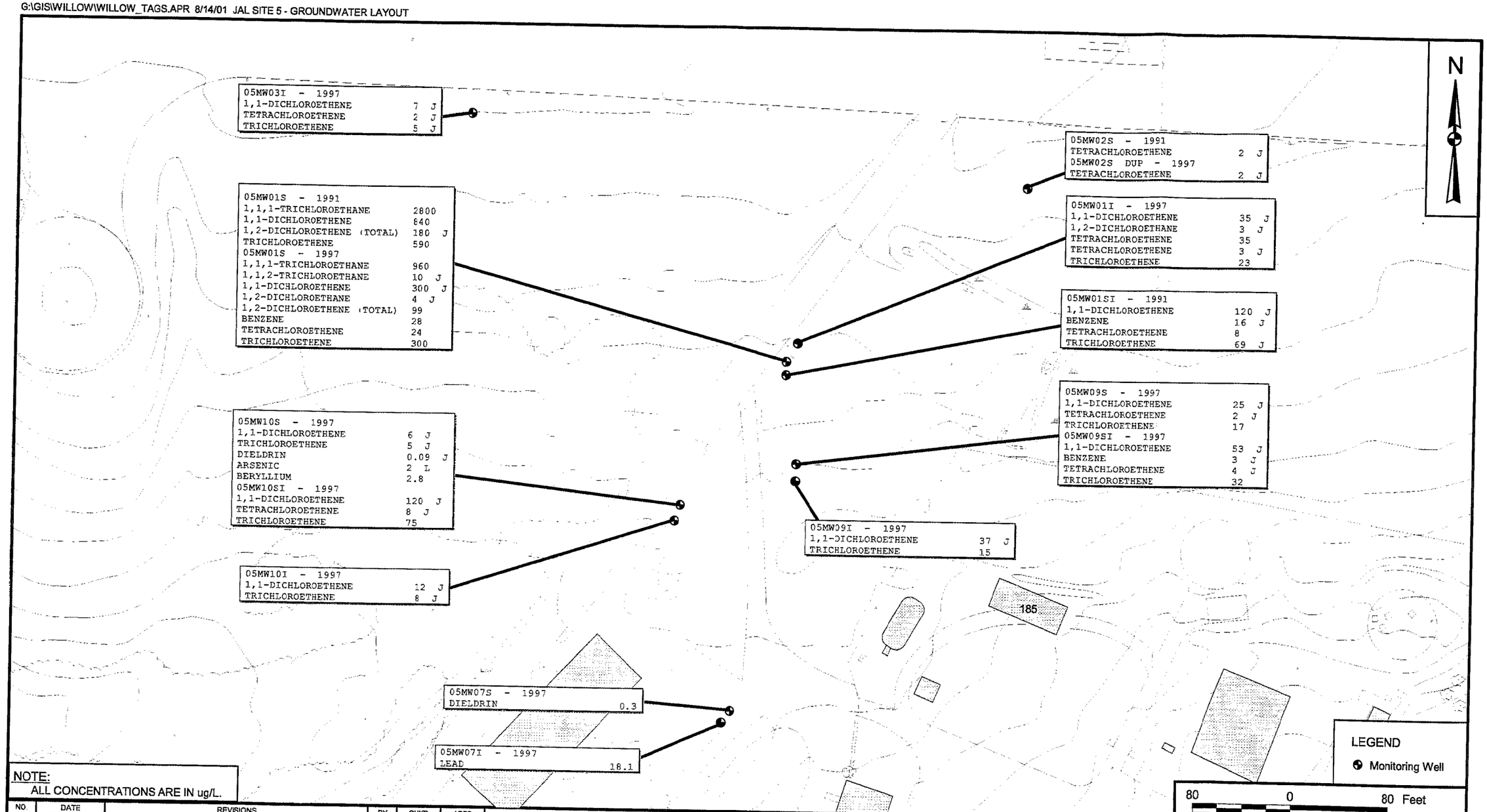
DRAWN BY LDL	DATE 9/7/01
CHECKED BY	DATE
COST/SCHEDULE-AREA	
SCALE AS NOTED	

Tetra Tech NUS, Inc.

CONCENTRATIONS ABOVE SCREENING AREAS
GROUNDWATER SAMPLES - SEPTEMBER 2000
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NUMBER 5466	OWNER NUMBER 2207
APPROVED BY R.E.T.	DATE
APPROVED BY	DATE
DRAWING NO. FIGURE 4-10A	REV

G:\GIS\WILLOW\WILLOW_TAGS.APR 8/14/01 JAL SITE 5 - GROUNDWATER LAYOUT



NOTE:
ALL CONCENTRATIONS ARE IN ug/L.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES
1	9/7/01	FIGURE NUMBER & COMPANY NAME REVISED, & NOTE ADDED.	LDL			

DRAWN BY S. TABLER DATE 3/25/96
CHECKED BY DATE
COST/SCHEDULE-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

CONCENTRATION ABOVE SCREENING LEVELS
HUMAN HEALTH RISK CRITERIA
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NUMBER 5466
OWNER NUMBER 2207
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4-10B
REV 1

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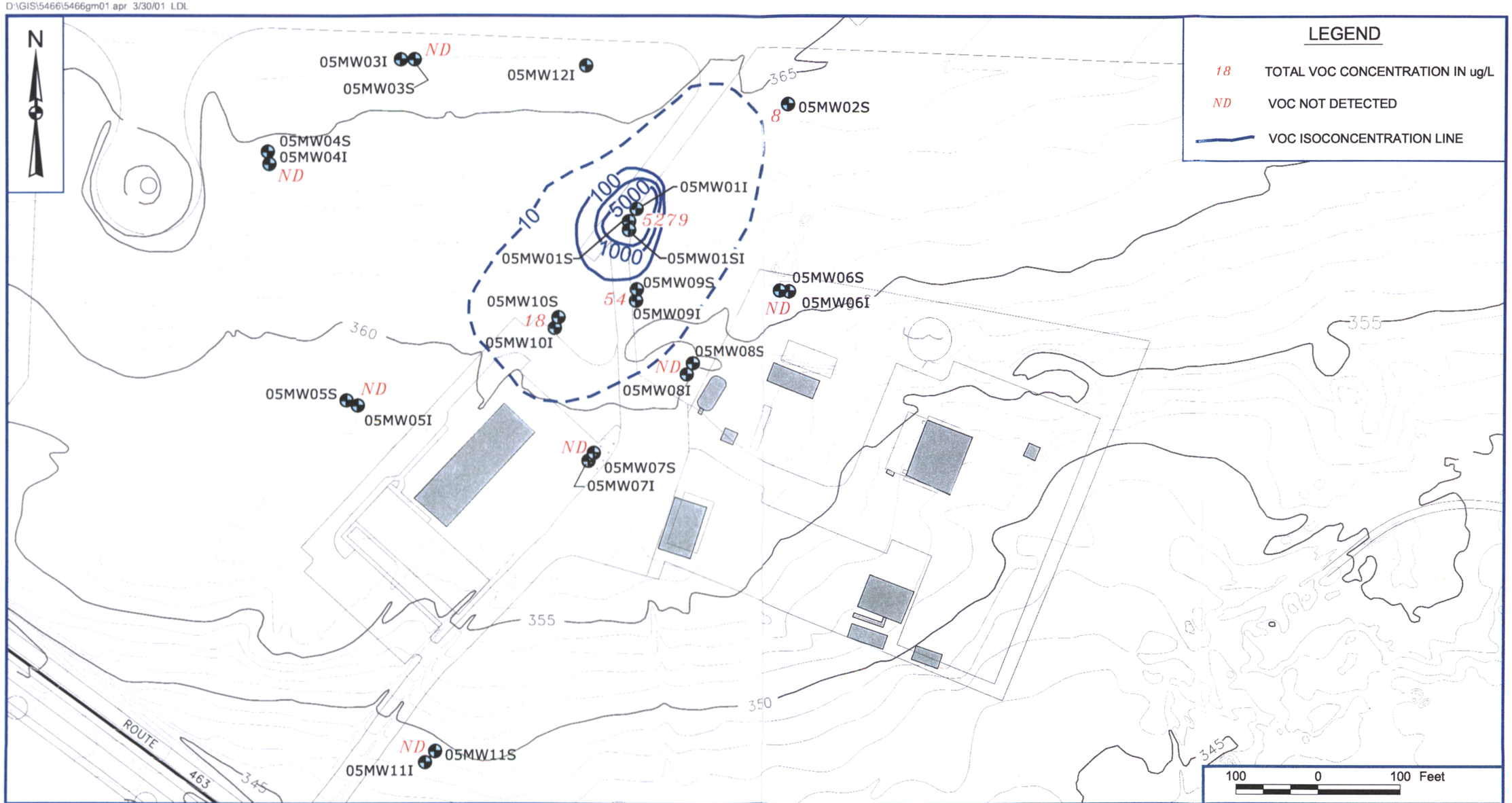

NO	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY LDL	DATE 8/10/01	Tetra Tech NUS, Inc.	CONTRACT NUMBER 5466	OWNER NUMBER 2207
CHECKED BY	DATE	TOTAL VOC'S (ug/L) (SEPTEMBER 2000) SHALLOW GROUNDWATER ZONE SITE 5 - FIRE TRAINING AREA NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	APPROVED BY	DATE
COST/SCHEDULE-AREA			APPROVED BY	DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4-11	REV

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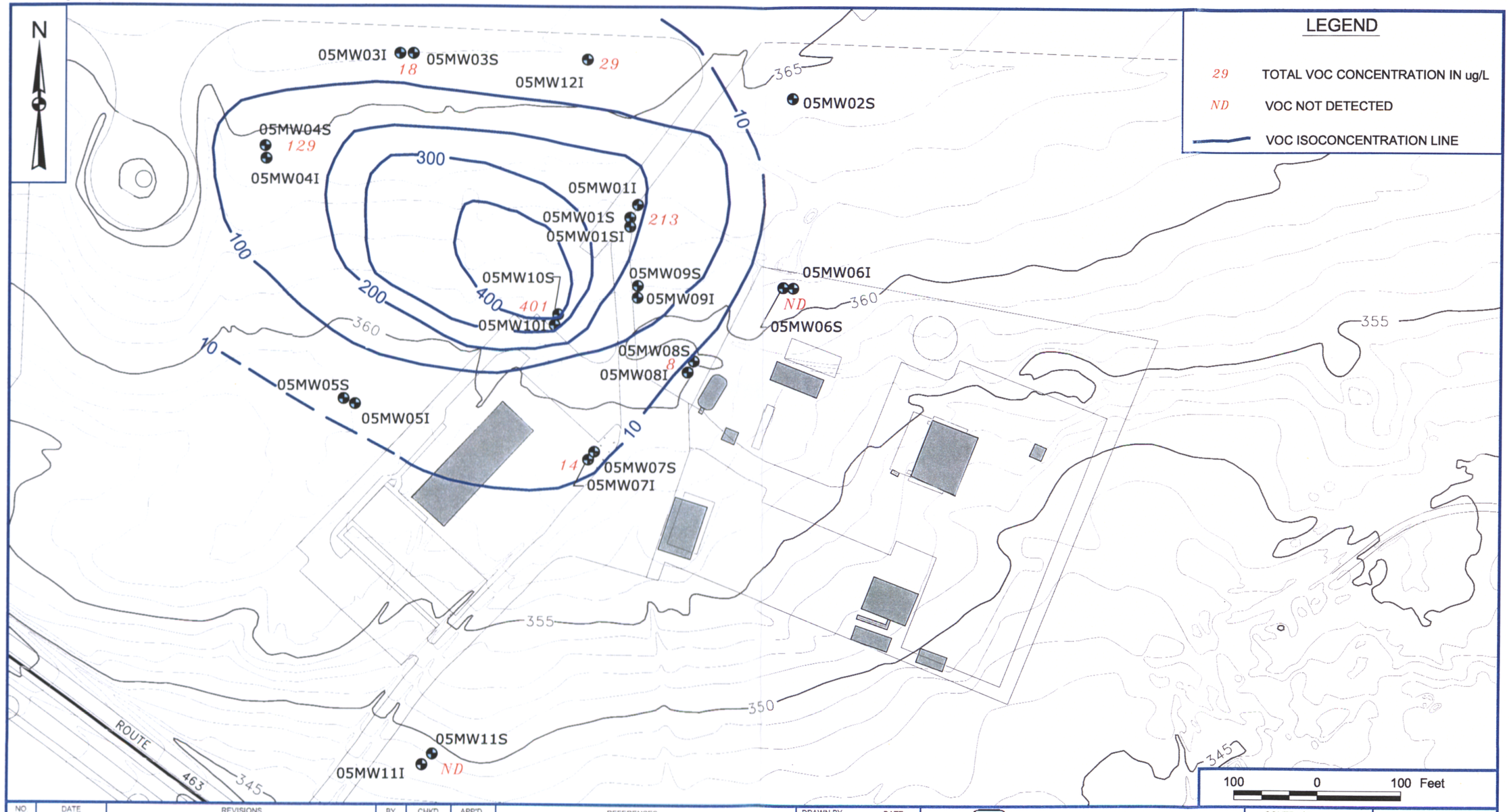

NO	DATE	REVISIONS	BY	CHK'D	APP'D	REFERENCES

DRAWN BY LDL — DATE 8/8/01
CHECKED BY — DATE
COST/SCHEDULE-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

TOTAL VOC's (ug/L) (September 2000)
INTERMEDIATE GROUNDWATER ZONE
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NUMBER 5466 — OWNER NUMBER 2207
APPROVED BY — DATE
APPROVED BY — DATE
DRAWING NO. FIGURE 4-12 — REV

Shallow Groundwater Zone

The shallow groundwater zone is represented by the monitoring wells that are screened across or just below the water table. The highest concentrations of VOCs in the shallow groundwater zone occur at cluster 05MW01, where the total VOC concentration exceeds 5,200 ug/L. The groundwater at this location has been impacted by a suite of chlorinated solvents (Fig. 4-10 tag map) that exceed screening levels, including 1,1,1-TCA (2,700 ug/L; TCE (890 ug/L); 1,1-DCA (620 ug/L); 1,1-DCE (600 ug/L); cis-1,2-DCE (460 ug/L); PCE (87 ug/L); 1,1,2-TCA (42 ug/L); and 1,2-DCA (13 ug/L. Other VOCs were relatively rare, with only benzene (58 ug/L) exceeding screening levels.

The concentrations of VOCs in the shallow groundwater zone rapidly decrease downgradient from 05MW01 (Figure 4-11). The total VOC concentration is 54 ug/L at monitoring well location 05MW09, including screening level exceedances of 1,1-DCE (20 ug/L); TCE (8.2 ug/L); PCE (1.6 ug/L); and benzene (1.2 ug/L). The total VOC concentration is 18 ug/L at monitoring well location 05MW10, including a screening level exceedance of 1,1-DCE (7.3 ug/L). VOCs were not detected in any other downgradient shallow monitoring wells.

Intermediate Groundwater Zone

The intermediate groundwater zone is represented by the monitoring wells that are screened within the elevation interval of approximately 237 to 298 feet amsl. The VOCs within the intermediate groundwater zone have a wider horizontal or lateral distribution than the VOCs at the water table (Fig. 4-12). The highest concentrations of VOCs in the intermediate groundwater zone occur at cluster 05MW10, where the total VOC concentration is 401 ug/L. Screening level exceedances at this location include 1,1-DCE (120 ug/L); 1,1-DCA (52 ug/L); carbon tetrachloride (19 ug/L); 1,1,2-TCA (2.5 ug/L); and 1,2-DCA (2 ug/L). The monitoring well in the most distal portion (furthest downgradient) portion of the VOC plume within the intermediate zone (05MW04) contains a total VOC concentration of 129 ug/L, including screening level exceedances of 1,1-DCA (29 ug/L); 1,1-DCE (25 ug/L); PCE (2.2 ug/L); and TCE (18 ug/L).

Deep Groundwater Zone

The deep groundwater zone is represented by the monitoring wells that are screened within the elevation interval of approximately 169 to 256 feet amsl, or about 96 to 209.5 feet below ground surface. The highest concentrations of VOCs in the deep groundwater zone occur at cluster 05MW09, where the total VOC concentration is 41.5 ug/L. Screening level exceedances at 05MW09 include 1,1-DCE (13 ug/L) and TCE (5.5 ug/L). Other screening level exceedances within the deep groundwater zone occur at

05MW05, with 1,1-DCE (9.2 ug/L) and TCE (2.9 ug/L), and at 05MW10, with 1,1-DCE (7.6 ug/L) and TCE (2.5 ug/L).

Discussion

The distribution of the VOCs in groundwater and the geometry of the groundwater plume are consistent with the groundwater flow directions as interpreted by the 3-dimensional distribution of hydraulic head, indicating that the VOCs are principally migrating via advection as a dissolved phase within the groundwater. Two hydrogeologic cross-sections (Figs. 4-4 and 4-5) were constructed to investigate the 3-dimensional distribution and migration of the groundwater and VOCs.

The cross-sections indicate that the highest concentrations of VOCs at Site 5 occur at the water table in the vicinity of monitoring well cluster 05MW01. This observation is consistent with the detections of VOCs in the soils at this location, and indicates that the source of the VOC plume is in this area. The vertical distribution of hydraulic head (Fig. 4-4) indicates that the vertical hydraulic gradient is oriented downward and is steeper than the horizontal gradient. Therefore, as the plume migrates laterally in a generally southward direction away from the source area at 05MW01, it also is migrating downward within the aquifer at a relatively rapid rate. This interpretation is consistent with the observation (discussed above) that the lateral extent of the VOC plume at the water table is largely restricted to the immediate vicinity of the source area.

The lateral extent of the VOCs increases across the site within the intermediate groundwater zone (Figs 4-5 and 4-12). Overall, the concentrations of the VOCs are lower than the concentrations detected within the shallow groundwater zone, which is consistent with the interpretation of an advective plume migrating laterally away and vertically downward from a shallow source area located in the vicinity of 05MW01 (Figs. 4-4 and 4-5). The groundwater plume within the intermediate groundwater zone chiefly migrates to the northwest, which is consistent with the interpreted directions of groundwater flow throughout the site and the location of the source area relative to the position of the groundwater divide. Neither the lateral extent of the plume beyond monitoring well cluster 05MW04 (Fig. 4-12) nor the vertical extent of the plume beneath 05MW04 are currently defined.

The lateral extent of the VOCs within the deep groundwater zone is generally similar to their extent within the intermediate zone, although there are less monitoring points within the deep zone. The concentrations of the VOCs within the deep groundwater zone are lower than the concentrations detected within the intermediate zone, which again is consistent with the interpretation of an advective plume migrating laterally away and vertically downward from a shallow source area located in the vicinity of 05MW01. The vertical extent of contamination in the vicinity of the source area appears to be well-

defined, as the deep well at 05MW01 did not contain VOCs, and the deep wells immediately downgradient from the source area (05MW09 and 05MW10) contained VOCs at generally low concentrations that were significantly lower than the concentrations detected in the intermediate wells at those locations.

Potential Effect of Geological Structure on Plume Migration

Monitoring wells 05MW03I and 05MW12I were installed to address regulatory concern regarding the potential effects of the geologic structure on the groundwater flow and plume migration. Specifically, EPA questioned if the dip of the bedrock to the northwest could cause a solvent DNAPL to migrate from the source area to the northwest. To investigate this hypothesis, the screens for monitoring wells 05MW03I and 05MW12I were installed just above a very fine-grained claystone unit that occurs beneath the source area near 05MW01 and dips to the northwest. The claystone was interpreted to have the highest potential of all the geologic units encountered during this investigation to function as a semi-confining to confining unit.

The results of this investigation indicate that DNAPL is not migrating downdip along bedding planes from the source area. In addition, there are no indications that DNAPL exists either at, or downdip from, the source area. The hydrogeological and chemical data and observations used to reach these conclusions include:

- Monitoring wells screened below the potential aquitards contain chlorinated solvents (Figs. 4-4 and 4-5), indicating that the geologic layers are not effectively retarding the migration of these chemicals. The gradational changes in chemical concentrations with depth appear to reflect typical attenuation and dilution processes rather than sharp changes across lithologic and hydrogeologic boundaries.

- The concentrations of the solvents at the source area and in the downdip monitoring wells do not suggest the presence of a DNAPL. An examination of the analytical data from the September 2000 sampling round and all of the historical data reveal that no compound approaches even one percent of its solubility in groundwater; the highest recorded concentration is for 1,1,1-TCA (2,800 ug/L in 1991). Even if the fine-grained units functioned as effective aquitards, the presence of a DNAPL would be required for the solvents to migrate as a separate phase along lithologic boundaries, rather than in a dissolved-phase plume migrating advectively with the groundwater.

- There are no indications of potential DNAPL observed by the rig geologist during the drilling of the boreholes (e.g., elevated PID readings, sheen on discharge water), indicating that DNAPL was not migrating downdip along any lithologic surfaces other than those ultimately monitored.

Public Supply Well: Horsham Township Municipal Authority No. 26

Horsham Township Municipal Authority (HTMA) Well No. 26 lies approximately 1,800 feet southwest of the Site 5 source area near 05MW01. This well is reportedly 400 feet deep, and pumps at a rate of approximately 275 gpm. The well does not pump continuously; pumping cycles are triggered by demand and are controlled by the water levels in holding and storage tanks. The previous interpretations of the plume geometry at Site 5 indicated that the groundwater plume was generally migrating to the southwest, or toward the HTMA well No. 26, although no chlorinated solvents had ever been reported from this well. Therefore, monitoring well cluster 05MW11 was installed downgradient of the mapped plume, between the source area and the well, and as close to the base boundary as possible (the presence of subsurface utilities at the fence line prevented the installation of monitoring wells there).

The subsurface conditions between the source area and cluster 05MW11 are illustrated in the hydrogeologic cross-section (Fig. 4-4). Although the groundwater plume is presently interpreted to migrate principally to the northwest at depth (see Fig. 4-12), this hydrogeologic cross-section suggests that there is also a southwestward component of groundwater flow and plume migration. No VOCs were detected at cluster 05MW11 in May 1998, shortly after the wells were installed. During the September 2000 sampling round, however, several VOCs were detected at low levels in the deep well at that cluster, including TCE (1.2 ug/L); xylene (1.4 ug/L); toluene (1.2 ug/L); benzene (1.2 ug/L); and chlorobenzene (1.3 ug/L). It cannot be stated for certain that the compounds detected at 05MW11 are from the source area at Site 5, although the compounds are similar (constituents of gasoline and solvents) to those found within the mapped groundwater plume. Also, if plume related, it is not known whether this southwestward component of plume migration is always present, or if it is a result of the temporary migration or movement of the groundwater divide in the intermediate groundwater zone relative to the position of the source area. The horizontal gradients within the intermediate zone are very low (Fig. 4-8), and relatively small changes in head at one or more locations could substantially alter the groundwater flow pattern.

The hydraulic head within the deep aquifer zone in the vicinity of the source area is lower than the head within the intermediate zone, but the vertical gradient is relatively small. South of monitoring well cluster 05MW10, however, the vertical gradient between the intermediate and deep zone increases markedly (Fig. 4-4). Originally, this increasing gradient was hypothesized to potentially represent a lowering of hydraulic head in response to the pumping of HTMA No. 26. To investigate this hypothesis, the Navy and the USGS conducted a long-term water-level study at Site 5. HTMA No. 26 was shut down for a period of approximately two weeks, and water levels were monitored throughout Site 5, Site 2 (Antenna Field Landfill), and Site 3 (9th Street Landfill), as well as selected off-base localities. Results reported by USGS (Appendix O) indicate that the pumping of HTMA No. 26 does not influence the hydraulic head at Site 5.

That is, the pumping of HTMA No. 26 is not influencing the migration of the Site 5 groundwater plume, and is not pulling the plume toward the HTMA No. 26 well. This does not mean, however (as discussed above), that the plume may not be migrating towards the well at times under ambient hydraulic conditions, although the geometry of the plume (especially in the intermediate zone) would suggest that a northwestward migration of the plume is more typical.

4.5.6 Conclusions

Soil borings in the vicinity of well cluster 05MW01 and groundwater samples from this cluster show the highest levels of contamination at Site 5, with VOCs and other organic compounds present. These locations are near the former drum storage area and indicate that the site is a likely the historical source of BTEX, VOC, and PAH contamination. The VOCs in groundwater form a generally predictable pattern that is consistent with the conceptual model of a dissolved groundwater plume that is migrating advectively with the groundwater flow. In the shallow groundwater zone, the plume is concentrated in the vicinity of the source area near 05MW01. In response to the downward vertical gradient in hydraulic head, the plume migrates relatively quickly into the intermediate groundwater zone, where it subsequently migrates chiefly to the northwest. There does appear to be a component of groundwater flow (and plume migration) to the southwest, or toward off-site supply well HTMA No. 26, although it is not known if this component of flow is constant or due to temporary variations in the groundwater flow patterns within the intermediate and deep groundwater zone.

4.6 CONTAMINANT FATE AND TRANSPORT

The principal contaminants associated with Site 5 are VOCs in groundwater, PAHs in soils and sediments, and PCBs in soils. Pesticides were detected in sediment samples but do not appear to be site related.

4.6.1 Transport and Transformation of Detected Contaminants

VOCs, such as the chlorinated aliphatics and monocyclic aromatics, released to soils quickly vaporize to the atmosphere or readily leach to groundwater. Adsorption to sediments and bioaccumulation in aquatic organisms are not important environmental fate processes. Hydrolysis and direct photodegradation are not significant degradation processes for most compounds of this class.

Due to their large octanol-water partition coefficients, PAHs in the environment will partition primarily to soils and sediments. Leaching to groundwater is not an important transport pathway for PAHs. The principal mode of transport of PAH-contaminated soils is via overland transport of eroded soil particles

during runoff. Microbial degradation is the primary degradation mechanism affecting PAHs in soils.

PCBs are extremely persistent in the environment. Due to such characteristics as thermal stability, resistance to acids, bases, oxidants and hydrolysis, low aqueous solubility, and low vapor pressure, PCBs were widely used in many industrial applications. These same properties serve to make PCBs very stable in the environment. PCBs bind strongly to the organic fraction of soils and sediments and are relatively immobile in soils.

4.6.2 Review of Natural Attenuation Parameters

The USEPA and many state agencies accept natural attenuation (NA) as a viable remedial alternative for appropriate sites. Consequently it is being considered as a remediation approach for many Navy sites, particularly where chlorinated solvents and/or petroleum hydrocarbons are present in groundwater systems. Natural attenuation of chlorinated hydrocarbons in groundwater is a combination of the natural effects of dilution, absorption and biodegradation by the natural flow of water through the aquifer zone. Natural attenuation of chlorinated hydrocarbons in groundwater, such as are found at Site 5, is generally promoted in anaerobic conditions, and would be characterized by the presence of high concentrations of hydrogen and daughter transformation products from the solvents of concern. The natural processes consist of a variety of physical, chemical or biological processes that act to reduce the mass, toxicity, mobility, volume or concentration of contaminants in soil or groundwater. These processes include volatilization, dilution, sorption, biodegradation, dispersion, chemical or biological stabilization, transformation, or destruction of contaminants. Some natural attenuation processes may result in the creation of transformation products that are more toxic than the original parent compound. For example, although reductive dehalogenation transforms TCE to 1,2-dichloroethene, an intermediate compound that in turn degrades to vinyl chloride (which is more toxic than TCE), the overall result is elimination of the contaminant from the groundwater system.

NA parameters were measured in the laboratory for groundwater samples collected at Site 5 in September 2001. Table 4-17A summarizes these results and provides a comparison to EPA typical NA indicator parameters. In general, hydrogen concentrations were high and oxygen concentrations were low, indicating that anaerobic conditions prevail at many of the sample locations. Halocarbons, such as TCE and PCE that predominate in Site 5 groundwater, are typically effectively treated naturally in anaerobic conditions. Laboratory analytical results of other indicator parameters such as the presence of chlorinated hydrocarbon degradation products (ethene, ethane and methane) indicate that NA of chlorinated hydrocarbon compounds would be favored in this matrix, and in fact is occurring in groundwater at Site 5.

4.6.3 Conclusions

VOCs detected in site soils at low levels, below reference criteria and EPA SSL's, historically have impacted the groundwater. However, residual soil contamination does not appear to be a significant continuing source of VOCs to groundwater.

PAHs appear to have transported via erosion and runoff of sediments of nearby surface waters. This transport mechanism is probably minimal at present due to the heavy vegetation and flat topography of the site.

The findings of the NA investigation indicate that natural degradation of chlorinated hydrocarbons is supported in the groundwater matrix at Site 5, resulting in ongoing natural remediation of the chlorinated hydrocarbons in the groundwater.

4.7 BASELINE HUMAN HEALTH RISK ASSESSMENT - SITE 5 (FIRE TRAINING AREA)

This section presents the baseline human health risk assessment for Site 5 at NASJRB Willow Grove. It describes a qualitative and quantitative assessment of actual or potential estimated risks for Site 5. It also includes the data evaluation, toxicity assessment, exposure assessment, risk characterization, and uncertainties in the risk assessment for Site 5. The methodologies and techniques used in the assessment are outlined in Section 3.1. Conclusions about the baseline human health risk assessment are presented in Section 4.7.6.

4.7.1 Data Evaluation

A list of the COPCs was developed for each environmental medium, as necessary. The COPCs were selected in accordance with the protocol established in Section 3.1. Only those chemicals found to be of potential concern were considered for evaluation in the quantitative risk assessment. A discussion of those chemicals identified as COPCs for each medium is provided in this section.

Surface Soils

Several 2,3,7,8-substituted-dioxins/furans, OCDD, OCDF, PAHs, phthalates, acetone, toluene, and metals were detected in Site 5 surface soil samples. The occurrence and distribution, COPC selection results, background comparisons, and representative concentrations for chemicals detected in Site 5 surface soils are presented in Table 4-18. Results of background comparison tests are presented in Table 4-4.

Table 4-18
Selection of Chemicals of Potential Concern in Surface Soils, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site		Are Site Results Above Background ?	Representative Concentration For Site Data	Residential Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum	Maximum				
1,2,3,4,6,7,8-HPCDD	2/2	0.972	5.15	NA	5.15	0.41	Y
1,2,3,4,6,7,8-HPCDF	2/2	0.0467	0.19	NA	0.19	0.41	Y
1,2,3,4,7,8,9-HPCDF	2/2	0.0028	0.0128	NA	0.0128	0.41	Y
1,2,3,4,7,8-HXCDD	2/2	0.0091	0.0271	NA	0.0271	0.041	Y
1,2,3,4,7,8-HXCDF	2/2	0.0109	0.0116	NA	0.0116	0.041	Y
1,2,3,6,7,8-HXCDD	2/2	0.0224	0.124	NA	0.124	0.041	Y
1,2,3,6,7,8-HXCDF	2/2	0.0031	0.006	NA	0.006	0.041	Y
1,2,3,7,8,9-HXCDD	2/2	0.0123	0.0508	NA	0.0508	0.041	Y
1,2,3,7,8,9-HXCDF	2/2	0.002	0.0059	NA	0.0059	0.041	Y
1,2,3,7,8-PECDD	2/2	0.0054	0.0146	NA	0.0146	0.0082	Y
1,2,3,7,8-PECDF	2/2	0.0016	0.0019	NA	0.0019	0.082	Y
2,3,4,6,7,8-HXCDF	2/2	0.0044	0.016	NA	0.016	0.041	Y
2,3,4,7,8-PECDF	2/2	0.0021	0.0029	NA	0.0029	0.0082	Y
2,3,7,8-tetrachlorodibenzo-p-dio	2/2	0.0035	0.0451	NA	0.0451	0.0041	Y
2,3,7,8-tetrachlorodibenzofuran	2/2	0.0026	0.0026	NA	0.0026	0.041	Y
octachlorodibenzo-p-dioxin	2/2	5.16	45.08	NA	45.1	4.1	Y
octachlorodibenzofuran	2/2	0.0763	0.0843	NA	0.0843	4.1	Y
aluminum	15/15	7890	12400	N	10600	7800	N
antimony	2/4	8.2	9.2	N	9.2	3.1	N
arsenic	15/15	1.3	10.5	N	6.04	0.43	N
barium	15/15	33.1	108	N	93.5	550	N
beryllium	15/15	0.3	1.1	N	0.894	0.15	N
cadmium	3/15	2.8	4.7	N	1.73	3.9	N
calcium	15/15	1150	69400	Y	32500	-	N
chromium	15/15	8.8	56.5	Y	23.8	39	Y
cobalt	15/15	4.3	13	Y	8.42	470	N
copper	15/15	6.5	28.4	Y	21.1	310	N

Table 4-18
Selection of Chemicals of Potential Concern in Surface Soils, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site		Are Site Results Above Background ?	Representative Concentration For Site Data	Residential Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum	Maximum				
iron	15/15	9320	21600	Y	16700	2300	Y
lead	15/15	7.4	412	Y	217	400	Y
magnesium	15/15	1410	42700	Y	15100	-	N
manganese	15/15	202	873	N	582	180	N
nickel	15/15	5.2	23.6	Y	11.5	160	N
potassium	12/15	447	2050	N	1290	-	N
sodium	9/15	113	448	Y	247	-	N
thallium	7/15	0.24	0.39	N	0.256	0.51	N
vanadium	15/15	14.3	36.3	Y	27.7	55	N
zinc	15/15	17	137	Y	87.6	2300	N
2-methylnaphthalene	7/16	50	16000	N	1270	-	N
acenaphthene	13/16	47	36000	Y	4370	470000	N
acenaphthylene	12/16	73	2300	Y	643	-	N
anthracene	14/16	140	54000	Y	11800	2300000	N
benz(a)anthracene	14/16	580	48000	Y	45400	880	Y
benzo(a)pyrene	14/16	750	36000	Y	26700	88	Y
benzo(b)fluoranthene	14/16	1200	35000	Y	35000	880	Y
benzo(g,h,i)perylene	14/16	400	13000	Y	5910	-	N
benzo(k)fluoranthene	13/16	750	29000	Y	22800	8800	Y
bis(2-ethylhexyl)phthalate	3/3	210	1200	NA	1200	46000	N
carbazole	13/16	160	19000	Y	3200	32000	N
chrysene	14/16	1100	45000	Y	37500	88000	Y
di-n-butylphthalate	2/16	85	120	N	120	780000	N
dibenz(a,h)anthracene	13/16	110	4800	Y	1710	88	Y
dibenzofuran	13/16	71	34000	Y	3120	31000	Y
fluoranthene	14/16	2400	140000	Y	140000	310000	N
fluorene	13/16	81	56000	Y	5560	310000	N

Table 4-18
Selection of Chemicals of Potential Concern in Surface Soils, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site		Are Site Results Above Background ?	Representative Concentration For Site Data	Residential Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum	Maximum				
indeno(1,2,3-cd)pyrene	14/16	550 -	18000	Y	9700	880	Y
naphthalene	5/16	52 -	22000	N	1610	310000	N
phenanthrene	14/16	1100 -	200000	Y	106000	-	N
pyrene	14/16	1800 -	120000	Y	120000	230000	N
acetone	1/5	17 -	17	NA	16.8	780000	N
toluene	1/10	1 -	1	NA	1	1600000	N

Notes:

Units are mg/kg for inorganics, ug/kg for organics.
Metals are selected as COPCs if maximum values exceed risk-based screening levels (RBCs) and site results are either above background or background comparison tests are indeterminate (NA).
Minerals that are essential nutrients (calcium, magnesium, sodium, potassium) are not included as COPCs.
The determination of site results exceeding background is based on an overall evaluation of statistical tests presented in a separate table.
Because most organics are not naturally occuring, selection of organic COPCs is based solely on exceedance of RBCs.
RBCs represent concentrations associated with a 10^{-6} cancer risk level or a non-cancer hazard index of 0.1.
Residential RBCs originate from EPA Region 3 RBCs for residential exposure, incidental soil ingestion, with non-cancer risk adjusted to 0.1 hazard inde
An RBC for lead based on cancer risk or hazard index is not available. The 400 mg/kg OSWER residential soil guideline is used as an RBC for soil ingestion.

The following chemicals were selected as COPCs in surface soils:

Inorganics	Organics
Chromium	15-2,3,7,8-substituted-Dioxin/Furan Isomers
Iron	OCDD
Lead	OCDF
	Benz(a)anthracene
	Benzo(a)pyrene
	Benzo(b)fluoranthene
	Benzo(k)fluoranthene
	Chrysene
	Dibenz(a,h)anthracene
	Indeno(1,2,3-cd)pyrene

The metals selected as COPCs, chromium, iron, and lead, were all detected in all surface soil samples, with both maximum and the representative concentrations for iron exceeding residential RBC values and the maximum concentrations of chromium and lead exceeding residential RBC values. Dioxin/furan congeners were detected in two out of two samples collected in surface soils. The concentrations of 1,2,3,4,6,7,8-HpCDD, 1,2,3,6,7,8-HxCDD, 1,2,3,7,8-PeCDD, 2,3,7,8-TCDD, and OCDD exceeded residential RBC values. Carcinogenic PAHs were generally detected in more than 80 percent of the surface soil samples collected at Site 5 with the maximum concentrations of benzo(a)pyrene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene exceeding residential RBC values. Dibenzofuran was detected at a frequency of 13 out of 16 samples with maximum concentrations exceeding residential RBC values.

Subsurface Soil

PAHs, phthalates, N-nitrosodiphenylamine, 1,1,1-TCA, 1,1,2-TCA, 1,1-DCA, 1,1-DCE, 2-butanone, 2-hexanone, 4-methyl-2-pentanone, acetone, benzene, carbon disulfide, chloroform, chloromethane, ethylbenzene, methylene chloride, PCE, and metals were detected in Site 5 subsurface soil samples. The occurrence and distribution, COPC selection results, background comparisons, and representative concentrations for chemicals detected in Site 5 subsurface soils are presented in Table 4-19. Results of background comparison tests are presented in Table 4-7.

Table 4-19
Selection of Chemicals of Potential Concern in Subsurface Soils, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site		Are Site Results Above Background ?	Representative Concentration For Site Data	Industrial Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum	Maximum				
aluminum	9/9	8420	12200	N	11400	100000	N
arsenic	9/9	1.1	5.4	N	4.73	3.8	N
barium	9/9	39.9	280	Y	264	14000	N
beryllium	9/9	0.47	1.3	N	1.08	1	N
calcium	9/9	416	8340	Y	5920	-	N
chromium	9/9	6.1	23.7	Y	18.8	1000	N
cobalt	9/9	5.9	14.9	Y	11.6	12000	N
copper	8/9	7.1	25.1	Y	16.6	8200	N
iron	9/9	11100	27900	Y	23600	61000	N
lead	9/9	5.4	64.8	Y	34.4	400	N
magnesium	9/9	533	5360	Y	3640		N
manganese	9/9	134	1550	Y	1100	4700	N
nickel	9/9	6.7	17.4	Y	14.3	4100	N
potassium	7/9	418	3130	N	3130	-	N
sodium	9/9	101	341	Y	199	-	N
thallium	3/9	0.24	0.27	N	0.218	16	N
vanadium	9/9	12.4	36.8	Y	32.2	1400	N
zinc	9/9	12.4	57.4	N	46.7	61000	N
2-methylnaphthalene	7/14	120	5500	Y	2520	-	N
acenaphthene	2/14	1400	5700	N	1090	2000000	N
acenaphthylene	2/14	160	890	N	321	-	N
anthracene	3/14	36	11000	N	2860	1000000	N
benz(a)anthracene	4/14	55	13000	N	3400	7800	Y
benzo(a)pyrene	4/14	45	11000	N	2860	780	Y
benzo(b)fluoranthene	4/14	64	12000	N	2930	7800	Y
benzo(g,h,i)perylene	3/14	250	4400	N	953	-	N
benzo(k)fluoranthene	2/14	2000	6900	N	1380	78000	Y

Table 4-19
Selection of Chemicals of Potential Concern in Subsurface Soils, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site		Are Site Results Above Background ?	Representative Concentration For Site Data	Industrial Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum	Maximum				
bis(2-ethylhexyl)phthalate	6/6	160	790	NA	688	410000	N
carbazole	2/14	1600	5300	N	1090	290000	N
chrysene	5/14	41	12000	N	3620	780000	Y
dibenz(a,h)anthracene	2/14	510	1400	N	426	780	Y
dibenzofuran	4/14	120	5200	N	1070	820000	N
fluoranthene	5/14	84	34000	N	10700	8200000	N
fluorene	4/14	93	10000	N	1950	8200000	N
indeno(1,2,3-cd)pyrene	3/14	170	5700	N	1220	7800	Y
N-nitrosodiphenylamine (1)	1/14	75	75	N	75	1200000	N
naphthalene	6/14	99	2300	N	1220	8200000	N
phenanthrene	5/14	46	43000	N	16700	-	N
pyrene	5/14	76	30000	N	8690	6100000	N
1,1,1-trichloroethane	1/56	140	140	NA	9.01	7200000	N
1,1,2-trichloroethane	2/61	5	15	NA	6.53	100000	N
1,1-dichloroethane	3/61	8	160	NA	9.92	20000000	N
1,1-dichloroethene	1/59	5	5	NA	5	9500	N
2-butanone	3/61	9	54	NA	11.3	1000000	N
2-hexanone	1/61	1	1	NA	1	-	N
4-methyl-2-pentanone	1/61	2	2	NA	2	16000000	N
acetone	6/24	14	140	NA	62.8	20000000	N
benzene	5/61	1	20	NA	6.83	200000	N
carbon disulfide	1/61	2	2	NA	2	20000000	N
chloroform	1/61	8	8	NA	6.4	940000	N
chloromethane	2/61	3	6	NA	6	440000	N
ethylbenzene	5/61	5	3400	NA	3400	20000000	N
methylene chloride	1/35	10	10	NA	10	760000	N
tetrachloroethene	1/61	10	10	NA	6.45	110000	N

Table 4-19
Selection of Chemicals of Potential Concern in Subsurface Soils, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site		Are Site Results Above Background ?	Representative Concentration For Site Data	Industrial Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum	Maximum				
toluene	3/61	2	14	NA	6.48	41000000	N
trichloroethene	2/61	2	8	NA	6.3	520000	N
xylene (total)	5/61	22	16000	NA	28.9	100000000	N

Notes:

Units are mg/kg for inorganics, ug/kg for organics.
Metals are selected as COPCs if maximum values exceed risk-based screening levels (RBCs) and site results are either above background or background comparison tests are indeterminate (NA).
Minerals that are essential nutrients (calcium, magnesium, sodium, potassium) are not included as COPCs.
The determination of site results exceeding background is based on an overall evaluation of statistical tests presented in a separate table.
Because most organics are not naturally occuring, selection of organic COPCs is based solely on exceedance of RBCs.
RBCs represent concentrations associated with a 10^{-6} cancer risk level or a non-cancer hazard index of 0.1.
Industrial RBCs originate from EPA Region 3 RBCs for industrial exposure, incidental soil ingestion, with non-cancer risk adjusted to 0.1 hazard index.
An RBC for lead based on cancer risk or hazard index is not available. The 400 mg/kg OSWER residential soil guideline is used as an RBC for soil ingestion.

The following chemicals were selected as COPCs in subsurface soils:

Inorganics	Organics
None Selected	Benz(a)anthracene
	Benzo(a)pyrene
	Benzo(b)fluoranthene
	Benzo(k)fluoranthene
	Chrysene
	Dibenz(a,h)anthracene
	Indeno(1,2,3-cd)pyrene

No metals were selected as COPCs because they were detected in subsurface soils at concentrations not above background or industrial RBC values. Carcinogenic PAHs were generally detected in approximately 20 percent of the subsurface soil samples collected at Site 5, with maximum concentrations of benzo(a)pyrene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene and Indeno(1,2,3-cd)pyrene exceeding residential RBC values.

Sediment

PAHs, aldrin, dieldrin, phthalates, 2-butanone, toluene, and metals were detected in Site 5 sediment samples. The occurrence and distribution, COPC selection results, background comparisons, and representative concentrations for chemicals detected in Site 5 sediments are presented in Table 4-20. Results of background comparison tests are presented in Table 4-13.
The following chemicals were selected as COPCs in sediments:

Inorganics	Organics
None Selected	Benz(a)anthracene
	Benzo(a)pyrene
	Benzo(b)fluoranthene
	Benzo(k)fluoranthene
	Chrysene
	Dibenz(a,h)anthracene
	Indeno(1,2,3-cd)pyrene

No metals were selected as COPCs because they were detected in sediment samples at concentrations that were not above background or RBC values. Carcinogenic PAHs were detected in two out of two sediment samples collected at Site 5, with the maximum concentration of benzo(a)pyrene (910 mg/kg)

Table 4-20
Selection of Chemicals of Potential Concern in Sediments, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site		Are Site Results Above Background ?	Representative Concentration For Site Data	Applicable Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum	Maximum				
aluminum	2/2	11200	12000	Y	12000	78000	N
antimony	2/2	5.6	6.1	Y	6.1	31	N
arsenic	2/2	4	4.5	N	4.5	4.3	N
barium	2/2	69.8	74.3	N	74.3	5500	N
beryllium	2/2	0.58	0.77	N	0.77	1.5	N
calcium	2/2	1420	12200	N	12200		N
chromium	2/2	8.8	12.9	N	12.9	390	N
cobalt	2/2	7.1	7.1	N	7.1	4700	N
copper	2/2	12.3	13.5	N	13.5	3100	N
iron	2/2	11000	11900	N	11900	23000	N
lead	2/2	7.9	31.7	N	31.7	4000	N
magnesium	2/2	1610	7650	N	7650		N
manganese	2/2	107	222	N	222	1800	N
nickel	2/2	9.4	11	N	11	1600	N
potassium	2/2	664	691	N	691		N
vanadium	2/2	15.6	21.2	N	21.2	550	N
zinc	2/2	14.8	40.1	N	40.1	23000	N
aldrin	1/2	11	11	N	11	380	N
dieldrin	2/2	17	220	Y	220	400	N
anthracene	2/2	160	160	Y	160	23000000	N
benz(a)anthracene	2/2	650	850	Y	850	8800	Y
benzo(a)pyrene	2/2	520	910	Y	910	880	Y
benzo(b)fluoranthene	2/2	720	1400	Y	1400	8800	Y
benzo(g,h,i)perylene	2/2	200	400	N	400		N
benzo(k)fluoranthene	2/2	430	700	Y	700	88000	Y
chrysene	2/2	720	1200	Y	1200	880000	Y
dibenz(a,h)anthracene	1/2	120	120	N	120	880	Y

Table 4-20
Selection of Chemicals of Potential Concern in Sediments, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site		Are Site Results Above Background ?	Representative Concentration For Site Data	Applicable Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum	Maximum				
fluoranthene	2/2	1300 -	1800	Y	1800	3100000	N
indeno(1,2,3-cd)pyrene	2/2	290 -	560	Y	560	8800	Y
phenanthrene	2/2	620 -	880	Y	880		N
pyrene	2/2	1500 -	1900	Y	1900	2300000	N
2-butanone	1/2	22 -	22	N	22	47000000	N
toluene	1/2	4 -	4	N	4	16000000	N

Notes:

Units are mg/kg for inorganics, ug/kg for organics.
Metals are selected as COPCs if maximum values exceed risk-based screening levels (RBCs) and site results are either above background or background comparison tests are indeterminate (NA).
Minerals that are essential nutrients (calcium, magnesium, sodium, potassium) are not included as COPCs.
The determination of site results exceeding background is based on an overall evaluation of statistical tests presented in a separate table.
Because most organics are not naturally occuring, selection of organic COPCs is based solely on exceedance of RBCs.
RBCs represent concentrations associated with a 10^{-6} cancer risk level or a non-cancer hazard index of 0.1.
Sediment RBCs are adapted using residential soil RBC X 10, due to less frequent exposure with recreational receptor activities.
An RBC for lead based on cancer risk or hazard index is not available. The 400 mg/kg OSWER residential soil guideline is used as an RBC for soil ingestion.

exceeding RBC values.

Surface Water

Dieldrin and metals were detected in Site 5 surface water samples. The occurrence and distribution, COPC selection results, background comparisons, and representative concentrations for chemicals detected in Site 5 surface water are presented in Table 4-21. Results of the individual background comparison test are presented in Table 4-10.

The following chemicals were selected as COPCs in surface water:

Inorganics	Organics
None Selected	Dieldrin

No metals were selected as COPCs because they were detected in surface water samples at concentrations that were not above background or RBC values. Dieldrin was detected at a frequency of one out of two samples, with the single detection (0.06 ug/l) exceeding RBC values.

Groundwater

Dieldrin, 1,1,1-TCA, 1,1,2-TCA, 1,1-DCA. 1,1-DCE, 1,2-DCA, benzene, PCE, TCE, and metals were detected in Site 5 groundwater samples. The occurrence and distribution, COPC selection results,

background comparisons, MCL comparisons, and representative concentrations for chemicals detected in Site 5 groundwater are presented in Table 4-22. Results of background comparison tests are presented in Table 4-16. The following chemicals were selected as COPCs in groundwater:

Inorganics	Organics
Aluminum	Dieldrin
Arsenic	1,1,1-TCA
Barium	1,1,2-TCA
Beryllium	1,1-DCA
Chromium	1,1-DCE
Iron	1,2-DCA
Lead	TCE
Manganese	PCE
Nickel	Benzene

Table 4-21
Selection of Chemicals of Potential Concern in Surface Water, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site		Are Site Results Above Background ?	Representative Concentration For Site Data	Applicable Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum	Maximum				
aluminum	1/1	926	926	NA	926	37000	N
arsenic	1/2	1.4	1.4	N	1.4	0.45	N
barium	2/2	23.3	44.8	N	44.8	2600	N
calcium	2/2	19900	24500	N	24500		N
iron	2/2	261	1170	Y	1170	11000	N
lead	2/2	1.3	3	Y	3	150	N
magnesium	2/2	4350	5420	N	5420		N
manganese	2/2	12.6	55.9	N	55.9	840	N
potassium	2/2	2180	2840	N	2840		N
sodium	2/2	2060	11200	N	11200		N
zinc	2/2	19	32.1	Y	32.1	11000	N
dieldrin	1/2	0.06	0.06	N	0.06	0.042	Y

Notes:

Units are ug/L.

Metals are selected as COPCs if maximum values exceed risk-based screening levels (RBCs) and site results are either above background or background comparison tests are indeterminate (NA).

Minerals that are essential nutrients (calcium, magnesium, sodium, potassium) are not included as COPCs.

The determination of site results exceeding background is based on an overall evaluation of statistical tests presented in a separate table.

Because most organics are not naturally occuring, selection of organic COPCs is based solely on exceedance of RBCs.

RBCs represent concentrations associated with a 10^{-6} cancer risk level or a non-cancer hazard index of 0.1.

Surface water RBCs are adapted using tap water RBC X 10, due to smaller and less frequent ingestion exposures with recreational activities.

An RBC for lead based on cancer risk or hazard index is not available. The 15 ug/L EPA MCL is used as an applicable RBC for tap water ingestion.

Table 4-22
Selection of Chemicals of Potential Concern in Groundwater, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site Minimum	Range of Positive Detections for Site Maximum	Are Site Results Above Background ?	Representative Concentration For Site Data	Applicable Drinking Water MCL	Chemical Exceeds MCL?	Tap Water Risk-Based Concentration	Chemical Selected as a COPC ?
aluminum	7/16	59.9	6970	N	1310	-	N	3700	N
arsenic	1/21	2	2	N	0.633	50	N	0.045	N
barium	21/21	43.8	1430	Y	575	2000	N	260	Y
beryllium	1/21	2.8	2.8	N	0.683	4	N	0.016	N
calcium	21/21	5740	39000	N	33100	-	N	-	N
chromium	7/21	6	40.8	N	7.32	100	N	18	N
cobalt	3/21	5.1	18.8	N	4.31	-	N	220	N
iron	18/21	61.4	7440	N	858	-	N	1100	N
lead	1/8	18.1	18.1	N	12.6	-	N	15	N
magnesium	21/21	1820	12000	N	7430	-	N	-	N
manganese	19/21	5	397	N	356	-	N	84	N
nickel	1/21	74.3	74.3	N	14.6	100	N	73	N
potassium	9/21	1630	26000	N	5400	-	N	-	N
sodium	21/21	7680	29100	Y	17200	-	N	-	N
vanadium	1/21	5	5	N	2.77	-	N	26	N
zinc	5/9	27.7	457	Y	457	-	N	1100	N
dieldrin	2/21	0.09	0.3	N	0.0723	-	N	0.0042	Y
1,1,1-trichloroethane	10/21	2	960	Y	114	200	N	79	Y
1,1,2-trichloroethane	1/21	10	10	N	5.55	5	Y	0.19	Y
1,1-dichloroethane	9/21	4	350	Y	45.9	-	N	81	Y
1,1-dichloroethene	9/21	6	300	Y	52.9	7	Y	0.044	Y
1,2-dichloroethane	2/21	3	4	N	4	5	N	0.12	Y
benzene	2/21	3	28	N	6.79	5	Y	0.36	Y
tetrachloroethene	8/21	1	35	N	9.48	5	N	1.1	Y
trichloroethene	9/21	5	300	Y	33.9	5	N	1.6	Y

Notes:

Units are ug/L.

Metals are selected as COPCs if maximum values exceed risk-based screening levels (RBCs) and site results are either above background or background comparison tests are indeterminate (NA).

Minerals that are essential nutrients (calcium, magnesium, sodium, potassium) are not included as COPCs.

Table 4-22
Selection of Chemicals of Potential Concern in Groundwater, Site 5
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site		Are Site Results Above Background ?	Representative Concentration For Site Data	Applicable Drinking Water MCL	Chemical Exceeds MCL?	Tap Water Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum	Maximum						

The determination of site results exceeding background is based on an overall evaluation of statistical tests presented in a separate table.
Because most organics are not naturally occuring, selection of organic COPCs is based solely on exceedance of RBCs.
RBCs represent concentrations associated with a 10^{-6} cancer risk level or a non-cancer hazard index of 0.1.
Tap water RBCs originate from EPA Region 3 RBCs for residential exposure, tap water ingestion, with non-cancer risk adjusted to 0.1 hazard index.
An RBC for lead based on cancer risk or hazard index is not available. The 15 ug/L EPA MCL is used as an applicable RBC for tap water ingestion.

Aluminum was detected at a frequency of seven out of 16 samples, with the maximum detected concentration (6,970 ug/l) exceeding the tap water RBC value. Arsenic was detected at a frequency of one out of 21 samples, with the detected concentration of 2 ug/l exceeding the tap water RBC value. Barium was detected at a frequency of 21 out of 21 samples, with the maximum concentration (1,430 ug/l) and the representative concentration (575 ug/l) exceeding the tap water RBC value. Beryllium was detected at a frequency of one out of 21 samples, with the detected concentration of 2.8 ug/l exceeding the tap water RBC value. Chromium was detected at a frequency of seven out of 21 samples, with the maximum concentration (40.8 ug/l) exceeding the tap water RBC value. Iron was detected at a frequency of 18 out of 21 samples, with the maximum concentration (7,440 ug/l) exceeding tap water RBC value. Lead was detected at a frequency of one out of eight samples, with the detected concentration of 18.1 ug/l exceeding the tap water RBC value. Manganese was detected at a frequency of 19 out of 21 samples, with the maximum concentration (397 ug/l) and representative concentration (356 ug/l) exceeding the tap water RBC value. Nickel was detected at a frequency of 1 out of 21 samples, with the detected concentration of 74.3 ug/l exceeding the tap water RBC value.

Dieldrin was detected at a frequency of two out of 21 samples with both the maximum and representative concentration exceeding the tap water RBC value. 1,1,1-TCA was detected at a frequency of 10 out of 21 samples, with both the maximum and representative concentration exceeding the tap water RBC value. 1,1,2-TCA was detected at a frequency of one out of 21 samples, with the detected concentration exceeding the tap water RBC value. 1,1-DCA and 1,1-DCE were detected at frequencies of nine out of 21 samples with both the maximum and representative concentrations of 1,1-DCE and the maximum concentration of 1,1-DCA exceeding the tap water RBC value. 1,2-DCA was detected at a frequency of two out of 21 samples with both the maximum and representative concentration exceeding the tap water RBC value. Benzene was detected at a frequency of two out of 21 samples, with both the maximum and representative concentration exceeding the tap water RBC value. PCE was detected at a frequency of eight out of 21 samples, with both the maximum and representative concentration exceeding the tap water RBC value. TCE was detected at a frequency of nine out of 21 samples, with both the maximum and representative concentration exceeding the tap water RBC value.

4.7.2 Toxicity Assessment

The toxicological profiles for selected COPCs at Site 5 are presented in Appendix J. All relevant quantitative and qualitative toxicity assessment information and methods are presented in Section 3.1.

4.7.3 Exposure Assessment

The COPCs that were selected for each environmental medium sampled at Site 5 are presented in

Section 7.5. The potential receptors identified in Section 3.1 include current occupational workers, current adolescent and adult trespassers, future excavation workers, future recreational children, and future residents. Consequently, the potential receptors and exposure pathways presented in Section 3.1 were evaluated quantitatively. Exposure parameters, exposure routes, intakes, and other relevant exposure assessment information are presented in Section 3.1. Example calculations for estimated intakes are presented in Appendix J.

4.7.4 Risk Characterization

This section presents the results of the quantitative risk assessment evaluated under a reasonable maximum exposure (RME) and a central tendency exposure (CTE). CTE will only be included if the total carcinogenic risk for an exposure pathway exceeds 1E-04 or if a HI (noncarcinogenic risk) for an exposure pathway exceeds 1.0. This section discusses the human health risk in four parts:

- Carcinogenic Risks
- Noncarcinogenic Risk
- Lead Risks
- A Discussion of the Impact of Subsurface Soil Exposure Risks to Future Residential Receptors

Carcinogenic Risks

Table 4-23 lists the estimated cumulative RME carcinogenic risks at Site 5 for current occupational workers, current trespassers, future recreational children, future excavation workers, and future residents. Table 4-24 lists the estimated cumulative CTE carcinogenic risks at Site 5 for current occupational workers, current trespassers, future recreational children, future excavation workers, and future residents. EPA's Target Cancer Risk Range of 1E-04 to 1E-06 is often used to determine the need for environmental remediation. Chemical-specific risks for COPCs are presented in Appendix J.

RME Risks

Estimated Cancer Risks Equal to or Exceeding EPA's Target Risk Range of 1E-04 to 1E-06

The estimated carcinogenic risk for the future resident is 1E-03, which exceeds the upper end of the EPA target cancer risk range of 1E-04 to 1E-06. Incidental ingestion of surface soil and ingestion of, dermal contact with, and inhalation of vapors in groundwater contribute the most to the cumulative carcinogenic risks for the future resident. The principal COPCs contributing to this cancer risk are dioxins/furan

Table 4-23
Summary of Exposure Pathway Risks by Site - Estimated RME Cancer Risks for Site 05
NASJRB Willow Grove

Area of Interest / Exposure Medium	Estimated Cancer Risk Current Occupational Worker				Estimated Cancer Risk Current Trespasser				Estimated Cancer Risk Future Recreational Child			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 05												
Surface Soil, TOTAL RISK:	5.29E-05	2.03E-05	5.77E-08	7.33E-05	1.75E-05	2.21E-06	4.77E-09	1.97E-05	4.67E-06	3.38E-07	6.37E-10	5.01E-06
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA	5.56E-07	NT	NA	5.56E-07	1.49E-07	NT	NA	1.49E-07
Surface Water, TOTAL RISK:	NA	NA	NA	NA	5.55E-10	1.48E-06	NA	1.48E-06	4.82E-09	1.18E-07	NA	1.23E-07
Groundwater, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GROUP TOTAL:	**5.29E-05**	**2.03E-05**	**5.77E-08**	**7.33E-05**	**1.81E-05**	**3.69E-06**	**4.77E-09**	**2.17E-05**	**4.83E-06**	**4.56E-07**	**6.37E-10**	**5.28E-06**

Area of Interest / Exposure Medium	Estimated Cancer Risk Future Excavation Worker				Estimated Cancer Risk Future Resident			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 05								
Surface Soil, TOTAL RISK:	2.44E-06	9.75E-08	8.32E-10	2.54E-06	4.74E-04	4.47E-05	5.04E-07	5.19E-04
Subsurface Soil, TOTAL RISK:	2.39E-07	NT	5.2E-11	2.39E-07	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA
Surface Water, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA
Groundwater, TOTAL RISK:	NA	NA	NA	NA	5.73E-04	9.57E-05	1.69E-04	8.38E-04
GROUP TOTAL:	**2.68E-06**	**9.75E-08**	**8.84E-10**	**2.78E-06**	**1.05E-03**	**1.40E-04**	**1.70E-04**	**1.36E-03**

Notes:

NA -- Not Applicable
NT -- No toxicity factor
NC -- No COPCs selected
RME -- Reasonable Maximum Exposure

Table 4-24
Summary of Exposure Pathway Risks by Site - Estimated CTE Cancer Risks for Site 05
NASJRB Willow Grove

Area of Interest / Exposure Medium	Estimated Cancer Risk Current Occupational Worker				Estimated Cancer Risk Current Trespasser				Estimated Cancer Risk Future Recreational Child			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 05												
Surface Soil, TOTAL RISK:	1.90E-05	7.31E-06	2.08E-08	2.64E-05	1.16E-06	2.07E-07	6.30E-10	1.36E-06	7.79E-07	1.11E-07	2.12E-10	8.90E-07
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA	3.67E-08	NT	NA	3.67E-08	2.48E-08	NT	NA	2.48E-08
Surface Water, TOTAL RISK:	NA	NA	NA	NA	7.33E-11	2.02E-07	NA	2.02E-07	1.61E-09	3.91E-08	NA	4.07E-08
Groundwater, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GROUP TOTAL:	**1.90E-05**	**7.31E-06**	**2.08E-08**	**2.64E-05**	**1.19E-06**	**4.08E-07**	**6.30E-10**	**1.60E-06**	**8.05E-07**	**1.51E-07**	**2.12E-10**	**9.56E-07**

Area of Interest / Exposure Medium	Estimated Cancer Risk Future Excavation Worker				Estimated Cancer Risk Future Resident			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 05								
Surface Soil, TOTAL RISK:	1.22E-06	4.88E-08	4.16E-10	1.27E-06	7.60E-05	1.37E-05	1.58E-07	8.99E-05
Subsurface Soil, TOTAL RISK:	1.19E-07	NT	2.6E-11	1.19E-07	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA
Surface Water, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA
Groundwater, TOTAL RISK:	NA	NA	NA	NA	1.24E-04	5.09E-05	4.94E-05	2.23E-04
GROUP TOTAL:	**1.34E-06**	**4.88E-08**	**4.42E-10**	**1.39E-06**	**2.00E-04**	**6.46E-05**	**4.96E-05**	**3.13E-04**

Notes:

NA -- Not Applicable
NT -- No toxicity factor
NC -- No COPCs selected
CTE -- Central Tendency Exposure

-congeners (especially 1,2,3,6,7,8-HPCDD, 2,3,7,8-TCDD, OCDD), benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene in surface soils and 1,1-DCE in groundwater. The estimated contribution to the carcinogenic risk for the future residents from groundwater exposure is 8E-04.

Cancer Risks Within EPA's Target Risk Range of 1E-04 to 1E-06

The estimated carcinogenic risk for the current occupational worker is 7E-05, which is within the EPA target cancer risk range of 1E-04 to 1E-06. The estimated carcinogenic risk for the current trespasser is 2E-05, which is within the EPA target cancer risk range of 1E-04 to 1E-06. The estimated carcinogenic risk for the future recreational child is 5E-06, which is within the EPA target cancer risk range of 1E-04 to 1E-06. The estimated carcinogenic risk for the future excavation worker is 3E-06, which is at the lower end of EPA target cancer risk range of 1E-04 to 1E-06. Incidental ingestion of surface soil contributes the most to the cumulative carcinogenic risks for the current occupational worker, the current trespasser, future recreational child and future excavation worker. The principal COPCs contributing to this cancer risk are dioxin/furan-congeners (especially 1,2,3,6,7,8-HPCDD, 2,3,7,8-TCDD, and OCDD), benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene (surface soils).

CTE Risks

Estimated Cancer Risks Equal to or Exceeding EPA's Target Risk Range of 1E-04 to 1E-06

The estimated carcinogenic risk for the future resident is 3E-04, which exceeds the upper end of the EPA target cancer risk range of 1E-04 to 1E-06. Incidental ingestion of surface soil and ingestion of, dermal contact with, and inhalation of vapors in groundwater contribute the most to the cumulative carcinogenic risks for the future resident. The principal COPCs contributing to this cancer risk are dioxin/furan-congeners (especially 1,2,3,6,7,8-HPCDD, 2,3,7,8-TCDD, OCDD), benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene in surface soils and 1,1-DCE in groundwater. The estimated contribution to the carcinogenic risk for the future residents from groundwater exposure is 2E-04.

Cancer Risks Within EPA's Target Risk Range of 1E-04 to 1E-06

The estimated carcinogenic risk for the current occupational worker is 3E-05, which is within the EPA target cancer risk range of 1E-04 to 1E-06. The estimated carcinogenic risk for the current trespassers is 2E-06, which is within the EPA target cancer risk range of 1E-04 to 1E-06. The estimated carcinogenic

risk for the future recreational child is 1E-06, which is within the EPA target cancer risk range of 1E-04 to 1E-06. The estimated carcinogenic risk for the future excavation worker is 1E-06, which is at the lower end of EPA target cancer risk range of 1E-04 to 1E-06. Incidental ingestion of surface soil contributes the most to the cumulative carcinogenic risks for the current occupational worker, current trespasser, future recreational child, and future excavation worker. The principal COPCs contributing to this cancer risk are dioxins/furan-congeners (especially 1,2,3,6,7,8-HPCDD, 2,3,7,8-TCDD, and OCDD), benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene (surface soils).

Noncarcinogenic Risks

Table 4-25 lists the estimated cumulative RME noncarcinogenic risks at Site 5 for current occupational workers, current trespassers, future recreational children, future excavation workers, and future residents. Table 4-26 lists the estimated cumulative CTE noncarcinogenic risks at Site 5 for current occupational workers, current trespassers, future recreational children, future excavation workers, and future residents. EPA's cumulative HI of 1.0 is often used to determine the need for environmental remediation. EPA's HI of 1.0 is a benchmark below which adverse noncarcinogenic health effects are not anticipated under conditions established in the exposure assessment. Chemical-specific risks for COPCs are presented in Appendix J.

RME Risks

Noncarcinogenic Hazard Indices Above 1.0

The cumulative HIs for the future residential child (5.1) and the future residential adult (2.2) exceed 1.0. Incidental ingestion of and dermal contact with surface soil and ingestion of groundwater are the main contributors to the HIs exceeding 1.0. The principal COPCs contributing to the noncarcinogenic risk are chromium and iron in surface soil and barium manganese, dieldrin, 1,1,1-TCA, 1,1-DCE, and TCE in groundwater. The chemicals affect the following target organs: chromium (kidney); iron (pancreas, liver, and GI tract), barium (heart and GI tract), manganese (CNS), dieldrin (liver), 1,1,1-TCA (kidney, liver, and CNS), 1,1-DCE (kidney, liver, and CNS), and TCE (kidney, liver, and CNS). The HI based on the kidney as the target affected organ of exceeds 1.0 for the residential child. The HI based on the liver as the target affected organ exceeds 1.0 for the residential child. The HI based on the CNS as the target affected organ exceeds 1.0 for the residential child. The HI based on the GI tract as the target affected organ exceeds 1.0 for the residential child. Iron and chromium were detected at elevated levels in all collected surface soil samples and were present at concentrations elevated above background concentrations. Barium was detected in groundwater at a frequency of 21 out of 21 samples, with the

Table 4-25
Summary of Exposure Pathway Risks by Site - Estimated RME Hazard Indices for Site 05
NASJRB Willow Grove

Area of Interest / Exposure Medium	Estimated Hazard Index Current Occupational Worker				Estimated Hazard Index Current Adult Trespasser				Estimated Hazard Index Current Adolescent Trespasser			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 05												
Surface Soil, TOTAL RISK:	2.99E-02	1.86E-01	NT	2.16E-01	5.75E-03	1.79E-02	NT	2.36E-02	1.26E-02	4.61E-02	NT	5.87E-02
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA	NT	NT	NA	NT	NT	NT	NA	NT
Surface Water, TOTAL RISK:	NA	NA	NA	NA	1.13E-06	3.23E-03	NA	3.23E-03	2.47E-06	6.16E-03	NA	6.17E-03
Groundwater, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GROUP TOTAL:	**2.99E-02**	**1.86E-01**	**NT**	**2.16E-01**	**5.75E-03**	**2.11E-02**	**NT**	**2.69E-02**	**1.26E-02**	**5.23E-02**	**NT**	**6.48E-02**

Area of Interest / Exposure Medium	Estimated Hazard Index Future Recreational Child				Estimated Hazard Index Future Excavation Worker				Estimated Hazard Index Future Residential Adult			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 05												
Surface Soil, TOTAL RISK:	1.10E-02	NT	8.76E-07	1.10E-02	3.45E-02	2.24E-02	NT	5.69E-02	8.38E-02	2.61E-01	NT	3.45E-01
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA	NT	NT	NT	NT	NA	NA	NA	NA
Sediment, TOTAL RISK:	NT	NT	NA	NT	NA	NA	NA	NA	NA	NA	NA	NA
Surface Water, TOTAL RISK:	7.02E-05	1.73E-03	NA	1.80E-03	NA	NA	NA	NA	NA	NA	NA	NA
Groundwater, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	1.44E+00	1.57E-01	2.93E-01	1.89E+00
GROUP TOTAL:	**1.11E-02**	**1.73E-03**	**8.76E-07**	**1.28E-02**	**3.45E-02**	**2.24E-02**	**NA**	**5.69E-02**	**1.52E+00**	**4.18E-01**	**2.93E-01**	**2.24E+00**

Area of Interest / Exposure Medium	Estimated Hazard Index Future Residential Child			
	Ingestion	Dermal Contact	Inhalation	Total
Site 05				
Surface Soil, TOTAL RISK:	7.83E-01	6.65E-01	NT	1.45E+00
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA
Surface Water, TOTAL RISK:	NA	NA	NA	NA
Groundwater, TOTAL RISK:	3.35E+00	3.20E-01	NA	3.67E+00
GROUP TOTAL:	**4.13E+00**	**9.85E-01**	**NA**	**5.12E+00**

Notes:

NA -- Not Applicable
NT -- No toxicity factor
NC -- No COPCs selected
RME -- Reasonable Maximum Exposure

Table 4-26
Summary of Exposure Pathway Risks by Site - Estimated CTE Hazard Indices for Site 05
NASJRB Willow Grove

Area of Interest / Exposure Medium	Estimated Hazard Index Current Occupational Worker				Estimated Hazard Index Current Adult Trespasser				Estimated Hazard Index Current Adolescent Trespasser			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 05												
Surface Soil, TOTAL RISK:	2.99E-02	1.86E-01	NT	2.16E-01	1.44E-03	8.94E-03	NT	1.04E-02	3.14E-03	2.37E-02	NT	2.68E-02
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA	NT	NT	NA	NT	NT	NT	NA	NT
Surface Water, TOTAL RISK:	NA	NA	NA	NA	5.64E-07	1.61E-03	NA	1.61E-03	1.23E-06	3.17E-03	NA	3.17E-03
Groundwater, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GROUP TOTAL:	**2.99E-02**	**1.86E-01**	**NT**	**2.16E-01**	**1.44E-03**	**1.06E-02**	**NT**	**1.20E-02**	**3.15E-03**	**2.68E-02**	**NT**	**3.00E-02**

Area of Interest / Exposure Medium	Estimated Hazard Index Future Recreational Child				Estimated Hazard Index Future Excavation Worker				Estimated Hazard Index Future Residential Adult			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 05												
Surface Soil, TOTAL RISK:	5.51E-03	NT	8.76E-07	5.51E-03	1.72E-02	1.12E-02	NT	2.84E-02	4.19E-02	2.61E-01	NT	3.03E-01
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA	NT	NT	NT	NT	NA	NA	NA	NA
Sediment, TOTAL RISK:	NT	NT	NA	NT	NA	NA	NA	NA	NA	NA	NA	NA
Surface Water, TOTAL RISK:	7.02E-05	1.71E-03	NA	1.78E-03	NA	NA	NA	NA	NA	NA	NA	NA
Groundwater, TOTAL RISK:	NA	NA	NA	NA	NA	NA	6.20E+01	6.20E+01	1.01E+00	1.57E-01	2.93E-01	1.46E+00
GROUP TOTAL:	**5.58E-03**	**1.71E-03**	**8.76E-07**	**7.29E-03**	**1.72E-02**	**1.12E-02**	**6.20E+01**	**6.21E+01**	**1.05E+00**	**4.18E-01**	**2.93E-01**	**1.76E+00**

Area of Interest / Exposure Medium	Estimated Hazard Index Future Residential Child			
	Ingestion	Dermal Contact	Inhalation	Total
Site 05				
Surface Soil, TOTAL RISK:	3.91E-01	6.58E-01	NT	1.05E+00
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA
Surface Water, TOTAL RISK:	NA	NA	NA	NA
Groundwater, TOTAL RISK:	2.35E+00	9.59E-01	NT	3.31E+00
GROUP TOTAL:	**2.74E+00**	**1.62E+00**	**NA**	**4.36E+00**

Notes:

NA -- Not Applicable
NT -- No toxicity factor
NC -- No COPCs selected
CTE -- Central Tendency Exposure

maximum concentration (1,430 ug/l) and the representative concentration (575 ug/l) exceeding the tap water RBC value. Manganese was detected in groundwater at a frequency of 19 out of 21 samples, with the maximum concentration (397 ug/l) and representative concentration (356 ug/l) exceeding the tap water RBC value. 1,1,1-TCA, 1,1-DCE, and TCE were detected in groundwater in approximately one-half of the collected samples. Dieldrin was detected in two out of 21 samples in groundwater at concentrations of 0.09 ug/l and 0.3 ug/l. No other combination of hazard quotients that effect the same target organ for the future residential child would result in an HI of greater than 1.0. The HIs based on the same target organ for the residential adult would all be less than 1.0.

Noncarcinogenic Hazard Indices Less Than 1.0

The HIs for current occupational workers, current trespassers, future recreational children, and future excavation workers at Site 5 are less than 1.0.

CTE Risks

Noncarcinogenic Hazard Indices Above 1.0

The cumulative HIs for the future residential child (4.4) and the future residential adult (1.8) exceed 1.0. Incidental ingestion of and dermal contact with surface soil and ingestion of groundwater are the main contributors to the HIs exceeding 1.0. The principal COPCs contributing to the noncarcinogenic risk are chromium and iron in surface soil and barium, manganese, dieldrin, 1,1,1-TCA, 1,1-DCE, and TCE in groundwater. The chemicals affect the following target organs: chromium (kidney); iron (pancreas, liver, and GI tract), barium (heart and GI tract), manganese (CNS), dieldrin (liver), 1,1,1-TCA (kidney, liver, and CNS), 1,1-DCE (kidney, liver, and CNS), and TCE (kidney, liver, and CNS). The HI based on the kidney as the target organ exceeds 1.0 for the residential child. The HI based on liver as the target organ exceeds 1.0 for the residential child. The HI based on the CNS as the target affected organ exceeds 1.0 for the residential child. Iron and chromium were detected in all surface soil samples collected and at concentrations elevated above background concentrations. Manganese was detected in groundwater at a frequency of 19 out of 21 samples, with the maximum concentration (397 ug/l) and representative concentration (356 ug/l) exceeding the tap water RBC value. 1,1,1-TCA, 1,1-DCE, and TCE were detected in groundwater at elevated levels in approximately one-half of the samples collected at elevated levels. Dieldrin was detected in groundwater in two out of 21 samples at concentrations of 0.09 ug/l and 0.3 ug/l. No other combination of hazard quotients that effect the same target organ for the future residential child would result in an HI of greater than 1.0. The HIs based on the same target organ for the residential adult would all be less than 1.0.

Noncarcinogenic Hazard Indices Less Than 1.0

The HIs for current occupational workers, current trespassers, future recreational children, and future excavation workers at Site 5 are less than 1.0.

Lead Risks

The IEUBK Lead Model (v. 0.99) was used to characterize risks from lead in soil, dust, and water for the hypothetical future residential children (ages 0 through 6), who are considered the most sensitive receptor group at Site 5. The simulated range of blood-lead values that might occur in a population as a result of exposures to lead was compared to a guideline level of 10 micrograms per deciliter (μg/dL).

Based on model results under an RME (using the maximum lead concentration in surface soil and groundwater), 18.6 percent of residential children exposed under similar conditions might have blood-lead levels exceeding 10 μg/dL. This exceeds a protective guideline of 5 percent for the maximum proportion of individuals with blood-lead levels exceeding 10 μg/dL (EPA, 1994). The model inputs were default parameter values and a site soil lead concentration of 412 mg/kg and a groundwater concentration of 18.1 ug/l. The IEUBK population histograms for Site 5 (based on RME exposure) exposures are presented in Appendix J.

Based on model results under CTE (using the average lead concentration in surface soil and groundwater), 4.1 percent of residential children exposed under similar conditions might have blood-lead levels exceeding 10 μg/dL. This is below a protective guideline of 5 percent for the maximum proportion of individuals with blood levels exceeding 10 μg/dL (EPA, 1994). The model inputs were default parameter values and a site soil lead concentration of 217 mg/kg lead and a groundwater concentration of 12.6 ug/l. The IEUBK population histograms for Site 5 (based on CTE exposure) exposures are presented in Appendix J.

Noncarcinogenic risks for occupational workers from exposures to lead in soil were estimated using the Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil (EPA, 1996). The model estimates the upper 95 percentile of fetal blood-lead concentrations at birth that would be associated with maternal exposure to lead in soil in an occupational environment. Based on the model, 5.4 ug/dl is the estimated upper 95 percentile of fetal blood-lead concentrations, assuming exposure to soil containing the maximum detected concentration (89.7 mg/kg) would result in a fetal blood-level of no greater than 5.4 ug/dl in 95 percent of an exposured population. Both values are below the 10 ug/dl benchmark value, which is the protection level most often considered during initial baseline risk evaluation.

A Discussion of the Impact of Subsurface Soil Exposure Risks to Future Residential Receptors

Subsurface soil exposure to future residential receptors can be evaluated using the COPCs that are the drivers for the risks in surface soil, carcinogenic PAHs (carcinogenic risks), iron (noncarcinogenic risks), and chromium (noncarcinogenic risks). Dioxin/furan congeners that were carcinogenic risk drivers in surface soils were not detected in subsurface soil. Benzo(a)pyrene and other PAHs are the main drivers to the carcinogenic risks to the excavation worker in subsurface soils. These chemicals are similar to those selected as COPCs for the future resident in surface soil with the exclusion of the carcinogenic risk drivers dioxins/furans and the noncarcinogenic driver iron. PAHs have representative concentrations approximately an order of magnitude less than those of carcinogenic PAHs in surface soil. Subsurface soil would be assumed to be surface soil for the future residential receptors. Assuming a standard residential RME exposure scenario for exposure to subsurface soils, the estimated carcinogenic risk to the future residential receptor would be within EPA's target cancer risk range of 1E-04 to 1E-06 for Site 3. The carcinogenic risks from carcinogenic PAHs would be estimated at greater than 1E-05, but still within EPA's target cancer risk range. The noncarcinogenic risks to the future residential child would exceed an HI of 1.0.

4.7.5 Uncertainties

Beyond the uncertainties associated with the human health risk assessment process discussed in Section 3.1, the following uncertainties should be considered in any evaluation of Site 5 risk assessment results:

- The uncertainty associated with the dermal exposure is high because of the derivation of the dermal slope factor and reference dose (see Section 3.1). The dermal toxicity factors are based on default oral absorption factors. This can result in an overestimation of the toxicity factors. It eventually causes dermal exposure to be a primary contributor to the cumulative cancer risk and HI (via surface soils) for the future residential receptors and current occupational workers. The uncertainty associated with the dermal exposure route may overestimate the risk at Site 5.

- Iron is the main contributor to the noncarcinogenic risks for the future residential child (surface soil exposure). There is uncertainty associated with the oral RfD for iron. Risks at Site 3 from iron exposure may be overestimated.

- Three chemicals, 2-hexanone (subsurface soil), benzo(g,h,i)perylene (surface soil, subsurface soil, and sediment), and phenanthrene (surface soil, subsurface soil, and sediment), did not have listed toxicity values for use in the quantitative risk assessment;

therefore, no risks were estimated for exposure to the COPCs. These chemicals generally had low or similar frequencies of detection as chemicals within the same class (i.e., PAHs). This uncertainty could possibly underestimate the carcinogenic and noncarcinogenic risk at Site 5, but, without additional toxicity information, this remains unknown.

4.7.6 Conclusions

The total cumulative carcinogenic risk for the current occupational worker is within EPA's target cancer risk range at Site 5 for RME and CTE scenarios. The total cumulative carcinogenic risk for the future residential receptor exceeds EPA's target cancer risk range at Site 5 for RME and CTE scenarios. Dioxin/furan congeners, carcinogenic PAHs in surface soil, and 1,1-DCE in groundwater at Site 5 are the main contributors the cancer risk for the potential receptors. The RME and CTE risk for groundwater consumption (untreated groundwater) for a future residential receptor is 8E-04 and 2E-04, respectively, both of which are at or exceed the EPA target cancer risk range of 1E-04 to 1E-06. Iron and chromium in surface soil and manganese, barium, dieldrin and several VOCs in groundwater are the main contributors to the RME and CTE noncarcinogenic risk at Site 5 for the future residential child receptor. All other noncarcinogenic HIs for the other potential receptors at Site 5 are less than 1.0. Dioxins and furans and carcinogenic PAHs are the main COPCs selected for Site 5 soils. These contaminants are consistent with past practices at Site 5, which was a fuel burning area (solvents, paint chemicals, xylenes, toluenes, and petroleum compounds). VOCs are the main COPCs in groundwater and these contaminants are also consistent with past practices of the site.

4.8 ECOLOGICAL RISK ASSESSMENT

This section presents the results of the ecological risk assessment performed at Site 5, the Fire Training Area.

4.8.1 Preliminary Problem Formulation

This section includes a discussion of available habitats, ecological receptors, contaminant sources, release mechanisms, migration pathways, exposure routes, selection of analytes to be investigated, assessment and measurement endpoints, and the conceptual site model.

4.8.1.1 Habitat Types and Ecological Receptors

Site 5 consists of disturbed areas of grass, weeds, and shrubs (Figure 4-13). The northern portion of the

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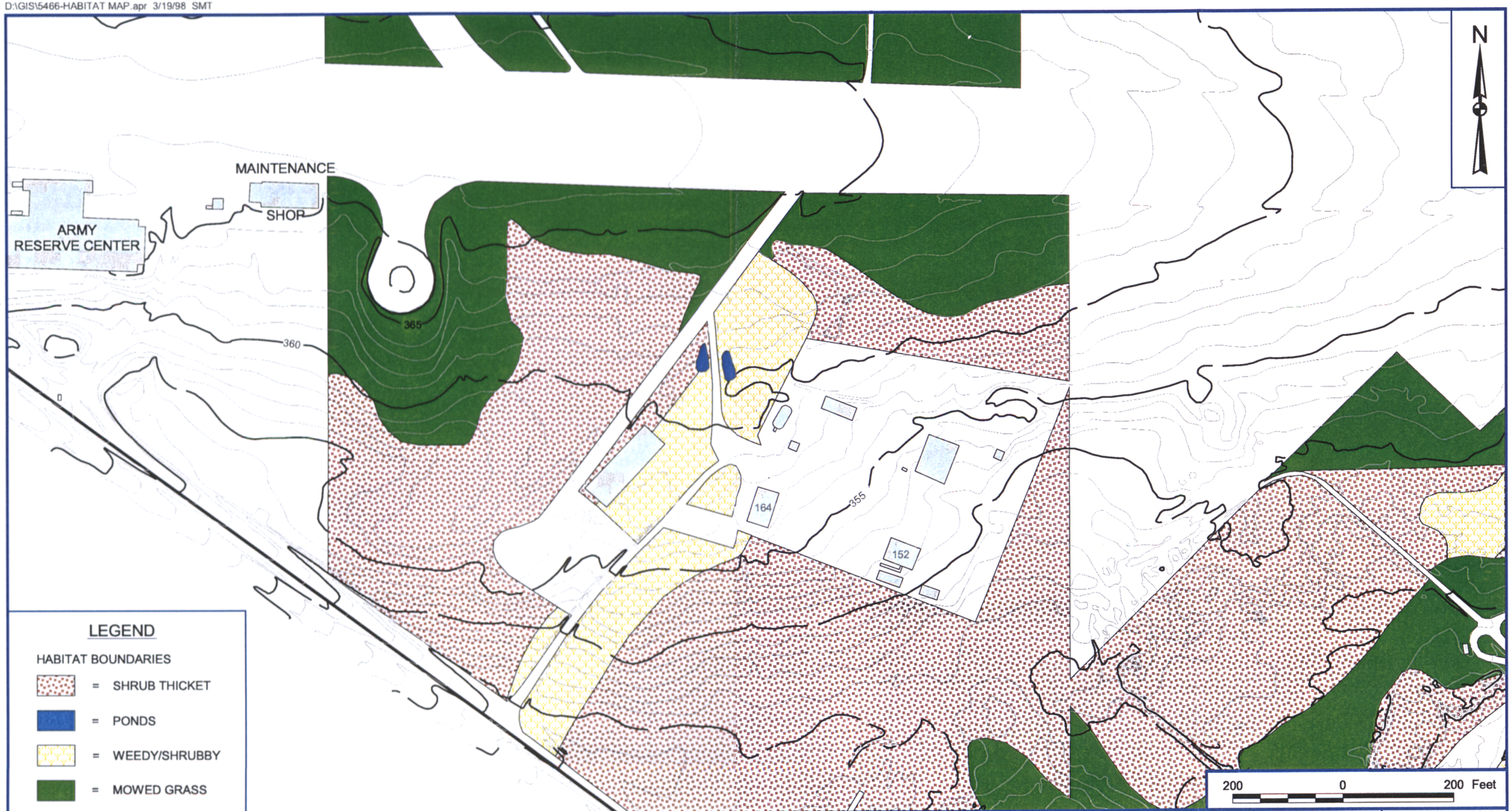

NO.	DATE	REVISIONS	BY	CHKD	APP'D	REFERENCES
1	9/11/01	DRAWING REDRAWN AND UPDATED.	LDL			

DRAWN BY S. TABLER	DATE 3/19/98
CHECKED BY RET	DATE
COST/SCHEDULE-AREA	
SCALE AS NOTED	

Tetra Tech NUS, Inc.

HABITAT MAP
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NUMBER 5466	OWNER NUMBER 2207
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO. FIGURE 4-13	REV 1

site is a regularly mowed grassy area adjacent to aircraft taxiway Juliet. A shrub thicket is located west of the paved access road into the site. An area of weeds and shrubs exists east of the access road in the vicinity of the former burn area. Sumac (*Rhus* spp.) and box-elder (*Acer negundo*) are abundant in that area. A shallow drainage ditch east of the access road separates the weedy area from the grassy area near the taxiway. The area surrounding the ditch is thickly vegetated with common reed (*Phragmites australis*) and cattail (*Typha* spp.). Two small, shallow excavated ponds (approximately 80 ft by 20 ft) are located approximately 100 feet south of the site. These ponds are not shown on the National Wetlands Inventory Map of the area (U.S. Department of the Interior, undated), but marsh vegetation has become established in the area surrounding the two ponds. The western pond was completely covered with a dense layer of cattail during a site visit in March 1999.

The site is adjacent to an open taxiway to the north, the Marine Corps Compound to the south and southeast, and a paved access road to the west. Thus, to a large extent, wildlife species at the site consist of those that have become accustomed to human disturbance. These include rabbits, raccoons, smaller mammals such as mice, reptiles and amphibians, and various birds. A woodchuck burrow was observed near the former burn area during the March 1999 site visit. During periods of relative human inactivity, deer and red foxes are known to occasionally utilize the site. Avian raptors are expected to forage in the grassy area adjacent to the taxiway. The two small ponds are inhabited by minnows, aquatic invertebrates, reptiles and amphibians, and are occasionally utilized by various receptors that forage on aquatic organisms (e.g., wading birds, waterfowl, raccoons, etc.). There are no known animals or plants state- or federally-listed as threatened, endangered, or candidates for listing, at the site.

4.8.1.2 Contaminant Sources, Release Mechanisms, and Migration Pathways

The contaminant source at Site 5 consists of the former Fire Training Area. Petroleum and related wastes were burned at the site for fire training exercises. Potential contaminant release pathways at the site include volatilization, wind erosion, overland runoff, and infiltration of contaminants. Combustion was probably a major transport mechanism during the period when the fire training area was in use. However, combustion is not a current transport mechanism at Site 5 since open burning activities have ceased.

Constituents in soil could volatilize from surficial material or become airborne via wind erosion. Contaminated fugitive dust can be generated during ground-disturbing activities, such as construction or excavation. The contaminants could then be dispersed in the surrounding environment and transported to downwind locations where they could repartition to surface soil, surface water, or sediment through gravitational settling, precipitation, and deposition. However, most of the site is heavily vegetated, minimizing the airborne contaminant transport pathway. The absence of vegetation in the immediate area of the burn ring could contribute to fugitive emissions of fine-grained soil particles, but since this area

is small, fugitive emissions are probably insignificant.

The flat topography in the vicinity of the site decreases the degree of precipitation runoff. However, two small ponds are approximately 100 feet from the site in a slight downslope direction. In addition, some runoff could eventually drain into ditches that exit the base approximately 2,000 ft south of the site. This drainage eventually flows into Pennypack Creek approximately 3,000 south of the air station.

Infiltrating precipitation can cause the contamination of subsurface soil and groundwater. After reaching the water table, contaminants can be carried with the flow of groundwater to downgradient locations. Contaminants transported in groundwater to surface water can be deposited subsequently in sediment or surface water, and can potentially accumulate in the tissues of aquatic organisms in the ponds.

Groundwater beneath Site 5 flows southeast or southwest, depending on location and depth. The nearest surface water (other than the two nearby ponds) into which site groundwater could discharge is Pennypack Creek, approximately 4,500 feet south of the site. There is no evidence from the RI indicating that groundwater discharges into Pennypack Creek.

4.8.1.3 Exposure Routes

Terrestrial animals at Site 5 can be exposed to soil contaminants through the ingestion of contaminated food items. In addition, animals can incidentally ingest soil while grooming fur, preening feathers, digging, grazing close to the soil, or feeding on items that are covered with soil (such as roots and tubers). Terrestrial vegetation can be exposed to contaminants through direct aerial deposition and root translocation. Aerial deposition could have been a significant exposure route during historical landfill activities. However, aerial deposition is presently minimal since most of the site is vegetated. Terrestrial receptors can also come into contact with contaminants in surface water by using it for drinking, although this exposure route generally represents a negligible portion of total exposure for most receptors.

Aquatic and semi-aquatic organisms in the ponds near Site 5 can be exposed to contaminants through direct contact with surface water and sediments, incidental ingestion of surface water and sediments, and consumption of contaminated food items. Exposure to contaminants in the soil via dermal contact can occur but is unlikely to represent a major exposure pathway because fur, feathers, and chitinous exoskeletons minimize the transfer of contaminants across dermal tissue.

Volatile constituents could be present in some site soils and soil-bound contaminant airborne suspension could occur at Site 5. However, inhalation does not represent a significant exposure pathway because this investigation assumes that air contaminant concentrations are quite low, even for burrowing wildlife.

Further more, inhalation ecotoxicity data for chronic exposure are lacking. Hence, the air pathway was not considered for ecological receptors.

4.8.1.4 Selection of Analytes to be Investigated

As discussed in Section 3.2.1.1, calcium, magnesium, potassium, and sodium were excluded as COPCs in all media because they are essential nutrients that are toxic only in extremely high concentrations. Otherwise, analytes selected for evaluation consisted of all analytes detected during current and previous sampling of surface water, sediment, and surface soil at Site 5.

4.8.1.5 Assessment and Measurement Endpoints

A description of assessment and measurement endpoints for this investigation is presented in Section 3.2.1.1.

4.8.1.6 Conceptual Site Model

Figure 4-14 shows the conceptual model for Site 5. The figure shows a complete exposure route for the wind erosion pathway. However, since most of the site is heavily vegetated, the wind erosion pathway is assumed to be minimal. In addition, the dermal (direct contact) exposure route is included in the conceptual model since it is theoretically possible, but as mentioned earlier, it represents a minor exposure route and was not investigated.

4.8.2 Preliminary Ecological Effects Evaluation

Ecologically-based screening values (e.g., ESVs, concentrations of contaminants in various media considered protective of ecological receptors) were compared to exposure point concentrations of detected analytes in surface water, sediment, and surface soil to determine if the analytes qualify as ecological COPCs at Site 5. The selection of ESVs was discussed in section 3.2.1.2.

4.8.3 Preliminary Exposure Estimate

The maximum detected contaminant concentrations in surface water, sediment, and surface soil were used as exposure point concentrations for comparison to ecological screening levels. Mean contaminant concentrations and 95% UCL of the mean contaminant concentrations (when available) were also compared to alternate guidelines in Step 3a of the assessment.

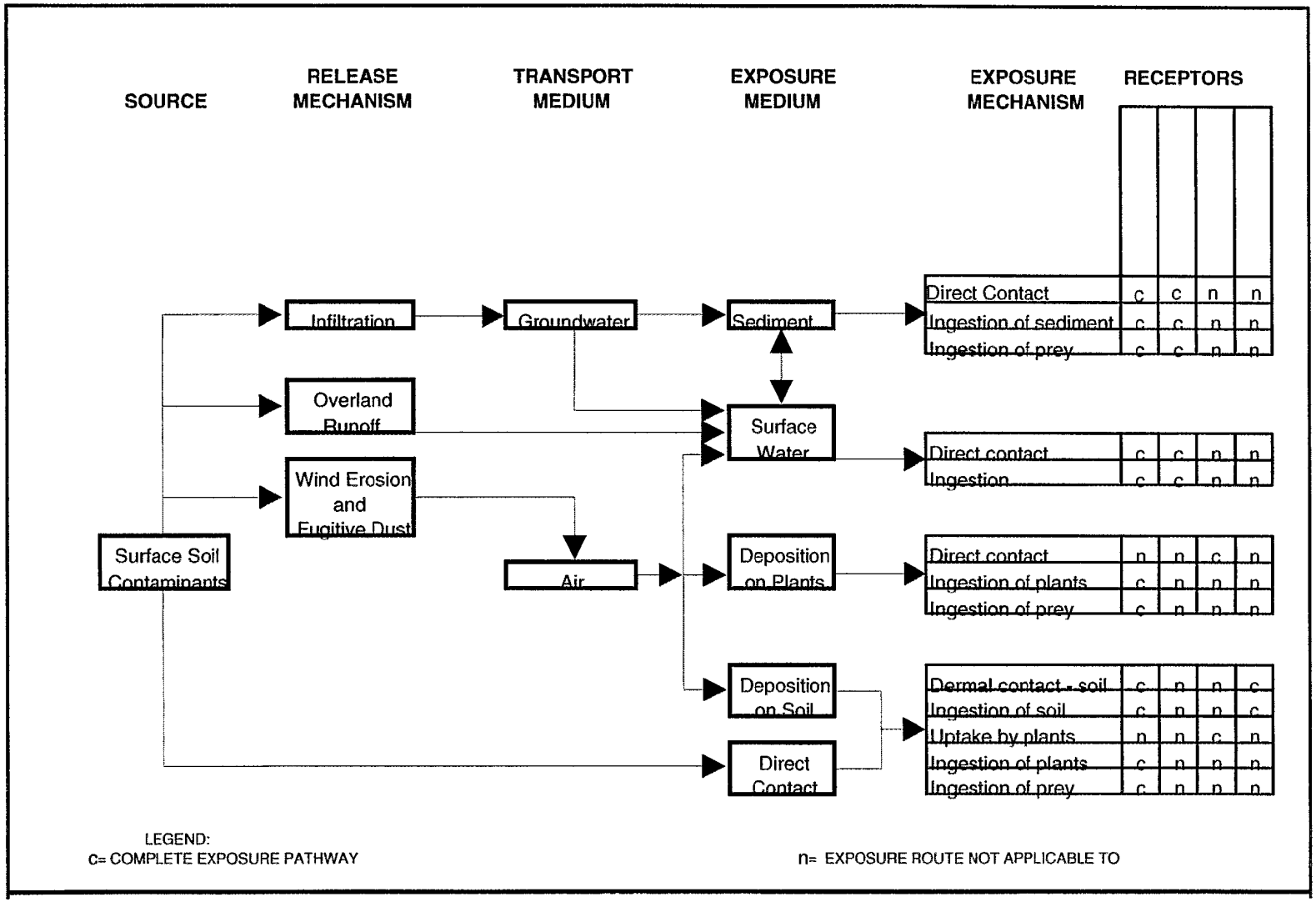

FIGURE 4-14
Conceptual Site Model
Site 5 - Fire Training Area
NASJRB Willow Grove

NAVY/5466/PHASEII/048009

4.8.4 Preliminary Risk Calculation

The maximum detected concentrations of aluminum, barium, iron, lead, and dieldrin in surface water exceeded screening levels and thus, they were retained as COPCs (Table 4-27).

No inorganic sediment analytes exceeded screening levels (Table 4-28). Aluminum, barium, beryllium, cobalt, iron, manganese, and vanadium were retained as sediment COPCs since no screening levels were available. Several organics in sediments were retained as COPCs since their maximum concentrations exceeded screening levels; these consisted of anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, phenanthrene, and pyrene. Aldrin, dieldrin, benzo(k)fluoranthene, 2-butanone, and toluene were retained as sediment COPCs since no screening levels were available.

Aluminum, antimony, arsenic, cadmium, chromium, iron, lead, manganese, thallium, vanadium, and zinc were retained as inorganic COPCs in surface soil since their maximum concentrations exceeded screening levels (Table 4-29). Several SVOCs (primarily PAHs) were retained as organic COPCs in surface soils because their maximum concentrations exceeded screening levels. Acetone and a few SVOCs were retained as COPCs because no screening levels were available.

4.8.5 Step 3a: Discussion

Step 3a considerations are discussed below on a COPC-specific basis.

4.8.5.1 Metals

Aluminum

Aluminum was a COPC in sediment because no initial screening level was available, and was a COPC in surface water and soil because its HQ exceeded 1.0. Its concentration in surface water was twice the ORNL lowest chronic value (Table 4-30). Aluminum concentrations in sediment were well below the only available alternate guideline (Table 4-31), which was a probable effects concentration (PEC) from the USEPA Assessment and Remediation of Contaminated Sediments Program (ARCS). The maximum concentration of aluminum in sediments was less than twice the average background concentration. Concentrations of aluminum in all surface soil samples were within the range of background concentrations.

Aluminum is not readily absorbed through the skin and gastrointestinal absorption of ingested aluminum is poor due to the transformation of aluminum salts into insoluble aluminum phosphate (Venugopal and

TABLE 4-27
SELECTION OF PRELIMINARY CONTAMINANTS OF CONCERN IN SURFACE WATER
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE

Contaminant	Frequency of Detection	Range of Detections (ug/l)		Location of Maximum	Screening Level (ug/l)	Hazard Quotient	Selected as PCOC?
		Minimum	Maximum				
Inorganics							
Aluminum	1/1	926.0	926.0	05SW02	25[1]	37.04	Yes
Arsenic	1/2	1.4	1.4	05SW02	190[2]	0.00	No
Barium	2/2	23.3	44.8	05SW02	3.9[3]	11.5	Yes
Iron	2/2	261	1170.0	05SW02	1,000[2]	1.2	Yes
Lead	2/2	1.3	3.0	05SW02	2.5[2]	1.2	Yes
Manganese	2/2	12.6	55.9	05SW02	80[3]	0.7	No
Zinc	2/2	19	32.1	05SW02	100[2]	0.3	No
Pesticides/PCBs							
Dieldrin	1/2	0.06	0.06	05SW02	0.0019[1]	31.58	Yes

1. Region III BTAG screening level (EPA, 1995)
2. AWQC or FCV (EPA, 1996)
3. Tier II value (EPA, 1996)

TABLE 4-28
SELECTION OF PRELIMINARY CONTAMINANTS OF CONCERN IN SEDIMENT
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE

Contaminant	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Screening Level	Hazard Quotient	Selected as PCOC?
		Minimum	Maximum				
Inorganics (mg/kg)							
Aluminum	2/2	11200.00	12000.00	05SD01	NA	NA	Yes
Antimony	2/2	5.60	6.10	05SD02	150[1]	0.04	No
Arsenic	2/2	4.00	4.50	05SD02	8.2[2]	0.5	No
Barium	2/2	69.80	74.30	05SD02	NA	NA	Yes
Beryllium	2/2	0.58	0.77	05SD02	NA	NA	Yes
Chromium	2/2	8.80	12.90	05SD02	81[2]	0.2	No
Cobalt	2/2	7.10	7.10	05SD02	NA	NA	Yes
Copper	2/2	12.30	13.50	05SD01	34[2]	0.40	No
Iron	2/2	11000.00	11900.00	05SD02	NA	NA	Yes
Lead	2/2	7.90	31.70	05SD02	47[2]	0.7	No
Manganese	2/2	107.00	222.00	05SD02	NA	NA	Yes
Nickel	2/2	9.40	11.00	05SD02	21[2]	0.5	No
Vanadium	2/2	15.60	21.20	05SD02	NA	NA	Yes
Zinc	2/2	14.80	40.10	05SD02	150[2]	0.27	No
Pesticides/PCBs (ug/kg)							
Aldrin	1/2	11.00	11.00	05SD02	NA	NA	Yes
Dieldrin	2/2	17.00	220.00	05SD02	NA	NA	Yes
SVOCs (ug/kg)							
Anthracene	2/2	160.00	160.00	05SD02	85.3[2]	1.88	Yes
Benz(a)anthracene	2/2	650.00	850.00	05SD02	261[2]	3.26	Yes
Benzo(a)pyrene	2/2	520.00	910.00	05SD02	430[2]	2.12	Yes
Benzo(b)fluoranthene	2/2	720.00	1400.00	05SD02	3200[1]	0.44	No

TABLE 4-28
SELECTION OF PRELIMINARY CONTAMINANTS OF CONCERN IN SEDIMENT
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE
PAGE 2 OF 2

Contaminant	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Screening Level	Hazard Quotient	Selected as PCOC?
		Minimum	Maximum				
Pesticides/PCBs (ug/kg) (continued)							
Benzo(g,h,i)perylene	2/2	200.00	400.00	05SD02	670[1]	0.60	No
Benzo(k)fluoranthene	2/2	430.00	700.00	05SD02	NA	NA	Yes
Chrysene	2/2	720.00	1200.00	05SD02	384[2]	3.13	Yes
Dibenz(a,h)anthracene	1/2	120.00	120.00	05SD02	63.4[2]	1.89	Yes
Fluoranthene	2/2	1300.00	1800.00	05SD02	600[2]	3.00	Yes
Indeno(1,2,3-cd)pyrene	2/2	290.00	560.00	05SD02	600[1]	0.93	No
Phenanthrene	2/2	620.00	880.00	05SD02	240[2]	3.67	Yes
Pyrene	2/2	1500.00	1900.00	05SD02	660[2]	2.9	Yes
Total PAHs	2/2	6,060	10,900	05SD02	4,000[2]	2.72	Yes
VOCs (ug/kg)							
2-butanone	1/2	22.00	22.00	05SD02	NA		Yes
Toluene	1/2	4.00	4.00	05SD02	NA		Yes

1 Region III BTAG screening level (EPA 1995)
2 ERL (Long et al 1995)

TABLE 4-29
SELECTION OF PRELIMINARY CONTAMINANTS OF CONCERN IN SURFACE SOIL
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE

Contaminant	Frequency of Detection	Range of Detections		Location of Maximum	Screening Level	Hazard Quotient	Selected as PCOC?
		Minimum	Maximum				
Inorganics (mg/kg)							
Aluminum	15/15	7890.00	12400.00	05SS25	1.0[1]	12400	Yes
Antimony	2/4	8.20	9.20	05SS20	5[2]	1.8	Yes
Arsenic	15/15	1.30	10.50	05SS19	10[2]	1.1	Yes
Barium	15/15	33.10	108.00	05SS17	412.5[3]	0.3	No
Beryllium	15/15	0.30	1.10	05SS17	10[2]	1.1	Yes
Cadmium	3/15	2.80	4.70	05SS28	3[2]	1.6	Yes
Chromium	15/15	8.80	56.50	05SS27	10[4]	5.6	Yes
Cobalt	15/15	4.30	13.00	05SS19	130[3]	0.1	No
Copper	15/15	6.50	28.4	05SS29	100[2]	0.3	No
Iron	15/15	9320.00	21600.00	05SS29	12[1]	1800	Yes
Lead	15/15	7.40	412.00	05SS22	50[4]	8.2	Yes
Manganese	15/15	202.00	873.00	05SS19	330[1]	2.65	Yes
Nickel	15/15	5.20	23.60	05SS19	30[2]	0.8	No
Thallium	7/15	0.24	0.39	05SS29	0.001[1]	390	Yes
Vanadium	15/15	14.30	36.3	05SS29	20[4]	1.8	Yes
Zinc	15/15	17.00	137.00	05SS29	50[4]	2.7	Yes
SVOCs (ug/kg)							
2-methylnaphthalene	7/16	50.0	16000.0	05SS30	NA	NA	Yes
Acenaphthene	13/16	47.0	36000.0	05SS30	100[1]	360.00	Yes
Acenaphthylene	12/16	73.0	2300.0	05SS30	NA	NA	Yes
Anthracene	14/16	140.0	54000.0	05SS30	2050[3]	26.3	Yes

TABLE 4-29
SELECTION OF PRELIMINARY CONTAMINANTS OF CONCERN IN SURFACE SOIL
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE
PAGE 2 OF 2

Contaminant	Frequency of Detection	Range of Detections		Location of Maximum	Screening Level	Hazard Quotient	Selected as PCOC?
		Minimum	Maximum				
SVOCs (ug/kg) (continued)							
Benz(a)anthracene	14/16	580.0	48000.0	05SS30	2050[3]	23.4	Yes
Benzo(a)pyrene	14/16	750.0	36000.0	05SS30	2050[3]	17.6	Yes
Benzo(b)fluoranthene	14/16	1200.0	35000.0	05SS30	2050[3]	17.1	Yes
Benzo(g,h,i)perylene	14/16	400.0	13000.0	05SS30	2050[3]	6.3	Yes
Benzo(k)fluoranthene	13/16	750.0	29000.0	05SS30	2050[3]	14.1	Yes
Bis(2-ethylhexyl)phthalate	3/3	210.0	1200.0	05SS27	3005[3]	0.4	No
Carbazole	13/16	160.0	19000.0	05SS30	NA	NA	Yes
Chrysene	14/16	1100.0	45000.0	05SS30	2050[3]	21.9	Yes
Di-n-butylphthalate	2/16	85.0	120.0	05SS22	3005[3]	0.04	No
Dibenz(a,h)anthracene	13/16	110.0	4800.0	05SS30	2050[3]	2.3	Yes
Dibenzofuran	13/16	71.0	34000.0	05SS30	NA	NA	Yes
Fluoranthene	14/16	2400.0	140000.0	05SS30	2050[3]	68.3	Yes
Fluorene	13/16	81.0	56000.0	05SS30	2050[3]	27.3	Yes
Indeno(1,2,3-cd)pyrene	14/16	550.0	18000.0	05SS30	2050[3]	8.8	Yes
Naphthalene	5/16	52.0	22000.0	05SS30	2050[3]	10.7	Yes
Phenanthrene	14/16	1100.0	200000.0	05SS30	2050[3]	97.6	Yes
Pyrene	14/16	1800.0	120000.0	05SS30	2050[3]	58.5	Yes
Total PAHs	14/16	11,900	928,000	05SS30	4,000[5]	232.0	Yes
VOCs (ug/kg)							
Acetone	1/5	17.0	17.0	05SB25	NA	NA	Yes
Toluene	1/10	1.0	1.0	05SB15	100[1]	0.01	No
Contaminant	**Frequency of Detection**	**Range of Detections**		**Location of Maximum**	**Screening Level**	**Hazard Quotient**	**Selected as PCOC?**
		Minimum	**Maximum**				
Dioxins/Furans (ug/kg)							
TCDD Toxicity Equivalents	2/2	0.0299	0.177	05SS14	10[1]	0.02	No

1 Region III BTAG screening level (EPA, 1995)
2 Will and Suter (1995b)
3 Netherlands (1994)
4 ORNL (1996)
5 ERL for sediment (Long et al, 1995)

TABLE 4-30
STEP 3A: REFINEMENT OF CONTAMINANTS OF POTENTIAL CONCERN – SURFACE WATER
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE

COPC	Maximum Concentration	Mean Concentration	Initial Screening Level	BTAG Screening Level	Alternate Screening Level	Mean/Max Background	Retained as Final COC?
Metals (ug/L)							
Aluminum	926.0	926	25	25	87[a]/460[b]	561[e]	No
Barium	44.8	34.1	3.9	10,000	4.0[c]	101/112	No
Iron	1170.0	716	1,000	320	158[b]	321/635	No
Lead	3.0	2.2	2.5	3.2	1.32[a]/12.3[b]	0.538/0.8	No
Pesticides (ug/L)							
Dieldrin	0.06	0.055	0.0019	0.0019	0.062[d]	ND	No

a AWQC (USEPA, 1995)
b ORNL Lowest Chronic Value (Suter and Tsao, 1996)
c Secondary Chronic Value (Suter and Tsao, 1996)
d Final Chronic Value (USEPA, 1996b)
e Aluminum was analyzed in only one background surface water sample.
ND = not detected.

TABLE 4-31
STEP 3A: REFINEMENT OF CONTAMINANTS OF POTENTIAL CONCERN – SEDIMENT
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE

COPC	Maximum Concentration	Mean Concentration	Initial Screening Level	BTAG Screening Level	ER-M[a]	PEL[b]	ARCS PEC[c]	Ontario MOE[d]	Other Screening Level	Mean/Max. Background	Retained as Final COC?
Metals (mg/kg)											
Aluminum	12000.00	11600	NA	NA	NA	NA	58030	NA	NA	6620/8950	No
Barium	74.30	72.1	NA	NA	NA	NA	NA	NA	20-60[g]	98.2/160.5	No
Beryllium	0.77	0.675	NA	NA	NA	NA	NA	NA	NA	0.878/1.2	No
Cobalt	7.10	7.1	NA	NA	NA	NA	NA	NA	50[h]	7.21/12.4	No
Iron	11900.00	11500	NA	NA	NA	NA	NA	20,000/40,000	NA	16500/35400	No
Manganese	222.00	165	NA	NA	NA	NA	1081	460/1110	300-500[g]	514/759	No
Vanadium	21.20	18.4	NA	NA	NA	NA	NA	NA	NA	22.6/52.6	No
Pesticides/PCBs (ug/kg)											
Aldrin	11.00	6.05	NA	NA	NA	NA	NA	2/80	NA	ND	No
Dieldrin	220.00	119	NA	NA	NA	4.3	NA	2/910	52[e]	2.26/3.1	No
SVOCS (ug/kg)											
Anthracene	160.00	160	85.3	85.3	1100	245	547.7	220/3700	NA	ND	No
Benz(a)anthracene	850.00	750	261	261	1600	693	4200	320/14800	NA	275/580	No
Benzo(a)pyrene	910.00	715	430	430	1600	763	393.7	370/14400	NA	268/530	No
Benzo(k)fluoranthene	700.00	565	NA	NA	NA	NA	NA	240/13400	NA	240/300	No
Chrysene	1200.00	960	384	384	2800	846	5200	340/4600	NA	238/640	No
Dibenz(a,h)anthracene	120.00	170	63.4	63.4	260	135	28.2	60/1300	NA	ND	No
Fluoranthene	1800.00	1550	600	600	5100	1494	834.27	750/10200	2900[e]	221/510	No
Phenanthrene	880.00	750	240	240	1500	544	NA	560/9500	850[e]	235/260	No
Pyrene	1900.00	1700	660	665	2600	1398	3225	490/8500	NA	315/1300	No
Total PAHs	10,900	8480	4,000	NA	44792	16,770	13660	4000/100,000	NA	834/4790	No
VOCS (ug/kg)											
2-Butanone	22.00	14.3	NA	NA	NA	NA	NA	NA	NA	ND	No
Toluene	4.00	5.25	NA	NA	NA	NA	NA	NA	670[f]	ND	No

a. Effects Range - Median (Long et al., 1995).
b. Probable Effects Levels (FDEP, 1994).
c. Assessment and Remediation of Contaminated Sediments Program; Probable Effects Concentration (USEPA 1996c).
d. Ontario Ministry of the Environment: LEL = lowest effect level / SEL = severe effect level (Jones et al, 1997).
e. EPA Sediment Quality Criteria (USEPA, 1996b)
f. EPA Sediment Quality Benchmark (USEPA, 1996b)
g. EPA Region 5 guideline indicating moderate pollution (Giesy & Hoeke, 1990).
h. Open water disposal guideline, Ontario Ministry of the Environment (Giesy & Hoeke, 1990)
NA = not available or not applicable.
ND = not detected.

Luckey, 1978). Another factor in the lack of accumulation of aluminum in animals with age or the absence of any increase in tissue levels of aluminum following fairly high dietary intake may be that certain organisms possess a homeostatic mechanism for this element. Aluminum compounds are generally not harmful to most terrestrial organisms and are considered to be toxicologically inert, except in cases of high experimental doses or prolonged inhalation (Venugopal and Luckey, 1978). Data on the toxicity of aluminum to aquatic organisms is somewhat limited. Freshwater organisms usually are not adversely affected when pH is between 6.5 and 9.0 (EPA, 1988). The pH in the surface water sample collected from the western small pond south of the site was within this range (pH=6.77, Appendix C). The pH in the surface water sample collected from the eastern small pond south of the site was slightly lower, at pH=6.35. Overall, however, the aluminum concentrations in Site 5 media are similar to background values. For these reasons, aluminum should be dropped from further consideration at Site 5.

Antimony

Antimony was a COPC in surface soil, but was not detected in surface water and was not a COPC in sediment. Antimony was not detected in background surface soil samples but its HQ was relatively low (HQ=1.8). Few alternate ESVs are available for antimony in surface soil (Table 4-32). Because of its absence in surface water and low concentrations in sediment, and its and relatively low concentrations in surface soil, antimony should be dropped from further consideration at Site 5.

Arsenic

Arsenic was not a COPC in surface water or sediment. Arsenic concentrations in surface soil exceeded the initial screening level in only one sample, and its HQ was low (HQ=1.1). The concentration in this sample was less than the BTAG screening level, less than all alternate ESVs, and was within the range of background values (Table 4-32). For these reasons, arsenic should be dropped from further consideration at Site 5.

Barium

Barium was a COPC in surface water and sediment, but an initial sediment ESV was not available. The maximum surface water concentration was much less than the BTAG ESV (Table 4-30). Barium was detected in both surface water and sediment samples from each of the two ponds, but all values were within the range of background concentrations (Tables 4-30 and 4-31). Barium is a common element in sediments and it is not generally associated with significant toxicity (ATSDR, 1997). For these reasons, barium should be dropped from further consideration at Site 5.

Beryllium

Beryllium was a COPC in sediment since an ESV was not available. Beryllium was not detected in surface water and was not a COPC in surface soil. Although no sediment ESVs were available for

TABLE 4-32
STEP 3A: REFINEMENT OF CONTAMINANTS OF POTENTIAL CONCERN – SURFACE SOIL
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE

Contaminant	Maximum Concentration	95% UCL	Mean Concentration	Initial Screening Level	BTAG Screening Level	ORNL[a,b]	Dutch B[c]	CCME[d]	Mean/Max. Background	Retained as Final COC?
Metals (mg/kg)										
Aluminum	12400.00	10600	9840	1.0	1.0	600[a]	NA	NA	11300/15000	No
Antimony	9.20	9.89	4.82	5	0.48	5[b]	NA	NA	ND	No
Arsenic	10.5	6.04	4.87	10	328	60[a]/10[b]	30	19	6.6/10.6	No
Cadmium	4.70	1.73	1.17	3	2.5	20[a]/4[b]	5.0	3.8	ND	No
Chromium	56.50	23.8	18.6	10	0.0075	0.4[a]/1.0[b]	250	64	15.3/20.8	No
Iron	21600.00	16700	14400	12	12	200[a]	NA	NA	14800/17600	No
Lead	412.00	217	90	50	0.01	500[a]	150	70	30.6/64.7	Yes
Manganese	873.00	582	494	330	330	100[a]/500[b]	NA	NA	642/1190	No
Thallium	0.39	0.26	0.202	0.001	0.001	1.0[b]	NA	NA	0.226/0.34	No
Vanadium	36.3	27.7	24.3	20	0.5	20[a]/2[b]	NA	130	24.9/28.2	No
Zinc	137.00	87.6	59.6	50	10	100[a]/50[b]	200	NA	90.1/597	No
SVOCs (ug/kg)										
2-methylnaphthalene	16000.0	1270	1170	NA	NA	NA	NA	NA	ND	Yes
Acenaphthene	36000.0	4370	2560	100	100	20,000[b]	NA	NA	178/64	Yes
Acenaphthylene	2300.0	643	356	NA	NA	NA	NA	NA	177/62	No
Anthracene	54000.0	11800	4290	2050	100	NA	10,000	NA	154/160	Yes
Benzo(a)anthracene	48000.0	45400	711	2050	100	NA	NA	NA	306/940	Yes
Benzo(a)pyrene	36000.0	26700	5760	2050	100	NA	1,000	750	394/1100	Yes
Benzo(b)fluoranthene	35000.0	39100	7260	2050	100	NA	NA	NA	507/1500	Yes
Benzo(g,h,i)perylene	13000.0	5910	2290	2050	100	NA	NA	NA	225/490	Yes
Benzo(k)fluoranthene	29000.0	22800	4630	2050	100	NA	NA	NA	370/920	Yes
Carbazole	19000.0	3200	1780	NA	NA	NA	NA	NA	213/310	No
Chrysene	45000.0	37500	7290	2050	100	NA	NA	NA	420/1200	Yes
Dibenz(a,h)anthracene	4800.0	1710	843	2050	100	NA	NA	NA	161/160	Yes
Dibenzofuran	34000.0	3120	2380	NA	NA	NA	NA	NA	172/120	No
Fluoranthene	140000.0	151000	17600	2050	100	NA	10,000	NA	902/2600	Yes
Fluorene	56000.0	5560	3890	2050	100	30,000[a]	400,000	NA	184/160	Yes

Contaminant	Maximum Concentration	95% UCL	Mean Concentration	Initial Screening Level	BTAG Screening Level	ORNL[a,b]	Dutch B[c]	CCME[d]	Mean/Max. Background	Retained as Final COC?
Indeno(1,2,3-cd)pyrene	18000.0	9700	3180	2050	100	NA	NA	NA	251/640	Yes
Naphthalene	22000.0	1610	1540	2050	100	NA	5,000	600	ND	Yes
Phenanthrene	200000.0	106000	18100	2050	100	NA	5,000	NA	667/1700	Yes
Pyrene	120000.0	135000	15800	2050	100	NA	10,000	NA	723/2100	Yes
Total PAHs	928,000	5,410,000	107,000	4,000	NA	NA	20,000	NA	4,450/14,100	Yes
VOCs (ug/kg)										
Acetone	17.0	16.8	7.7	NA	NA	NA	NA	NA	ND	No

a. Oak Ridge National Laboratory (ORNL) screening levels; a = lowest valve for earthworms and soil micro-organisms (Efroymson et al, 1997a).
b. ORNL screening levels; b = soil phytotoxicity (Efroymson et al, 1997b).
c. Dutch "B" soil valve: moderate soil contamination that requires further study (Beyer, 1990).
d. Canadian Council of Ministers of the Environment Soil Quality Guidelines (CCME, 1997).
NA = not available or not applicable.
ND = not detected.

beryllium, its concentrations in sediment samples from both ponds were within the range of background concentrations (Table 4-31). Therefore, beryllium should be dropped from further consideration at Site 5.

Cadmium

Cadmium was a COPC in surface soil, but was not detected in surface water or sediment. It was detected in 3 of 15 surface soil samples, and it exceeded the initial ESV in only one sample (Appendix A, Table A-18), with an HQ of 1.6. Its concentration in this single sample (4.7 mg/kg) was less than, or only slightly greater than the alternate ESVs shown in Table 4-32. Because of its absence in surface water and sediment, and its relatively low concentrations in surface soil, cadmium should be dropped from further consideration at Site 5.

Chromium

Chromium was a COPC in surface soil, but was not detected in surface water and was not a COPC in sediment. Chromium concentrations in surface soil exceeded twice the average background concentration in only one sample (05SS27) at 56.5 mg/kg (Appendix A, Table A-18).

There is a wide range among available surface soil ESVs for chromium (Table 4-32). The ORNL values in table 4-32 are for hexavalent chromium, the most toxic form of this metal (Efroymson et al, 1997a; 1997b). All chromium concentrations at Site 5 are total chromium. The CCME value of 64 mg/kg is for total chromium (CCME, 1997). The Dutch B value of 250 mg/kg is also for total chromium (Beyer, 1990). Although not shown in Table 4-32, the Dutch "A" value representative of background values (Beyer, 1990), as well as the Dutch "Target Value" that represents the "soil quality required for the full restoration of the soil's functionality for human, animal and plant life" is 100 mg/kg (NMHSP&E, 1994). Since chromium concentrations exceeded twice the average background concentration in only one of 15 samples, and the concentration in this sample was less than most ESVs for total chromium, potential ecological risks (if any) appear to be limited to a small area. Therefore, chromium should be dropped from further consideration at Site 5.

Cobalt

Cobalt was a COPC in sediment because no initial ESV was available. It was not detected in surface water and was not a COPC in surface soil. Cobalt was detected at the same concentration (7.1 mg/kg) in both sediment samples. This value was within the range of background sediment concentrations, and was considerably less than the only available ESV of 50 mg/kg (Table 4-31). Cobalt is present in all natural media, and is a component of certain B vitamins, which are essential for birds and mammals. (ATSDR, 1997). For these reasons, cobalt should be dropped from further consideration at Site 5.

Iron

Iron was a COPC in surface water and surface soil because it exceeded the initial ESVs for these media and was a COPC in sediment since an initial ESV was not available. The maximum concentration of iron in surface water only slightly exceeded the ESV (HQ = 1.2). The maximum sediment concentration was within the range of background sediment concentrations, and was considerably less than the lowest available ESV, which is a "lowest effect level" established by the Ontario Ministry of the Environment (Table 4-31). All surface soil concentrations of iron were less than twice the average background concentration (Table 4-32). Because its concentration in surface water only slightly exceeded the ESV, and since its presence in surface soil and sediment was similar to background concentrations, iron should be dropped from further consideration at Site 5.

Lead

Lead was a COPC in surface water and surface soil but not in sediment. The surface water HQ was low (HQ=1.2) and the maximum concentration in surface water (3.0 µg/L) was less than the BTAG ESV and the ORNL lowest chronic value (Table 4-30). In addition, the concentrations in each of the two surface water samples were flagged with a "K" qualifier (Appendix A, Table A-20), indicating that the values are "biased high due to exceedance of technical quality control criteria". Lead concentrations in five of 15 surface soil samples exceeded twice the average background concentration. Lead concentrations in all five of these samples exceeded the CCME guideline, and the Dutch "B" value was exceeded in two samples (Table 4-32). All soil lead concentrations were less than the ORNL ESV of 500 mg/kg. The maximum concentration of 412 mg/kg was in sample 05SS22 at the southern portion of the former burn area. Lead in this sample might pose potential risks to ecological receptors.

Manganese

Manganese was a COPC in sediment because an initial ESV was not available, and was a COPC in surface soil with an HQ of 2.65. Its maximum concentration in sediment was within the range of background sediment concentrations, and was considerably less than all available screening levels (Table 4-31). Most surface soil concentrations exceeded the few available ESVs (Table 4-32), but the HQ of 2.65 was relatively low (Table 4-29). All surface soil concentrations were within the range of background soil concentrations. Manganese is a common element in the earth's crust and an essential nutrient. Because of its relatively low HQ and its presence at concentrations within the range of background concentrations, manganese should be dropped from further consideration at Site 5.

Thallium

Thallium was a COPC in surface soil but was not detected in surface water or sediment. Thallium was detected in 7 of 15 surface soil samples and all surface soil concentrations were less than twice the

average background value (Table 4-32). Only two ESVs were available for thallium in surface soil, and these differed by a factor of 1,000 (Table 4-32), so its potential toxicity is difficult to assess. However, all soil concentrations were less than the ORNL screening level of 1.0 mg/kg, a value established for soil phytotoxicity (Efroymson et al., 1997b). Because of this, and since thallium in surface soil was similar to background soil concentrations, thallium should be dropped from further consideration at Site 5.

Vanadium

Vanadium was a COPC in sediment because an initial ESV was not available, and was a COPC in surface soil with an HQ of 1.8. Vanadium was not detected in surface water. No sediment ESVs were available for vanadium, but all sediment concentrations at Site 5 were within the range of background sediment concentrations (Table 4-31). Surface soil concentrations were generally within the range of background soil concentrations, and all surface soil concentrations were less than twice the average background soil concentration (Table 4-32). Available ESVs cover a wide range of values (Table 4-32), so the potential toxicity is difficult to assess, but vanadium is not generally considered to be toxic in the environment (Mailman, 1980). Because of this, and since concentrations at Site 5 were similar to background concentrations, vanadium should be dropped from further consideration at Site 5.

Zinc

Zinc was a COPC in surface soil with an HQ of 2.7, and was not a COPC in surface water or sediment. All surface soil concentrations were within the range of background soil concentrations (Table 4- 32). Soil concentrations were greater than the lowest available ESV of 10 mg/kg, but less than the Dutch "B" value. Because zinc was not a COPC in surface water or sediment, and its concentrations in Site 5 soil samples were well within the range of background soil concentrations, zinc should be dropped from further consideration at Site 5.

4.8.5.2 Pesticides

Aldrin

Aldrin was a sediment COPC since an initial ESV was not available. It was not detected in surface water or surface soil. The single detected value of aldrin in sediment was considerably less than the Ontario severe effects level (SEL) for aldrin (Table 4-31). The SEL values are based on actual observed field effects. Although aldrin was not detected in background sediments, it was probably used base-wide in the past for pest control and is unrelated to Site 5. For these reasons, aldrin should be dropped from further consideration at Site 5.

Dieldrin

Dieldrin was a sediment COPC since an initial ESV was not available, and was a COPC in surface water

(HQ=31.6). It was not detected in surface soil. The single detected value of dieldrin in surface water was less than the alternate guideline for dieldrin. Sediment concentrations were considerably less than the SEL value (Table 4-31). As with aldrin, it is probable that dieldrin was used base-wide in the past for pest control and is unrelated to Site 5. For these reasons, dieldrin should be dropped from further consideration at Site 5.

4.8.5.3 Semivolatile Organic Compounds

Several SVOCs were retained as COPCs in sediment and surface soil; none were detected in surface water. Carbazole and dibenzofuran were detected in most surface soil samples but in no sediment samples. There were no soil ESVs for carbazole or dibenzofuran, but their concentrations were elevated only in a single sample (05SS30, Appendix A, Table A-18). Because ESVs were not available for these two compounds, and since they were elevated in only one sample, carbazole and dibenzofuran should be dropped from further consideration at Site 5.

PAH Compounds

All other SVOCs at Site 5 consisted of PAH compounds. Eight PAHs, as well as total PAHs, were retained as sediment COPCs since their maximum concentrations exceeded ESVs. The HQ values for these compounds were relatively low, and none of the maximum concentrations of those compounds exceeded ER-M values or SEL values (Table 4-31). In addition, although not naturally-occurring, the concentrations of most of those compounds in Site 5 sediments were not markedly greater than the concentrations in background sediments. PAHs are common in media from industrialized areas, especially areas that experience vehicular traffic. One PAH compound (benzo(k)fluoranthene) was retained as a sediment COPC since no ESV was available, but its maximum concentration was comparable to the maximum concentrations of similar PAHs which did not exceed their alternate guidelines. Concentrations of total PAHs in all sediment samples were less than the ER-M, PEL, PEC, and SEL values shown in table 7-31. For the reasons discussed above, no PAH compounds were retained as final sediment COCs, and PAH compounds in sediments should be dropped from further consideration at Site 5.

Several PAHs were retained as surface soil COPCs since their maximum concentrations exceeded ESVs or because ESVs were not available. Concentrations of most PAHs in surface soil samples located west of the access road and furthest from the burn area (samples 05SS26, 05SS27, and 05SS28; Figure 4-9A) were not significantly elevated. These samples were located in close proximity to the aircraft taxiway, and PAH concentrations in these samples may be the result of runoff.

Concentrations of several PAHs in samples collected closer to the burn pit were significantly elevated over initial ESVs and alternate guidelines. Specifically, concentrations of several PAHs in samples collected along the western edge of the burn area (05SS17, 05SS18, 05SS21, and 05SS22), the southern edge of the burn area (05SS23, 05SS24, and 05SS25), and the eastern edge of the burn area (05SS29 and 05SS30) were considerably elevated. Concentrations of all PAHs were highest in sample 05SS30, reaching a maximum of 200,000 μg/kg (for phenanthrene).

An examination of complete exposure pathways for PAHs at Site 5 is required to assess the potential risks posed by the elevated concentrations of these compounds. Contaminants generally fall into one of two categories: 1) chemicals for which the exposure route of concern is direct contact, and 2) chemicals for which the exposure route of concern is the food web. PAH compounds show little tendency to biomagnify in the food web (Eisler, 1987), and thus, PAHs fall in the first category: toxicity through direct contact is the applicable exposure route for PAHs at the site. This exposure route would pose potential risks for soil invertebrates, especially those that ingest soil, (*i.e.*, earthworms). Burrowing animals such as woodchucks could also be directly exposed to elevated PAHs in soil. Plants can absorb PAHs from soil through their roots, but PAH-induced toxicity to plants is rare (Eisler, 1987). Many aquatic species (especially mollusks and crustaceans) are sensitive to PAHs (Eisler, 1987). As mentioned in Sections 4.2 and 4.8.1.1, a shallow drainage ditch originates slightly northeast of the former burn pit. This ditch would be expected to carry surface runoff to the southeast, where it eventually empties into Pennypack Creek approximately one mile from Site 5. However, the ditch in the vicinity of Site 5 does not consist of aquatic habitat. It only rarely, if ever, contains surface water, and does not contain wetland vegetation or wetland soils. The flat character of the site and abundant vegetation in the ditch and surrounding vicinity probably result in minimal surface water runoff into the ditch; subsequently, offsite migration of PAHs via the ditch is probably negligible. Sediment data from the two ponds south of the burn pit indicate that southward migration of PAHs into the ponds is also negligible. In summary, potential PAH-related risks are limited primarily to soil invertebrates and burrowing animals. Several individual PAHs and total PAHs east of the access road near the burn area appear to pose potential risks to these terrestrial receptors at Site 5, and therefore, PAHs are selected as surface soil COCs (Table 4-32).

4.8.5.4 Volatile Organic Compounds

Acetone

Acetone was a COPC in surface soil since an ESV was not available. Acetone was not detected in surface water or sediment. Because acetone is a common laboratory contaminant, and since it was detected in only one soil sample and in no surface water or sediment samples, it should be dropped from further consideration at Site 5.

2-Butanone

2-butanone was detected in one sediment sample and was a COPC since an ESV was not available. Acetone was not detected in surface water or surface soil. Because of its relatively low concentration in one sediment sample (22 µg/kg), and the absence of detections in other media at Site 5, 2-butanone should be dropped from further consideration at Site 5.

Toluene

Toluene was detected in one sediment sample and was a COPC since an ESV was not available. It was not a COPC in surface soil and was not detected in surface water. The only detection of toluene in sediment (4 µg/kg) was much less than its alternate guideline (670 µg/kg), an EPA sediment quality benchmark (Table 4-31). Because of its relatively low concentration in one sediment sample and its absence as a COPC in other media at Site 5, toluene should be dropped from further consideration at Site 5.

4.8.6 Screening Level and Step 3a Uncertainty Analysis

Uncertainty is associated with all aspects of the ERA process. A detailed discussion of the general uncertainties involved in this ERA, and how the uncertainties may affect the final risk values and conclusions, was presented in Section 3.2.5. This section discusses how site-specific uncertainties may affect the results and conclusions of the ERA for Site 5.

Site 5 has probably received contaminant inputs from sources other than former activities at the Fire Training Area. For example, at least some portions of Site 5 probably receive contaminant inputs from the adjacent aircraft taxiway north of the site. The extent that other sources are responsible for the presence of COCs at Site 5 is uncertain. However, the high concentrations of PAHs in the vicinity of the former burn area suggest that the former fire-fighting activities are responsible for the PAH "hot spot" in this area.

Few data are available for investigating risks to reptiles and amphibians. As a result, direct conclusions about the potential risks to reptiles and amphibians cannot be made. However, contaminants do not appear to have migrated to the two nearby ponds from the Fire Training Area. Thus, potential risks to amphibians and aquatic reptiles in the vicinity of the ponds appear to be low.

The maximum detected chemical concentrations were initially used to represent the chemical concentrations to which ecological receptors might be exposed. If the maximum concentration of a chemical in a given medium was collected in a "hot spot" of contamination and was much higher than the remaining values in the data set, potential risks may be grossly over-estimated. Conversely, if samples

were not collected from the Site area of highest contamination, then potential risks could be underestimated. Undiscovered areas of high contaminant concentration could result from inadequate remedial investigation where insufficient numbers of samples are obtained, or portions of the site are not represented by the data set. However, uncertainties related to the location of samples were reduced in this ERA by the large number of surface soil samples collected. Fifteen soil samples were collected at a relatively small site. Thus, the soil concentrations probably present a relatively accurate characterization of soil contamination at the site.

4.8.7 Ecological Risk Summary

Several inorganic and organic contaminants were present in Site 5 surface water, sediment, and surface soil samples in concentrations in exceedance of ecological screening levels and were, therefore, retained as COPCs. Several other contaminants in all media assessed in this ERA were retained as COPCs since screening levels were not available. Most of these contaminants were eliminated as COCs in Step 3a of the risk assessment process for one or more reasons, such as low frequency of detection, concentrations comparable to background values (primarily inorganics) or alternative screening levels, and spatial analysis of detections.

Contaminants do not appear to have migrated to the two nearby ponds from the Fire Training Area. Potential risks to aquatic receptors that inhabit the ponds appear to be low. Therefore, no COCs were selected for surface water and sediment.

The number and location of surface soil samples appear to be sufficient to delineate the nature and extent of surface soil contamination at Site 5. Organic compounds that could pose potential risks to terrestrial receptors on and near Site 5 are limited to PAH compounds. Concentrations of PAHs in surface soil samples collected west of the access road that borders the burn area were only slightly elevated, and that area may receive PAH inputs from the taxiway to the north. Conversely, concentrations of several PAHs in samples collected around the burn pit greatly exceeded screening levels for individual and total PAHs. Therefore, these PAHs are selected as COCs in Site 5 surface soils around the burn area. The high concentrations of PAHs in the vicinity of the former burn area suggest that the former fire-fighting activities are responsible for the PAH "hot spot" in this area. Lead was the only inorganic COC in Site 5 surface soil, and appears to pose potential ecological risks only in the area that is also the hot spot for PAH compounds.

4.9 EVALUATION SUMMARY AND RISK MANAGEMENT RECOMMENDATIONS

Consistent with EPA guidelines, the "reasonable anticipated future land use" exposure scenario is

Occupational Worker. Under the current occupational worker exposure scenario, the human health risk assessment estimated that carcinogenic risks are within the EPA's acceptable range for all media. Also, there is no estimated human health noncarcinogenic risk [Hazard Index (HI)] greater than 1 for this exposure scenario. The result of the human health risk assessment found that the site does not pose a threat to current or reasonably anticipated future human receptors. However, ecological risk screening concluded that risks from surface soils may be a concern, and other issues or guidelines in law must be considered, as discussed by medium below.

Soils

No specific action is recommended or deemed necessary to further evaluate or remove soils for limited lead and PAH hot spots found at Site 5.

Lead and PAHs found in soils (mostly in the area of the former burning ring, but also at other discrete areas) may present potential exposure risk to organisms eating soil (e.g., worms) and some burrowing animals. However, the site-specific ecological risk assessment performed for Site 5 concluded that potential ecological risks to these receptors is minimal, not warranting further actions.

Sediments and Surface Water

No further action is recommended.

Potential ecological risk to aquatic or semi-aquatic receptors in or near the two (sometimes dry) ponds appears to be low. It does not appear that contaminants from the burn area have migrated to the ponds.

Groundwater

Based on data obtained to date, an FS is recommended to evaluate options for Site 5 groundwater.

Chlorinated VOC compounds were found in groundwater at concentrations above MCLs. A feasibility study is recommended to evaluate remedial alternatives for groundwater.

REFERENCES

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Jones, D.S., G. W. Suter II, and R.N. Hull. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision. ES/ER/TM-95/R4. Oak Ridge national Laboratory, Health Sciences Division, Oak Ridge, TN.

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APPENDIX A

ANALYTICAL RESULTS

For analytical results prior to 1997 see Phase II Remedial Investigation Report Appendices (TtNUS, April 1998)

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW01D	05MW01I	05MW01I	05MW01S	05MW01S	SCREENING VALUES			
LOCATION:	05MW01I	05MW01I	05MW01I	05MW01S	05MW01S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	07/07/97	06/23/97	09/25/00	06/23/97	09/18/91				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	89.4	50 U	n/a	50 U	n/a	-	-	-	37000
barium	363	502	n/a	266	n/a	2000	700	2000	2600
calcium	30100	31000	n/a	13100	n/a	-	-	-	-
chromium, total	10.7	5 U	n/a	5 U	n/a	100 *	1000	100	110
iron	220 J	142	n/a	71	n/a	-	-	-	11000
lead	1.2 B	2.5 B	n/a	7 B	n/a	15.0	-	5.00	15.0
magnesium	12000	8610	n/a	5750	n/a	-	-	-	-
manganese	81.5	55.1	n/a	397	n/a	-	-	-	730
potassium	9420	10700	n/a	1500 U	n/a	-	-	-	-
sodium	23400	15600	n/a	15800	n/a	-	-	-	-
zinc	6.2 B	18.1 B	n/a	21.8 B	n/a	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10 U	54	10 U	960 E	2800 E	200	200 a	200	3200
1,1,2-trichloroethane	10 U	10 U	10 U	10 E J	250 U	5.00	3.00 a	5.00	0.190
1,1-dichloroethane	10 U	50 E	10 U	350 E	420 E	-	-	27.0	800
1,1-dichloroethene	10 U	35 E J	10 U	300 E J	840 E	7.00	7.00 a	7.00	0.0440
1,2-dichloroethane	10 U	3 E J	10 U	4 E J	250 U	5.00	700	5.00	0.120
1,2-dichloroethene (total)	10 U	6 J	n/a	99 E	180 E J	70.0 a	70.0 a	70.0	55.0
acetone	10 U	10 U	2.8 J	10 U	500 U	-	-	3700	610
benzene	10 U	10 U	10 U	28 E	250 U	5.00	200	5.00	0.320
methylene chloride	5 B	7 B	10 U	7 B	250 U	5.00	2000 d	5.00	4.10
tetrachloroethene	35 E	3 E J	10 U	24 E	500 U	5.00	10.0 a	5.00	1.10
trichloroethene	10 U	23 E	10 U	300 E	590 E	5.00	-	5.00	1.60

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW01S-RE-D	05MW01S-RE	05MW01SI	05MW01SI	05MW02S	SCREENING VALUES			
LOCATION:	05MW01S	05MW01S	05MW01SI	05MW01SI	05MW02S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	09/25/00	09/25/00	09/20/91	09/25/00	06/24/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
barium	n/a	n/a	n/a	n/a	43.8	2000	700	2000	2600
calcium	n/a	n/a	n/a	n/a	7200	-	-	-	-
magnesium	n/a	n/a	n/a	n/a	2230	-	-	-	-
sodium	n/a	n/a	n/a	n/a	9410	-	-	-	-
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	2700 E	2400 E J	260 E	73	10 U	200	200 a	200	3200
1,1,2-trichloroethane	38 E J	42 E	5 U	10 U	10 U	5.00	3.00 a	5.00	0.190
1,1-dichloroethane	590 E	620 E J	84 E	54 E	10 U	-	-	27.0	800
1,1-dichloroethene	530 E	600 E J	120 E J	43 E	10 U	7.00	7.00 a	7.00	0.0440
1,2-dichlorobenzene	200 U	4.5 J	n/a	10 U	10 U	600	600 a	600	550
1,2-dichlorobenzene	200 U	4.5 J	n/a	10 U	10 U	600	600 a	600	550
1,2-dichloroethane	200 U	13 E	5 U	10 U	10 U	5.00	700	5.00	0.120
1,2-dichloroethene (total)	n/a	n/a	11 J	n/a	1 J	70.0 a	70.0 a	70.0	55.0
1,4-dichlorobenzene	200 U	21 E	n/a	10 U	10 U	75.0	75.0 a	75.0	0.470
1,4-dichlorobenzene	200 U	21 E	n/a	10 U	10 U	75.0	75.0 a	75.0	0.470
acetone	74 J	10 U	10 U	10 U	10 U	-	-	3700	610
benzene	53 E J	58 E	16 E J	10 U	10 U	5.00	200	5.00	0.320
chloroform	200 U	1.1 E J	5 U	10 U	10 U	80.0	4000	100	0.150
cis-1,2-dichloroethene	450 E	460 E J	n/a	9.8 J	n/a	70.0	70.0 a	70.0	61.0
methylcyclohexane	200 U	18	n/a	10 U	n/a				6300
methylene chloride	200 U	5.9 E J	6 B	10 U	5 B	5.00	2000 d	5.00	4.10
tetrachloroethene	79 E J	87 E	8 E	4.2 E J	1 J	5.00	10.0 a	5.00	1.10
toluene	200 U	10 U	3 B	10 U	10 U	1000	1000 a	1000	750
trans-1,2-dichloroethene	200 U	3.5 J	n/a	10 U	n/a	100	100 a	100	120
trichloroethene	890 E	740 E J	69 E J	29 E	10 U	5.00	-	5.00	1.60

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW02S	05MW02S	05MW02S-DUP	05MW02S	05MW03I	SCREENING VALUES			
LOCATION:	05MW02S	05MW02S	05MW02S	05MW02S	05MW03I	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	08/07/97	09/18/91	06/24/97	09/18/00	06/24/97				
INORGANICS	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
aluminum	n/a	n/a	50 U	n/a	282	-	-	-	37000
barium	n/a	n/a	45.6	n/a	77.5	2000	700	2000	2600
calcium	n/a	n/a	7120	n/a	32700	-	-	-	-
chromium, total	n/a	n/a	5 U	n/a	7.2 K	100 *	1000	100	110
iron	n/a	n/a	50 U	n/a	357	-	-	-	11000
lead	n/a	n/a	2.1 B	n/a	1.2 B	15.0	-	5.00	15.0
magnesium	n/a	n/a	2220	n/a	3620	-	-	-	-
manganese	n/a	n/a	5 U	n/a	14 K	-	-	-	730
potassium	n/a	n/a	1500 U	n/a	3300	-	-	-	-
sodium	n/a	n/a	9320	n/a	17500	-	-	-	-
zinc	n/a	n/a	5 U	n/a	7.5 B	-	2000 a	2000	11000
SEMIVOLATILES	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
di-n-butyl phthalate	2 B	n/a	10 U	n/a	10 U	-	-	3700	3700
VOLATILES	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
1,1,1-trichloroethane	n/a	5 U	10 U	10 U	13	200	200 a	200	3200
1,1-dichloroethane	n/a	5 U	10 U	10 U	18	-	-	27.0	800
1,1-dichloroethene	n/a	5 U	10 U	10 U	7 E J	7.00	7.00 a	7.00	0.0440
1,2-dichloroethene (total)	n/a	5 U	1 J	n/a	2 J	70.0 a	70.0 a	70.0	55.0
acetone	n/a	10 U	10 U	2.1 J	10 U	-	-	3700	610
cis-1,2-dichloroethene	n/a	n/a	n/a	2.7 J	n/a	70.0	70.0 a	70.0	61.0
methylene chloride	n/a	8 B	6 B	10 U	6 B	5.00	2000 d	5.00	4.10
tetrachloroethene	n/a	2 E J	2 E J	5.6 E J	2 E J	5.00	10.0 a	5.00	1.10
trichloroethene	n/a	5 U	10 U	10 U	5 E J	5.00	-	5.00	1.60

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW03I	05MW03S	05MW03S	05MW03S	05MW04I	SCREENING VALUES			
LOCATION:	05MW03I	05MW03S	05MW03S	05MW03S	05MW04I	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	09/18/00	06/24/97	09/18/91	09/18/00	09/21/00				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
barium	n/a	44.5	n/a	n/a	136 B	2000	700	2000	2600
calcium	n/a	7300	n/a	n/a	n/a	-	-	-	-
chromium, total	n/a	6.3 K	n/a	n/a	1 U	100 *	1000	100	110
iron	n/a	124	n/a	n/a	n/a	-	-	-	11000
lead	n/a	2.1 B	n/a	n/a	1.9 U	15.0	-	5.00	15.0
magnesium	n/a	2110	n/a	n/a	n/a	-	-	-	-
manganese	n/a	7.5 K	n/a	n/a	n/a	-	-	-	730
sodium	n/a	7680	n/a	n/a	n/a	-	-	-	-
zinc	n/a	19.6 B	n/a	n/a	n/a	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	3.7 J	10 U	1 B	10 U	50	200	200 a	200	3200
1,1-dichloroethane	5.5 J	10 U	5 U	10 U	29 E	-	-	27.0	800
1,1-dichloroethene	3.5 E J	10 U	5 U	10 U	25 E	7.00	7.00 a	7.00	0.0440
acetone	2.1 J	10 U	10 U	2.2 J	3 J	-	-	3700	610
cis-1,2-dichloroethene	1.6 J	n/a	n/a	10 U	5 J	70.0	70.0 a	70.0	61.0
methylene chloride	10 U	6 B	4 B	10 U	10 U	5.00	2000 d	5.00	4.10
tetrachloroethene	2 E J	10 U	5 U	10 U	2.2 E J	5.00	10.0 a	5.00	1.10
trichloroethene	2.5 E J	10 U	5 U	10 U	18 E	5.00	-	5.00	1.60

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW04S	05MW04S	05MW04S	05MW05I	05MW05I-F	SCREENING VALUES			
LOCATION:	05MW04S	05MW04S	05MW04S	05MW05I	05MW05I	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Filt. Mon. Well				
SAMPLE DATE:	06/25/97	09/18/91	09/21/00	09/21/00	09/21/00				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	82.9 B	n/a	n/a	n/a	n/a	-	-	-	37000
arsenic	1 UL	n/a	n/a	8.3 B	6.8 B	5.00	-	50.0	0.0450
barium	56.8	n/a	n/a	164 B	132 B	2000	700	2000	2600
calcium	5740	n/a	n/a	n/a	n/a	-	-	-	-
chromium, total	5 U	n/a	n/a	10.2	n/a	100 *	1000	100	110
iron	61.4	n/a	n/a	n/a	n/a	-	-	-	11000
lead	2.9 B	n/a	n/a	3.8	1.9 U	15.0	-	5.00	15.0
magnesium	2240	n/a	n/a	n/a	n/a	-	-	-	-
manganese	5 K	n/a	n/a	n/a	n/a	-	-	-	730
sodium	9200	n/a	n/a	n/a	n/a	-	-	-	-
zinc	39.2 B	n/a	n/a	n/a	n/a	-	2000 a	2000	11000
SEMIVOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
bis(2-ethylhexyl)phthalate	1 B	n/a	n/a	n/a	n/a	6.00	-	6.00	4.80
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10 U	3 B	10 U	7.3 J	n/a	200	200 a	200	3200
1,1-dichloroethane	10 U	5 U	10 U	2.9 J	n/a	-	-	27.0	800
1,1-dichloroethene	10 U	5 U	10 U	9.2 E J	n/a	7.00	7.00 a	7.00	0.0440
acetone	10 U	10 U	10 U	3.5 J	n/a	-	-	3700	610
methylene chloride	17 B	5 U	10 U	10 U	n/a	5.00	2000 d	5.00	4.10
trichloroethene	10 U	5 U	10 U	2.9 E J	n/a	5.00	-	5.00	1.60

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW05S		05MW05S		05MW05S-DUP		05MW05S		05MW06I		SCREENING VALUES				
LOCATION:	05MW05S		05MW05S		05MW05S		05MW05S		05MW06I		Maximum Contaminant Level (MCL)		Drinking Water Health Advisory (Lowest Criterion Shown)		PADEP Groundwater MSC (res.) <2500 TDS		Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well		Monitoring Well		Monitoring Well		Monitoring Well		Monitoring Well								
SAMPLE DATE:	06/24/97		09/20/91		09/20/91		09/12/00		06/25/97								
INORGANICS	ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L
aluminum	50	U	n/a		n/a		n/a		59.5	B	-		-		-		37000
barium	190		n/a		n/a		n/a		178		2000		700		2000		2600
calcium	6860		n/a		n/a		n/a		7640		-		-		-		-
chromium, total	6	K	n/a		n/a		n/a		5	U	100	*	1000		100		110
iron	85.9		n/a		n/a		n/a		50	U	-		-		-		11000
lead	3.4	B	n/a		n/a		n/a		1	U	15.0		-		5.00		15.0
magnesium	1820		n/a		n/a		n/a		5790		-		-		-		-
manganese	5.5	K	n/a		n/a		n/a		5	U	-		-		-		730
potassium	1500	U	n/a		n/a		n/a		26000		-		-		-		-
sodium	12300		n/a		n/a		n/a		25200		-		-		-		-
zinc	9	B	n/a		n/a		n/a		5	U	-		2000	a	2000		11000
VOLATILES	ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L
acetone	10	U	10	U	10	U	1.8	J	10	U	-		-		3700		610
methylene chloride	5	B	5	U	3	B	10	U	17	B	5.00		2000	d	5.00		4.10

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW06I	05MW06I	05MW06S	05MW06S	05MW06S	SCREENING VALUES			
LOCATION:	05MW06I	05MW06I	05MW06S	05MW06S	05MW06S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	09/13/00	09/20/91	06/25/97	09/20/91	09/13/00				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	n/a	n/a	68.3 B	n/a	n/a	-	-	-	37000
barium	n/a	n/a	111	n/a	n/a	2000	700	2000	2600
calcium	n/a	n/a	7320	n/a	n/a	-	-	-	-
lead	n/a	n/a	2.8 B	n/a	n/a	15.0	-	5.00	15.0
magnesium	n/a	n/a	3410	n/a	n/a	-	-	-	-
manganese	n/a	n/a	14.2 K	n/a	n/a	-	-	-	730
sodium	n/a	n/a	8510	n/a	n/a	-	-	-	-
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
acetone	2.2 J	10 U	10 U	10 U	2 J	-	-	3700	610
methylene chloride	10 U	5 U	16 B	5 U	10 U	5.00	2000 d	5.00	4.10
toluene	10 U	1 B	10 U	5 U	10 U	1000	1000 a	1000	750

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW07I	05MW07I	05MW07I	05MW07S	05MW07S	SCREENING VALUES			
LOCATION:	05MW07I	05MW07I	05MW07I	05MW07S	05MW07S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	06/23/97	09/14/00	09/20/91	06/23/97	09/20/91				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
barium	460	n/a	n/a	95.1	n/a	2000	700	2000	2600
calcium	35600	n/a	n/a	24300	n/a	-	-	-	-
iron	90.3	n/a	n/a	71.8	n/a	-	-	-	11000
lead	18.1 E	n/a	n/a	1 U	n/a	15.0	-	5.00	15.0
magnesium	6980	n/a	n/a	9850	n/a	-	-	-	-
manganese	142	n/a	n/a	6.4 K	n/a	-	-	-	730
potassium	2330	n/a	n/a	1500 U	n/a	-	-	-	-
sodium	10000	n/a	n/a	10700	n/a	-	-	-	-
zinc	5 U	n/a	n/a	24.1 B	n/a	-	2000 a	2000	11000
SEMIVOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
bis(2-ethylhexyl)phthalate	10 U	n/a	n/a	6 B	n/a	6.00	-	6.00	4.80
di-n-butyl phthalate	3 B	n/a	n/a	3 B	n/a	-	-	3700	3700
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10 U	3.3 J	6	10 U	2 J	200	200 a	200	3200
1,1-dichloroethane	10 U	2.9 J	2 J	10 U	1 J	-	-	27.0	800
1,1-dichloroethene	10 U	5.4 E J	4 E J	10 U	5 U	7.00	7.00 a	7.00	0.0440
acetone	10 U	2.1 J	10 U	10 U	10 U	-	-	3700	610
methylene chloride	6 B	10 U	3 B	6 B	5 U	5.00	2000 d	5.00	4.10
toluene	10 U	10 U	2 B	10 U	1 B	1000	1000 a	1000	750
trichloroethene	10 U	2.4 E J	2 E J	10 U	5 U	5.00	-	5.00	1.60
PESTICIDES/PCBS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
dieldrin	0.1 U	n/a	n/a	0.3 E	n/a	-	0.500	0.0410	0.00420

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW07S	05MW08I	05MW08I-DUP	05MW08I	05MW08S	SCREENING VALUES			
LOCATION:	05MW07S	05MW08I	05MW08I	05MW08I	05MW08S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	09/14/00	06/23/97	06/23/97	09/15/00	06/25/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	n/a	230	213	n/a	173 B	-	-	-	37000
barium	n/a	372	378	n/a	75.9	2000	700	2000	2600
calcium	n/a	35100	35700	n/a	27300	-	-	-	-
iron	n/a	300	269	n/a	256	-	-	-	11000
lead	n/a	1 B	1.2 B	n/a	1 U	15.0	-	5.00	15.0
magnesium	n/a	8560	8710	n/a	6650	-	-	-	-
manganese	n/a	6.5 K	6.5 K	n/a	57.1	-	-	-	730
potassium	n/a	1500 U	1500 U	n/a	2770	-	-	-	-
sodium	n/a	10100	10100	n/a	15100	-	-	-	-
zinc	n/a	34.8 K	24.9 B	n/a	49.1	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10 U	2 J	10 U	10 U	10 U	200	200 a	200	3200
acetone	2.1 J	10 U	10 U	3 J	10 U	-	-	3700	610
methylene chloride	10 U	7 B	6 B	10 U	16 B	5.00	2000 d	5.00	4.10

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW08S-DUP	05MW08S	05MW08SI	05MW08SI	05MW09I	SCREENING VALUES			
LOCATION:	05MW08S	05MW08S	05MW08S	05MW08SI	05MW09I	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	09/15/00	09/15/00	09/15/00	06/23/97	06/23/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	n/a	n/a	n/a	679	162 B	-	-	-	37000
barium	n/a	n/a	n/a	487	594	2000	700	2000	2600
calcium	n/a	n/a	n/a	39000	38400	-	-	-	-
chromium, total	n/a	n/a	n/a	5 U	7.3 K	100 *	1000	100	110
cobalt	n/a	n/a	n/a	5 U	8.1 K	-	-	2200	2200
iron	n/a	n/a	n/a	765	450	-	-	-	11000
lead	n/a	n/a	n/a	1.5 B	2.2 B	15.0	-	5.00	15.0
magnesium	n/a	n/a	n/a	8450	10100	-	-	-	-
manganese	n/a	n/a	n/a	46.3	21.4 K	-	-	-	730
sodium	n/a	n/a	n/a	12400	10300	-	-	-	-
zinc	n/a	n/a	n/a	24.9 B	27.7 K	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10 U	10 U	1.9 J	10 U	38	200	200 a	200	3200
1,1-dichloroethane	10 U	10 U	1.2 J	10 U	26	-	-	27.0	800
1,1-dichloroethene	10 U	10 U	3.7 E J	10 U	37 E J	7.00	7.00 a	7.00	0.0440
1,2-dichloroethene (total)	n/a	n/a	n/a	10 U	1 J	70.0 a	70.0 a	70.0	55.0
acetone	2 J	2 J	1.6 J	10 U	10 U	-	-	3700	610
methylene chloride	10 U	10 U	10 U	7 B	6 B	5.00	2000 d	5.00	4.10
trichloroethene	10 U	10 U	1.5 J	10 U	15 E	5.00	-	5.00	1.60

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW09I	05MW09S	05MW09S	05MW09SI	05MW09SI	SCREENING VALUES			
LOCATION:	05MW09I	05MW09S	05MW09S	05MW09SI	05MW09SI	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	09/21/00	06/24/97	09/26/00	06/23/97	09/21/00				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	n/a	50 U	n/a	59.9	n/a	-	-	-	37000
barium	n/a	143	n/a	401	n/a	2000	700	2000	2600
calcium	n/a	9650	n/a	26700	n/a	-	-	-	-
chromium, total	n/a	5 U	n/a	6.9 K	n/a	100 *	1000	100	110
cobalt	n/a	5 U	n/a	18.8 K	n/a	-	-	2200	2200
iron	n/a	62.1	n/a	267	n/a	-	-	-	11000
lead	n/a	2.6 B	n/a	1 U	n/a	15.0	-	5.00	15.0
magnesium	n/a	3100	n/a	5460	n/a	-	-	-	-
manganese	n/a	148	n/a	244	n/a	-	-	-	730
potassium	n/a	1680	n/a	1500 U	n/a	-	-	-	-
sodium	n/a	20700	n/a	16100	n/a	-	-	-	-
zinc	n/a	13.7 B	n/a	37.6 K	n/a	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	11	28	11	64	41	200	200 a	200	3200
1,1-dichloroethane	12	27	12	42 E	35 E	-	-	27.0	800
1,1-dichloroethene	13 E	25 E J	20 E	53 E J	57 E	7.00	7.00 a	7.00	0.0440
1,2-dichloroethane	10 U	10 U	10 U	10 U	1.1 E J	5.00	700	5.00	0.120
1,2-dichloroethene (total)	n/a	10 U	n/a	3 J	n/a	70.0 a	70.0 a	70.0	55.0
benzene	10 U	10 U	1.2 E J	3 E J	10 U	5.00	200	5.00	0.320
cis-1,2-dichloroethene	10 U	n/a	10 U	n/a	2.1 J	70.0	70.0 a	70.0	61.0
methylene chloride	10 U	4 B	10 U	7 B	10 U	5.00	2000 d	5.00	4.10
tetrachloroethene	10 U	2 E J	1.6 E J	4 E J	2.9 E J	5.00	10.0 a	5.00	1.10
trichloroethene	5.5 E J	17 E	8.2 E J	32 E	26 E	5.00	-	5.00	1.60

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW10I	05MW10I	05MW10S	05MW10S	05MW10SI	SCREENING VALUES			
LOCATION:	05MW10I	05MW10I	05MW10S	05MW10S	05MW10SI	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	06/24/97	09/18/00	06/24/97	09/15/00	09/18/00				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	50 U	n/a	6970	n/a	n/a	-	-	-	37000
arsenic	1 U	n/a	2 E L	n/a	n/a	5.00	-	50.0	0.0450
barium	403	n/a	1430 E	n/a	n/a	2000	700	2000	2600
beryllium	1 U	n/a	2.8	n/a	n/a	4.00	30000	4.00	73.0
calcium	34500	n/a	16300	n/a	n/a	-	-	-	-
chromium, total	5 U	n/a	40.8	n/a	n/a	100 *	1000	100	110
cobalt	5 U	n/a	5.1	n/a	n/a	-	-	2200	2200
copper	10 U	n/a	20.8 B	n/a	n/a	1300	-	1000	1500
iron	87.5	n/a	7440	n/a	n/a	-	-	-	11000
lead	1 U	n/a	19.9 B	n/a	n/a	15.0	-	5.00	15.0
magnesium	10900	n/a	7220	n/a	n/a	-	-	-	-
manganese	22.4 K	n/a	356	n/a	n/a	-	-	-	730
nickel	20 U	n/a	74.3	n/a	n/a	-	100 a	100	730
potassium	1630	n/a	3770	n/a	n/a	-	-	-	-
sodium	11600	n/a	29100	n/a	n/a	-	-	-	-
vanadium	5 U	n/a	5 E	n/a	n/a	-	-	2.10	260
zinc	14.1 B	n/a	457	n/a	n/a	-	2000 a	2000	11000
SEMIVOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
bis(2-ethylhexyl)phthalate	10 U	n/a	1 B	n/a	n/a	6.00	-	6.00	4.80
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	18	5.5 J	13	4.8 J	120	200	200 a	200	3200
1,1,2-trichloroethane	10 U	10 U	10 U	10 U	2.5 E J	5.00	3.00 a	5.00	0.190
1,1-dichloroethane	9 J	4.3 J	4 J	3 J	52 E	-	-	27.0	800
1,1-dichloroethene	12 E J	7.6 E J	6 E J	7.3 E J	120 E	7.00	7.00 a	7.00	0.0440
1,2-dichloroethane	10 U	10 U	10 U	10 U	2 E J	5.00	700	5.00	0.120
acetone	10 U	2.3 J	10 U	1.8 J	2.5 J	-	-	3700	610
carbon tetrachloride	10 U	10 U	10 U	10 U	19 E	5.00	200 d	5.00	0.160
cis-1,2-dichloroethene	n/a	10 U	n/a	10 U	8.8 J	70.0	70.0 a	70.0	61.0

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW10I	05MW10I	05MW10S	05MW10S	05MW10SI	SCREENING VALUES			
LOCATION:	05MW10I	05MW10I	05MW10S	05MW10S	05MW10S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	06/24/97	09/18/00	06/24/97	09/15/00	09/18/00				
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
methylene chloride	4 B	10 U	17 B	10 U	10 U	5.00	2000 d	5.00	4.10
tetrachloroethene	10 U	10 U	10 U	10 U	8.7 E J	5.00	10.0 a	5.00	1.10
trichloroethene	8 E J	2.5 E J	5 E J	2.8 E J	68 E	5.00	-	5.00	1.60
PESTICIDES/PCBS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
dieldrin	0.1 U	n/a	0.09 E J	n/a	n/a	-	0.500	0.0410	0.00420

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW10SI	05MW11I	05MW11I	05MW11S	05MW11S	SCREENING VALUES			
LOCATION:	05MW10SI	05MW11I	05MW11I	05MW11S	05MW11S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	06/24/97	05/28/98	09/13/00	05/28/98	09/12/00				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	101	387	n/a	50.2	n/a	-	-	-	37000
antimony	20 U	1.9 B	n/a	1.9 B	n/a	6.00	6.00 a	6.00	15.0
arsenic	1 U	2.3 U	n/a	3.3 E	n/a	5.00	-	50.0	0.0450
barium	354	201	n/a	98.3	n/a	2000	700	2000	2600
beryllium	1 U	0.47 K	n/a	0.62 K	n/a	4.00	30000	4.00	73.0
cadmium	5 U	0.21 L	n/a	0.31 L	n/a	5.00	5.00 a	5.00	18.0
calcium	32100	64100	n/a	14200	n/a	-	-	-	-
chromium, total	5 U	8.4 K	n/a	1.8 K	n/a	100 *	1000	100	110
cobalt	5 U	3	n/a	0.87 K	n/a	-	-	2200	2200
copper	10 U	4.4	n/a	1.8 K	n/a	1300	-	1000	1500
cyanide	5 U	10.3	n/a	10 U	n/a	200	200	200	730
iron	263	769	n/a	83.5	n/a	-	-	-	11000
magnesium	6550	13300	n/a	3030	n/a	-	-	-	-
manganese	75.7	185	n/a	5 K	n/a	-	-	-	730
mercury	0.2 U	0.1	n/a	0.1 U	n/a	2.00	2.00	2.00	3.70
nickel	20 U	6.5	n/a	4	n/a	-	100 a	100	730
potassium	1500 U	7640	n/a	842	n/a	-	-	-	-
sodium	17700	19000	n/a	10100	n/a	-	-	-	-
vanadium	5 U	0.5 B	n/a	0.5 B	n/a	-	-	2.10	260
zinc	17.6 B	34.3	n/a	28.7	n/a	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	140	10 U	10 U	10 U	10 U	200	200 a	200	3200
1,1-dichloroethane	45 E	10 U	10 U	10 U	10 U	-	-	27.0	800
1,1-dichloroethene	120 E J	10 U	10 U	10 U	10 U	7.00	7.00 a	7.00	0.0440
1,2-dichloroethene (total)	6 J	10 U	n/a	10 U	n/a	70.0 a	70.0 a	70.0	55.0
acetone	10 U	6 B	2.5 J	6 B	14	-	-	3700	610
benzene	10 U	10 U	1.2 E J	10 U	10 U	5.00	200	5.00	0.320
chlorobenzene	10 U	10 U	1.3 J	10 U	10 U	-	-	100	110

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW10SI	05MW11I	05MW11I	05MW11S	05MW11S	SCREENING VALUES			
LOCATION:	05MW10SI	05MW11I	05MW11I	05MW11S	05MW11S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	06/24/97	05/28/98	09/13/00	05/28/98	09/12/00				
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
chloroform	10 U	10 U	1 E J	10 U	10 U	80.0	4000	100	0.150
methylene chloride	20 B	2 B	1.3 J	3 B	10 U	5.00	2000 d	5.00	4.10
tetrachloroethene	8 E J	10 U	10 U	10 U	10 U	5.00	10.0 a	5.00	1.10
toluene	10 U	10 U	1.2 J	10 U	10 U	1000	1000 a	1000	750
trichloroethene	75 E	10 U	1.2 J	10 U	10 U	5.00	-	5.00	1.60
xylenes, total	10 U	10 U	1.4 J	10 U	10 U	10000	10000 a	10000	12000
PESTICIDES/PCBS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Aroclor-1221	2 UJ	2 U	n/a	0.98 B	n/a	0.500	-	1.30	0.0330
dieldrin	0.1 UJ	0.1 U	n/a	0.0051 E J	n/a	-	0.500	0.0410	0.00420
endrin aldehyde	0.1 UJ	0.021 B	n/a	0.054 B	n/a				11.0
gamma-chlordane	0.05 UJ	0.0049 J	n/a	0.05 U	n/a	2.00	60.0	2.00	0.190
heptachlor	0.05 UJ	0.014 B	n/a	0.02 B	n/a	0.400	10.0	0.400	0.0150

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW11SI		05MW11SI-DUP		05MW11SI		05MW12I		05MW12I-DUP		SCREENING VALUES			
LOCATION:	05MW11SI		05MW11SI		05MW11SI		05MW12I		05MW12I-DUP		Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well		Monitoring Well		Monitoring Well		Monitoring Well		Monitoring Well					
SAMPLE DATE:	05/28/98		05/28/98		09/12/00		09/21/00		09/21/00					
INORGANICS	ug/L		ug/L		ug/L		ug/L		ug/L		ug/L	ug/L	ug/L	ug/L
aluminum	105		73.9		n/a		n/a		n/a		-	-	-	37000
antimony	1.9	B	1.9	B	n/a		n/a		n/a		6.00	6.00 a	6.00	15.0
barium	170		166		n/a		125	B	125	B	2000	700	2000	2600
beryllium	0.51	K	0.59	K	n/a		n/a		n/a		4.00	30000	4.00	73.0
cadmium	0.22	L	0.25	L	n/a		0.49	U	0.49	U	5.00	5.00 a	5.00	18.0
calcium	15300		15000		n/a		n/a		n/a		-	-	-	-
chromium, total	0.9	U	0.9	U	n/a		1.3	B	1.4	B	100 *	1000	100	110
cobalt	0.93	K	0.6	B	n/a		n/a		n/a		-	-	2200	2200
copper	1.6	K	1.5	K	n/a		n/a		n/a		1300	-	1000	1500
cyanide	10	UJ	160	J	n/a		n/a		n/a		200	200	200	730
iron	320	J	253	J	n/a		n/a		n/a		-	-	-	11000
lead	1.2	U	1.2	U	n/a		2.3	B	2.7	B	15.0	-	5.00	15.0
magnesium	3010		2930		n/a		n/a		n/a		-	-	-	-
manganese	15.3		13.9		n/a		n/a		n/a		-	-	-	730
nickel	3		2.2		n/a		n/a		n/a		-	100 a	100	730
potassium	869		837		n/a		n/a		n/a		-	-	-	-
selenium	3.5	UL	3.5	UL	n/a		2.9	B	2.1	U	50.0	50.0 a	50.0	180
sodium	10600		10400		n/a		n/a		n/a		-	-	-	-
vanadium	0.5	B	0.5	B	n/a		n/a		n/a		-	-	2.10	260
zinc	24.4		21		n/a		n/a		n/a		-	2000 a	2000	11000
VOLATILES	ug/L		ug/L		ug/L		ug/L		ug/L		ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10	U	10	U	10	U	5.4	J	5.3	J	200	200 a	200	3200
1,1-dichloroethane	10	U	10	U	10	U	9.5	J	12		-	-	27.0	800
1,1-dichloroethene	10	U	10	U	10	U	4.5	E J	4.2	E J	7.00	7.00 a	7.00	0.0440
acetone	10	U	6	B	10	U	10	U	3.1	J	-	-	3700	610
cis-1,2-dichloroethene	n/a		n/a		10	U	2.4	J	2.2	J	70.0	70.0 a	70.0	61.0
methylene chloride	2	B	2	B	10	U	10	U	10	U	5.00	2000 d	5.00	4.10
tetrachloroethene	10	U	10	U	10	U	2.9	E J	2.8	E J	5.00	10.0 a	5.00	1.10

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW11SI	05MW11SI-DUP	05MW11SI	05MW12I	05MW12I-DUP	SCREENING VALUES			
LOCATION:	05MW11SI	05MW11SI	05MW11SI	05MW12I	05MW12I-DUP	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	05/28/98	05/28/98	09/12/00	09/21/00	09/21/00				
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
trichloroethene	10 U	10 U	10 U	2.9 E J	2.8 E J	5.00	-	5.00	1.60
PESTICIDES/PCBS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Aroclor-1221	2 U	1.2 B	n/a	n/a	n/a	0.500	-	1.30	0.0330
dieldrin	0.1 U	0.004 J	n/a	n/a	n/a	-	0.500	0.0410	0.00420
endrin aldehyde	0.1 U	0.11 B	n/a	n/a	n/a				11.0
heptachlor	0.0046 B	0.058 B	n/a	n/a	n/a	0.400	10.0	0.400	0.0150

Footnotes to sample results:

U - Compound or element was not detected. Value is the detection limit (inorganics) or quantitation limit (organics).

UJ - Not detected. Detection limit or quantitation limit shown is considered estimated due to exceedance of data validation quality control criteria.

UL - Not detected. Detection limit or quantitation limit shown is considered biased low due to exceedance of data validation quality control criteria.

n/a - Constituent was not analyzed for in this sample.

B - (Organic Data). Value is considered a nondetected result due to blank contamination.

B - (Inorganic Data). Value is greater than the Instrument Detection Limit (IDL), but less than the Contract Required Detection Limit (CRDL).

J - Value is estimated because concentration is below the quantitation limit or because of exceedance of data validation quality control criteria.

L - Value is considered biased low because of exceedance of data validation quality control criteria.

K - Value is considered biased high because of exceedance of data validation quality control criteria.

E - Result exceeds one or more of the selected ARARs.

Footnotes to MCLs:

- - No standard is available for this chemical in this classification.

a - Where applicable, value(s) represent the more stringent of criteria for total, cis-, and trans- isomers.

* - Criteria are for total chromium.

** - Copper action level 1300 ug/L for water treatment technology for public water supply systems.

*** - Lead action level 15 ug/L for water treatment technology for public water supply systems.

Footnotes to Health Advisories:

- - No standard is available for this chemical in this classification.

a - The listed health advisory criterion, lifetime adult, is equal to the most stringent of the EPA health advisories for this chemical.

b - The listed health advisory criterion, long-term adult, is equal to the most stringent of the EPA health advisories for this chemical.

c - The listed health advisory criterion, one-day child, is equal to the most stringent of the EPA health advisories for this chemical.

d - The listed health advisory criterion, ten-day child, is equal to the most stringent of the EPA health advisories for this chemical.

e - The listed health advisory criterion, long-term child, is equal to the most stringent of the EPA health advisories for this chemical.

Footnotes to PADEP Criteria:

MSC - Medium-Specific Concentration.

NATURAL ATTENUATION PARAMETER RESULTS – SITE 5
NASJRB WILLOW GROVE, PENNSYLVANIA

	H	CO2	O	Nitrogen	Methane	Ethane	Ethene	pH*
Well	(nM/L)	(mg/L	mg/L	(mg/L)	(u/L)	(ug/L)	(ug/L)	
05MW01S	6.4	128.4	1.09	10.4	15.8	0.03	0.05	5.8
05MW01SI	8.8	71.9	0.75	13.6	0.3	nd	0.02	6.2
05MW01I	8.0	6.3	3.15	14.0	nd	nd	nd	7.3
05MW03S	4.1	23.2	5.3	8.0	nd	nd	nd	5.5
05MW03I	3.4	45.6	2.92	11.5	nd	0.01	0.01	6.1
05MW04S	7.1	38.2	5.07	10.5	nd	nd	nd	5.2
05MW04I	7.0	55.1	4.00	14.4	nd	nd	nd	6.0
05MW05S	S**	76.2	2.31	11.1	nd	nd	nd	5.9
05MW06S	S	95.6	2.46	11.7	nd	nd	nd	5.4
05MW06I	S	8.8	2.12	11.4	161.9	nd	nd	7.6
05MW07S	S	119.1	0.64	9.4	nd	nd	0.01	5.7
05MW07I	S	21.8	1.95	13.3	1.5	nd	nd	6.8
05MW08S	S	122	0.86	10.8	nd	nd	nd	5.7
05MW08SI	S	67.2	0.82	11.7	nd	nd	nd	6.4
05MW08I	S	16.1	2.33	10.9	nd	nd	nd	6.8
05MW09S	11.1	174.9	0.36	11.5	0.8	0.01	0.05	5.4
05MW09SI	6.6	90.5	0.73	12.5	nd	nd	0.02	6.2
05MW09I	7.0	21.8	1.92	12.8	nd	0.01	0.01	6.9
05MW10S	S	192.9	0.52	9.7	2.8	nd	0.01	5.5
05MW10SI	S	58.2	1.06	11.4	nd	0.01	0.01	6.5
05MW10I	S	6.5	3.89	16.8	nd	0.01	0.02	7.3
05MW11S	1.8	100.4	0.21	11.3	nd	nd	0.01	5.5
05MW11SI	2.5	83.5	3.05	8.5	nd	nd	nd	5.5
05MW11I	S	1.7	1.09	13	1.3	nd	nd	7.7
05MW12I	9.9	55.0	3.30	12.7	nd	nd	nd	5.7

Criteria (US EPA, 1998)

Tolerated	> 1	> 2 x backgr	< 0.5	< 1	> 0.5	> 0.1	> 0.01	5<pH<9
Score	3	1	3	2	3	3	2	0
not tolerated	< 1		> 5	> 1	< 0.5			5>pH>9
Score	VC oxid.		-3	0	VC oxid.			-2

*pH data from Groundwater Sample Log Sheet (September 2000).

**S-Compound saturated detector, actual result > 50 nM/L.

nd - Not detected.

APPENDIX B

SOIL GAS SURVEY REPORT

For soil gas survey reporting prior to 1997 see Phase II Remedial Investigation Report Appendices (TtNUS, April 1998)

APPENDIX C

SOIL BORING AND MONITORING WELL INSTALLATION LOGS

For soil boring and monitoring well installation logs prior to 1997
see Phase II Remedial Investigation Report
Appendices (TtNUS, April 1998)

BORING LOG

PROJECT NAME: NAS Willow Grove
PROJECT NUMBER:
DRILLING COMPANY: Advanced Drilling
DRILLING RIG: Strata Stan 25

BORING NUMBER: MW 11S
DATE: 3/30 – 4/1/98
GEOLOGIST: D. Whalen
DRILLER:

Sample No. and Type or RQD	Depth (Ft.) or Run No	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
1101	0.0 – 2.0					Brn	sandy clayey silt		damp				
	4.0					Brn	silt to						
1104	6.0												
	8.0												
1114	10.0					Red-Brn	clayey silt weathered mudstone		dusty				
	12.0												
	14.0					Red	mudstone		dry, dusty				
	16.0												
1127	18.0						silty FGR sandstone		less dust				
131	20.0			*									
							VFGR to FGR sandstone						
				*									
	40.0												
	4.0												
	50.0												

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks:

Drilling Area Background (ppm):

Converted to Well: Yes ____ No ____ Well I.D. #:

BORING LOG

PROJECT NAME: NAS Willow Grove
PROJECT NUMBER:
DRILLING COMPANY: Advanced
DRILLING RIG: Strata Star 25
BORING NUMBER: MW-11S
DATE: 4/1/98
GEOLOGIST: P. Whalen
DRILLER:

	Sample No. and Type or RQD	Depth (Ft.) or Run No	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
1118		53.0					purple	VFGR SS micaceous		~70-80gpm				
157		55.0					l. gray	FGR SS		fractured 43-47				
		57.0					beige	F-mgr SS						
	1237	60.0												
1417							l. brn-gray	FGR sandstone						
								F-mgr SS						
450	1445	65.0												
							gray-brn	F-mgr SS, v usty						
	1525	70								~80gpm?				
					T.P.									

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: 1128 stop at ~54' pump out bin 1139 resume

Drilling Area Background (ppm):

Converted to Well: Yes _____ No _____ Well I.D. #: _____

BORING LOG

PROJECT NAME: NAS Willow Grove
PROJECT NUMBER: 5466
DRILLING COMPANY: Advanced
DRILLING RIG: Santa Star 25
BORING NUMBER: MW 11 I
DATE: 3/30/98 + 4/3
GEOLOGIST: Dowhalen
DRILLER:

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	OVM/ID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
1305	2.0					Brn	sandy clayey silt		damp				
	4.0					Brn	silt to clayey silt, some mica		damp/moist				
1308	6.0					red							
1314													
	8.0					Brn	clayey silt, micaceous		damp				
1318	10					red-Brn	weathered mudstone		damp				
1320	12.0												
				*		red-Brn	silty sandstone		~8 ppm at ~13' 3-5				
1323	16 20.0												
1329	18.0								5-10 ppm				
12 1021 1025	20.0			*		red-gray	silty FGR sandstone micaceous		wet water table				
1028				*					~3 ppm ~5-10				
						Brn-Gr	FGR sandstone						
1044	25.0								~10-12				
1049									~20-30				
1118	30.0								~35 ppm-40 ~40 ppm				
1125						Brn-Gray	FGR SS, rust specks						
1206	35.0												
1216	1232	37.0											
1415	1431	40.0											
1444				*		red-Brn	VFGR sandstone		fractured at ~41' and 41.5				
	1500	43.0											
1510	1521	45.0		*		red	mudstone		~70 ppm				
1636						red red/Brn	mudstone/siltstone						
	1649	49.0											
	1657	50.0				purple red	VFGR sandstone mudstone		70-75 ppm				

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: 1296 Stop 34.5' water reaching gully
1232 Stop at 37'

Drilling Area Background (ppm):

Converted to Well: Yes _____ No _____ Well I.D. #: _____

BORING LOG

PROJECT NAME: Willow Grove
PROJECT NUMBER: 5466
DRILLING COMPANY: Advanced
DRILLING RIG: Strata Star 25
BORING NUMBER: MW-11I
DATE: 4-3-98/4-6/4-7
GEOLOGIST: D. Whalen
DRILLER:

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
0827	51.0					purple	VF-FGR sandstone		~80? gpm				
0906													
0916 0926	55.0					Brn gray	FGR sandstone, rust specks						
1056 1110	56.0												
1121 1135	58.0												
1147 1201	60												
1213 1226	61.0					lt. brn gray and red-gray	FGR sandstone						
1341 1356							large pieces of red-gray sandstone		poss. fracture				
1406 1421	64.0												
1429 1441	65.0						FGR sandstone and red silty sandstone (crumbly)						
1452 1504	67.0					Brn-gray	FGR arkosic sandstone		fractures at ~66' dirty water				
1625 1638													
1646 1656	70.0												
1754	72.0								80-100 gpm				
0830						red-brn	mudstone		soft				
0850	75.0								7 min				
1016 1027	76.0					Pink gray	F-mgr sandstone						
1033 1044 1101						lt. brn gray							
1052 1126 1145							w/rust specks						
1117 1257 1310	80.0								5 min				
1321 1326 1338 1347													
1354 1402 1414 1422	82.0												
1538 1545 1554 1603													
1611 1624 1633 1651	85.0	0950		0911 0918 0926		lt. brn-gray	MGR arkosic sandstone		~100 gpm? 5 min				
1745				1125									
1200	90.0												
1204													
1232	93.0						NGR-CGR sandstone arkosic		+ calcite fast drilling 95-95'				
1241 1246	95.0												
1317	97.0								~~[illegible]~~				
									Sc fy at 98'				
1325	100.0					red-gray-brown	silty FGR sandstone/VFGR micaceous		large pieces				

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm):

Remarks: 0906 stop at 53.5' 1201 59.5' 1213 bounce 1421 Sump at 64'
1110 stop at 56 1121 bounce 1226 61'
1135 stop at 58 1147 " 1357 62.5

Connected to Well: Yes ____ No ____ Well I.D. #: ____

BORING LOG

PROJECT NAME: Willow Grove
PROJECT NUMBER: 5466
DRILLING COMPANY:
DRILLING RIG:

BORING NUMBER: MW-11I
DATE: 4-7-98/4-8
GEOLOGIST:
DRILLER:

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
1357													
	102.0					vld-brn	siltstone/mudstone		soft				
	1407 1409						mudstone						
1417	1412	105.0											
	1427						silty VFGR sandstone		harder				
						red	mudstone		soft				
	1437	110.0											
1441													
	1445	113.0											
	1449	115.0											
1455													
0808	1506	117.0					siltstone / VF gr sandstone		harder soft				
	0816 0828	120.0				red			~~[illegible]~~ 100-[illegible] gpm?				
0834	0847	121.0					VFGR sandstone		harder at 119'				
0930	1011					red							
	1027					red-gray	some siltstone						
	1059	1250				vld	siltstone/VFGR sandstone		dirty water at 124'				
102	1118	1260				Purple+ vld	VFGR sandstone micaceous w/ siltstone interbeds		soft at 124-125 harder				
1154													
	1232	130		?					fractures 128-129.5'				
1309	1234	132											
				?					water alert, at 132.5				
	1334	135		?			siltstone		soft 134-137 ~110 gpm				
1338	1349	137					VFGR sandstone and siltstone		harder				
0912	0846 0858	140.0							soft 138-139				
0905	0921 0937	141.0							hard soft at 143-144				
0950									soft 144.5-147				
	1123	145.0											
1241	1250 1311	147.0											
1346	1417	150.0					VF-FGR sandstone		~110 gpm				

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

56497

Drilling Area Background (ppm):

Remarks: 1235 spent on spread tank
1309 [illegible] 1345 tank full 0812-0847 tank full
0850-0935 1050-1121 1241-1311

Converted to Well: Yes ____ No ____ Well I.D. #:

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NASJRB Willow Grove
BORING NUMBER: 05MW04I
PROJECT NUMBER: 5466
DATE: 7/25/00
DRILLING COMPANY: Raab Drilling, Inc.
GEOLOGIST: Robert Good
DRILLING RIG: Ingersoll Rand T3
DRILLER: Joe DiPasquale

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
1135	0												
1138						BRN	SILT LOAM W/ ROOTS & SANDSTONE PIECES		DAMP				
1145 1147	3					BRN	SANDSTONE BOULDER		DAMP - DRY 0.0 ppm				
						ORANGE BRN	SILTY CLAY		MOIST				
	10					RED-BRN	SILTY CLAY		MOIST				
						RED-BRN	V. WEATHERED MUDSTONE		MOIST				
									0.0 ppm				
						RED-BRN	WEATHERED MUDSTONE		DAMP				
							MICACEOUS MUDSTONE & SILTSTONE		DAMP - DRY				
	20												
1154 1156	23					RED-GRAY	WEATHERED FGR SANDSTONE		MOIST				
				10" BOREHOLE									
1200	28			6" CASING					WET TO SATURATED TRACE WATER 0.0 ppm				
1328	30			6" BOREHOLE		RED-GRAY	WEATHERED FGR. SANDSTONE		DAMP TO MOIST				
									TRACE WATER @ 39' TO 40' 0.0 ppm				*
	40					RED-BRN	MUDSTONE						
1331 1332	41					BRN			DRY				
									DRY - DAMP				
	50								POSS SLIGHT WATER @ 50' 0.0 ppm				*

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): ____

Remarks: 10" AIR HAMMER TO 28'; 6" STEEL CASING TO 28'; 6" AIR HAMMER TO 50'

Converted to Well: Yes ✓ No ____ Well I.D. #: 05MW04I

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NASJRB Willow Grove
PROJECT NUMBER: 5466
DRILLING COMPANY: Raab Drilling, Inc.
DRILLING RIG: Ingersoll Rand T3

BORING NUMBER: 05MW04I
DATE: 7/25/00
GEOLOGIST: Robert Good
DRILLER: Joe DiPasquale

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
	50												
						RED-GRAY TO BRN	FGR SANDSTONE, SM RUSTY STAINING		MOIST				
							↓						
									NO WATER DURING DRILLING				
	60						↓						
1338 / 1339	61					RED-GRAY & BRN	FGR SANDSTONE, SOME WHITE CLAY & FRACTURE FILLINGS, SOME RUSTY STAINING		WATER AFTER ROD CONNECTION, EST 3-5 GPM				
							↓		0.0 PPM				
							(SOME INTERBEDDED VFGR REDDISH-GRAY SANDSTONE TO SILTSTONE)						
	70						↓						
							↓		FRACTURED 75'-78' WATER INCREASE				*
						BRN & OLIVE GRAY	FGR-MGR, SOME CGR SANDSTONE, WEATHERED & FRACTURED		LG. CUTTINGS, SOME COLLAPSE OF BOREHOLE				
	80						↓		EST 25 GPM, 0.0 PPM				
1348 / 1354	81												
									POSS STILL FRACTURED TO APPX 85'				
							↓						
	90					RED-GRAY & BRN	FGR-MGR SANDSTONE W/ RUSTY STAINS		EST 25-30 GPM				
							↓		0.0 PPM				
							(POSS SOME COARSE-GRAINED ARKOSE & MUDSTONE CONGLOMERATE)		POSS FRACTURE @ 95'				* ?
							↓						
	100												

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): [ ]

Remarks: 6" AIR HAMMER 50' TO 100'

Converted to Well: Yes ✓ No ____ Well I.D. #: 05MW04I

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NASJRB Willow Grove
PROJECT NUMBER: 5466
DRILLING COMPANY: Raab Drilling, Inc.
DRILLING RIG: Ingersoll Rand T3

BORING NUMBER: 05MW04I
DATE: 7/25/00
GEOLOGIST: Robert Good
DRILLER: Joe DiPasquale

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	100												
1401 1403	101						SANDSTONE AS BEFORE		≥ 30 GPM 0.0 PPM				
						RED-GRAY	FGR-VFGR SANDSTONE & SILTSTONE						
						RED-BRN	MICACEOUS SILTSTONE, SOME SOFTER MUDSTONE						
	110												
						LT-MED GRAY	FGR-VFGR SANDSTONE, SOME BRN, RUSTY & OLIVE MGR TO CGR SANDSTONE LAYERS, TRACE LIGNITE						
						LT-MED GRAY	FGR SANDSTONE, HARD						
	120								≥ 30 GPM 0.0 PPM				
1411 1413	121								POSS SL. WATER INCREASE				* ?
						RED-BRN	MUDSTONE & SILTSTONE, SOFT						
	130												
						LT. GRAY	FGR-MGR SANDSTONE		≥ 30 GPM 0.0 PPM				
	140												
1423 1425	141					LT. GRAY	FGR-MGR ARKOSIC SANDSTONE						
1431	150								TOTAL YIELD ≥ 30 GPM 0.0 PPM				

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm):

Remarks: 6" AIR HAMMER 100' TO 150'

Converted to Well: Yes ✓ No _____ Well I.D. #: 05MW04I

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NASJRB Willow Grove
PROJECT NUMBER: 5466
DRILLING COMPANY: Raab Drilling, Inc.
DRILLING RIG: Ingersoll Rand T3

BORING NUMBER: 05MW05I
DATE: 7/27/00
GEOLOGIST: Robert Good
DRILLER: Joe DiPasquale

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
0947	0					BRN	SILT LOAM W/ ROOTS		MOIST - WET				
						MED-BRN	SILTY CLAY		MOIST				
0944 / 0952	3					GRAY BRN			0.0 PPM				
						RED-BRN	SILTY CLAY		MOIST				
						RED-BRN	V. WEATH MUDSTONE & SILTSTONE		MOIST				
	10												
						GRAY, BRN	V. WEATH., FGR SANDSTONE		MOIST				
				10" BOREHOLE 6" CASING		RED-GRAY & BRN	WEATH., FGR SANDSTONE BEDROCK W/ RUSTY STAINS, BECOMING HARDER		DAMP 0.0 PPM				
1004	18												
1049	20			6" BOREHOLE		RED-GRAY &	FGR SANDSTONE, SLIGHTLY WEATHERED, SOME RUSTY		DAMP 0.0 PPM				
1050 / 1051	21					BRN	STAINING						
	30					OLIVE							
						BRN-GRAY	FGR SANDSTONE W/ RUSTY STAINING		DAMP 0.0 PPM				
						LT. GRAY	FGR - MGR ARKOSIC SANDSTONE						
						BRN	FGR - MGR SANDSTONE W/ SOME RUSTY STAINS						
	40								39' POSS FRACTURE OR SOFT ZONE, POSS				*
1058 / 1100	41						SOME INTERBEDDED FGR-VFGR, REDDISH-GRAY SANDSTONE & SILTSTONE		SOME WATER				
						BRN	SANDSTONE AS BEFORE		DAMP 0.0 PPM				
	50												

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): ____

Remarks: 10" AIR HAMMER 0' TO 18'; 6" STEEL CASING TO 18'; 6" AIR HAMMER 18' TO 50'

Converted to Well: Yes ✓ No ____ Well I.D. #: 05MW05I

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NASJRB Willow Grove
PROJECT NUMBER: 5466
DRILLING COMPANY: Raab Drilling, Inc.
DRILLING RIG: Ingersoll Rand T3

BORING NUMBER: 05MW05I
DATE: 7/27/00
GEOLOGIST: Robert Good
DRILLER: Joe DiPasquale

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
	50					BRN	FGR-MGR SANDSTONE w/ SOME RUSTY STAINS		DAMP				
							↓						
									54'-57' MORE WEATH. OR FRACTURED...				*
									POS WATER ZONE				
						RED-BRN	MUDSTONE, SOFT		MOIST 0.0 PPM				
	60						↓						
1105 1107	61								MUD AFTER ROD CONN.				
						BRN-GRY	FGR SANDSTONE		MOIST - WET				
							↓						
	70								MOIST 0.0 PPM				
							↓						
						RED-GRY, BRN	VFGR SANDSTONE TO SILTSTONE, HARD						
						RED-BRN	MUDSTONE, SOFTER		DRY - DAMP				
	80												
1114 1115	81					RED-GRY & RED-BRN	ALTERNATING LAYERS OF MUDSTONE & HARDER SILTSTONE & VFGR SANDSTONE		WET - MUDDY AFTER ROD CONNECTION. POOR CUTTINGS RETURNS				
							↓						
	90												
							↓						
						BRN	FGR SANDSTONE		MOIST 0.0 PPM				
1122 1204	96					BRN-GRY	FGR-MGR SANDSTONE, SM RUSTY STAINS		BREAK FOR RIG REPAIR 1122-1204 ... WATER, EST 3-4 GPM AFTER RECHARGE				
							↓ (POSS SOME COARSE MAT'L OR CONGLOMERATE)						
	100								0.0 PPM				

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm):

Remarks: 6" AIR HAMMER 50' TO 100'

Converted to Well: Yes ✓ No _____ Well I.D. #: 05MW05I

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NASJRB Willow Grove
PROJECT NUMBER: 5466
DRILLING COMPANY: Raab Drilling, Inc.
DRILLING RIG: Ingersoll Rand T3

BORING NUMBER: OSMW05I
DATE: 7/27/00
GEOLOGIST: Robert Good
DRILLER: Joe DiPasquale

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**	
	100													
1207 / 1241	101					RED-GRAY	FGR SANDSTONE		BREAK FOR AIR REPAIR 1207-1241 ... POOR					
									CUTTINGS RETURNS EST 3 GPM					
									0.0 PPM					
									POSS WATER INCREASE ?					* ?
	110					RED BRN	MUDSTONE & SILTSTONE SOFTER							
						RED GRAY	SILTSTONE TO VFGR SANDSTONE, HARDER		POSS WATER INCREASE ?					* ?
	120								POOR CUTTINGS RET.					
1249 / 1257	121					RED-GRAY & BRN	FGR SANDSTONE		EST 3-4 GPM					
									0.0 PPM					
						BRN	FGR-MGR SANDSTONE w/ SM RUSTY STAINING							
	130													
									EST 3-4 GPM					
						RED-GRAY BRN	HARD SILTSTONE w/ WHITE FRACTURE FILLINGS		0.0 PPM					
	140					RED GRAY	VFGR SANDSTONE & SILTSTONE SM GREENISH CLAYS							
1301 / 1303	141					BRN GRAY	FGR-MGR SANDSTONE		EST 10-12 GPM (SHALLOW WATER ZONES CLEANING UP ?)					
						RED-BRN	POSS SOME COARSER GRAINED MAT'L ...							
						RED-GRAY	COLORS VARIED							
									POSS FRACTURE w/ LO CUTTINGS @ APPX 148 FT ?					*
	150													

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): [ ]

Remarks: 6" AIR HAMMER 100' TO 150'

Converted to Well: Yes ✓ No ____ Well I.D. #: OSMW05I

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NASJRB Willow Grove
BORING NUMBER: 05MW05I
PROJECT NUMBER: 5466
DATE: 7/27/00
DRILLING COMPANY: Raab Drilling, Inc.
GEOLOGIST: Robert Good
DRILLING RIG: Ingersoll Rand T3
DRILLER: Joe DiPasquale

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	150												
						VAR BRN,	FGR-MGR SANDSTONE (COLOR) VARIED		INCREASED WATER FROM BEFORE				
						GRAY, RED-BRN							
						RED-GRAY							
	160								EST 20-25 GPM				
1313 / 1314	161								0.0 PPM				
						RED-BRN	VFGR SANDSTONE & HARD SILTSTONE						
	170												
						RED-BRN	MUDSTONE & SILTSTONE, SOFTER		EST 20-25 GPM 0.0 PPM				
	180												
1323 / 1325	181					RED-BRN	MUDSTONE & HARDER SILTSTONE		EST 20-25 GPM 0.0 PPM				
						RED-BRN,	HARDER SILTSTONE						
						RED-GRAY							
	190												
						RED-BRN TO	SILTSTONE & VFGR SANDSTONE		EST ≥ 25 GPM 0.0 PPM				
						GRAY							
						RED-GRAY	VFGR-FGR SANDSTONE, HARDER						
	200												

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm):

Remarks: 6" AIR HAMMER 150' TO 200'

Converted to Well: Yes ✓ No _____ Well I.D. #: 05MW05I

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NASJRB Willow Grove
PROJECT NUMBER: 5466
DRILLING COMPANY: Raab Drilling, Inc.
DRILLING RIG: Ingersoll Rand T3

BORING NUMBER: 05MW05I
DATE: 7/27/00
GEOLOGIST: Robert Good
DRILLER: Joe DiPasquale

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
	200												
1336 / 1338	201					RED-GRAY	VFGR SANDSTONE		≥ 25 GRAM 0.0 ppm				
						RED-GRAY	FGR SANDSTONE, HARD						
	210												
							- AS ABOVE - OCCASIONAL WHITE CALCITE AND/OR CLAY FRAGMENTS		≥ 25 GRAM 0.0 ppm				
	220												
1348 / 1350	221						- AS ABOVE - W SOME INTER BEDDED HARD SILTSTONE		≥ 25 GRAM 0.0 ppm				
						RED-BRN	SILTSTONE, SOFTER						
	230					RED-GRAY &	VFGR SANDSTONE & HARD SILTSTONE						
						RED-BRN			≥ 30 GRAM 0.0 ppm				
						RED-GRAY	VFGR-FGR SANDSTONE, HARD, SOME SILTSTONE						
	240												
1401 / 1404	241								≥ 30 GRAM 0.0 ppm				
						RED-BRN TO GRAY	SILTSTONE, SL. SOFTER		POSS WATER INCREASE ?				
	250					RED-GRAY	SILTSTONE & VFGR SANDSTONE						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm):

Remarks: 6" AIR HAMMER 200' TO 250'

Converted to Well: Yes ✓ No _____ Well I.D. #: 05MW05I

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NASJRB Willow Grove
PROJECT NUMBER: 5466
DRILLING COMPANY: Raab Drilling, Inc.
DRILLING RIG: Ingersoll Rand T3

BORING NUMBER: 05MW05I
DATE: 7/27/00
GEOLOGIST: Robert Good
DRILLER: Joe DiPasquale

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	250												
						RED-GRAY	VFGR - FGR SANDSTONE, HARD, SOME SILTSTONE		≥ 30 GPM				
									0.0 ppm				
1416	261			T.D.									

* When rock coring, enter rock brokeness.
** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): ____

Remarks: 6" AIR HAMMER 250' TO 261'. DEVELOP BOREHOLE W/ AIR FOR APPX 12 MIN UNTIL WATER FREE OF CUTTINGS.

Converted to Well: Yes ✓ No ____ Well I.D. #: 05MW05I

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NASJRB Willow Grove
PROJECT NUMBER: 5466
DRILLING COMPANY: Raab Drilling, Inc.
DRILLING RIG: Ingersoll Rand T3
BORING NUMBER: 05MW12I
DATE: 7/24/00, 7/25/00
GEOLOGIST: Robert Good
DRILLER: Joe DiPasquale

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
1431	0												
						BRN	SILT LOAM W/ROOTS & FEW RK FRAG.		MOIST				
1434 / 1434	3					BRN RED-BRN	SANDY SILT / SILTY CLAY		MOIST				
						RED-BRN	V. WEATH. MUDSTONE		DAMP				
	10												
							WEATH. MICACEOUS SILTSTONE & MUDSTONE		DAMP				
							(BECOMING HARDER)						
						BRN	SOFTER CLAY SEAM		MOIST TO WET				
	20			HAMMER		RED-BRN	SL. WEATH. MICACEOUS SILTSTONE		DAMP				
1444 / 1450	23			10" BOREHOLE			AS ABOVE W/ SOME SOFTER MUDSTONE LAYERS		DAMP TO DRY				
				6" CASING									
7/24 1453 / 7/25 0922	28					RED-BRN	MICACEOUS SILTSTONE W/ SOME THIN VFGR-FGR SANDSTONE INTERBEDS		DAMP				
	30			6" BOREHOLE									
									POSS. SOFTER OR FRACTURED BETWEEN 35 AND 45 FT. POSS. SL. WATER AROUND 38'. 0.0 PPM				
	40												
0927 / 0928	41					RED-BRN	SILTSTONE W/ SOME INTERBEDDED VFGR-FGR SANDSTONE LAYERS		INJECT WATER WHILE DRILLING TO REMOVE MUD & CUTTINGS.				
									0.0 PPM				
0930	50												

* ?

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): ____

Remarks: 10" AIR HAMMER TO 28', 6" STEEL CASING TO 28', 6" AIR HAMMER 28' TO 50'

Converted to Well: Yes ✓ No ____ Well I.D. #: 05MW12I

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NASJRB Willow Grove
PROJECT NUMBER: 5466
DRILLING COMPANY: Raab Drilling, Inc.
DRILLING RIG: Ingersoll Rand T3

BORING NUMBER: 05MW12I
DATE: 7/25/00
GEOLOGIST: Robert Good
DRILLER: Joe DiPasquale

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**	
0430	50					RED-BRN	SILTSTONE		0.0 ppm					
	60								POSS WATER INCREASE AT 55'-60' (APPX).					*
0435 0438	61					BRN	FGR-MGR SANDSTONE, TRACE LT GREENISH-WHITE CLAYS		EST: 7-8 GPM					
									0.0 ppm					
						BRN, GRAY	SANDSTONE AS ABOVE w/ RUSTY STAINED GRAINS & SURFACES							
	70													
						DARK RED-GRAY	VFGR SANDSTONE TO SILTSTONE		POSS SOFT ZONE OR FRACTURE @ 75'					
						BRN, GRAY	FGR-MGR SANDSTONE AS BEFORE		0.0 ppm					
	80					TAN & GRAY	FGR-MGR SANDSTONE							
0448 0450	81					RUSTY BRN								
						OLIVE BRN-GRAY	FGR SANDSTONE		EST 7-8 GPM					
						BRN	FGR SANDSTONE							
	90					BRN	FGR SANDSTONE w/ SOME		POSS WATER INCREASE EST 10-12 GPM					*
							RUSTY STAINING		0.0 ppm					
									POSS FRACTURE @ 95' POSS WATER INCREASE					*
						BRN	SANDSTONE AS ABOVE w/ SOME REDDISH-GRAY SILTSTONE		0.0 ppm					
0455	100						STRINGERS & TRACE WHITE FRACTURE FILLING							

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm):

Remarks: 6" AIR HAMMER 50' TO 100'

Converted to Well: Yes ✓ No _____ Well I.D. #: 05MW12I

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NASJRB Willow Grove
PROJECT NUMBER: 5466
DRILLING COMPANY: Raab Drilling, Inc.
DRILLING RIG: Ingersoll Rand T3
BORING NUMBER: 05MW12I
DATE: 7/25/00
GEOLOGIST: Robert Good
DRILLER: Joe DiPasquale

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
	100												
0958 / 1000	101					RED-GRAY & BRN	VFGR - FGR SANDSTONE		EST 20-25 GPM 0.0 PPM				
							AS ABOVE W/ NUMEROUS SMALL WHITE FRACTURE FILLINGS						
	110												
									POSS FRACTURE @ 113'				*
									POSS. WATER INCREASE ≥ 30 GPM				
									6.0 PPM POSS COLLAPSE OF FRAG. MAT'L ; LG CUTTINGS				
	120					RED-GRAY & BRN	VFGR SANDSTONE TO SILTSTONE						
1008 / 1012	121						SILTSTONE						
						RED-BRN	MUDSTONE, SOFTER, TRACE WHITE & GREEN CLAYS		STILL EST ≥ 30 GPM 0.0 PPM				
	130					RED-GRAY & BRN	SILTSTONE, HARDER						
						RED GRAY	FGR SANDSTONE						
						MED. BRN	FGR SANDSTONE		STILL EST. ≥ 30 GPM				
						LT.	FGR - MGR ARKOSIC SANDSTONE		0.0 PPM				
	140					GRAY BRN	MUM. RUSTY STAINS						
1022 / 1027	141					LT. GRAY	FGR - MGR ARKOSIC SANDSTONE						
							SOME COARSE GRAINED & POSS CONGLOMERATE						
									EST TOTAL YIELD 35 TO 40 GPM				
1032	150						- AS ABOVE -		0.0 PPM				

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm):

Remarks: 6" AIR HAMMER 100' TO 151'

Converted to Well: Yes ✓ No _____ Well I.D. #: 05MW12I

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NASJRB WILLOW GROVE
PROJECT NUMBER: 5466
DRILLING COMPANY: RAAB DRILLING, INC.
DRILLING RIG: MOBILE B-57
BORING NUMBER: 05RC01
DATE: 9-8-00
GEOLOGIST: R. GOOD
DRILLER: MIKE HUBER, JOE DIPASQUALE

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
1048	0					BR	SILT LOAM		DAMP	0	0	0	0
						RED-BR	SILTY CLAY						
							↓		MOIST	—	0	20-30	0
	5												
									MOIST	—	0	20-30	0
							↓						
1058	10					RED-BR	SILTY CLAY, WEATHERED MUDSTONE SAPROLITE		MOIST	—	0	30-50	0
							↓						
							↓						
							↓						
1102	15					RED-BR	WEATHERED MUDSTONE		MOIST	—	0	20-30	0
							↓						
							↓						
							↓						
							↓						
1110	20					RED-BRN	MUDSTONE / SILTSTONE		DAMP (TOO SOFT TO CORE)	—	0	20-40	0
							↓		PROGRESSIVELY HARDER 20 - 23½ FT.				
							↓						
							↓		DAMP	—	0	10-20	0
							↓	VBR					
	①						↓						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: 3¼-INCH I.D. HSA TO 23½ FT. NX CORE BARREL 23½ FT TO 40½ FT

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: -NA-

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NASJRB WILLOW GROVE
PROJECT NUMBER: 5466
DRILLING COMPANY: RAAB DRILLING, INC
DRILLING RIG: MOBILE B-57
BORING NUMBER: OSRC01
DATE: 9-8-00
GEOLOGIST: R. GOOD
DRILLER: MIKE HUBER, JOE DIPASQUALE

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
	25												
						REA-BR	MICACEOUS MUDSTONE	VBR	NUM. BEDDING PLANE, NEAR HORIZONTAL	0	0	5	0
RQD									FRACTURES, BL. ORANGE COATING OR LT. GR.				
0%	(1)		4.0/7.0						CLAY ON FRACTURE SURFACES				
◆	30.5		◆					VBR		–	0	0	0
									MUDSTONE FRACTURES AS ABOVE				
RQD	35					REA-BR	MUDSTONE AS ABOVE w/ MORE HARDER SILTSTONE	BR					
~60%	(2)		9.75/10.0							0	0	0	0
						REA-GR	FGR TO CGR ARKOSIC SANDSTONE	M	SANDSTONE FRACTURE SURFACES SHOW FE-STAINING AND SOME GRAIN & CEMENT DISSOLUTION				
▲	40.5		▲										

* When rock coring, enter rock brokeness.
** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks:

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

BORING NO.: _____

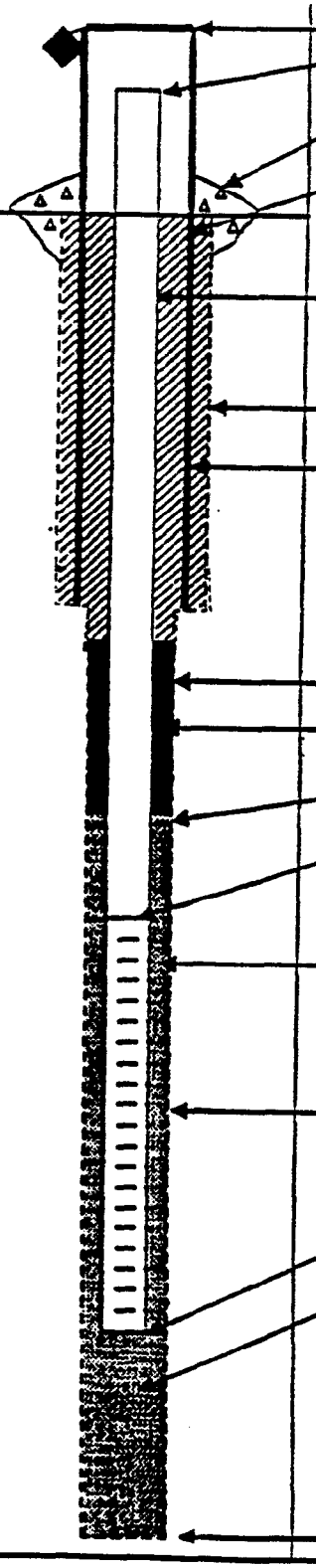
BROWN & ROOT ENVIRONMENTAL

MONITORING WELL SHEET

PROJECT NASJRB Willow Grove
PROJECT NO. 5466
ELEVATION _____
FIELD GEOLOGIST D. Whalen

LOCATION Site 5
BORING 05 MW 11 S
DATE 5/4/98

DRILLER Advanced
DRILLING METHOD air hammer
DEVELOPMENT METHOD submersible pump



ELEVATION OF TOP OF PERM. CASING : _____
ELEVATION OF TOP OF RISER PIPE: _____

TYPE OF SURFACE SEAL: cement

I.D. OF PERM. CASING: 6"
TYPE OF SURFACE CASING: steel

RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC

BOREHOLE DIAMETER: 10"

PERM. CASING I.D. 6"
TYPE OF CASING & BACKFILL: cement/bentonite grout

ELEVATION / DEPTH TOP OF SEAL: 13'
TYPE OF SEAL: bentonite

DEPTH TOP OF SAND PACK: 18.5'

ELEVATION/DEPTH TOP OF SCREEN: 20'
TYPE OF SCREEN: 0.02" slot size

TYPE OF SAND PACK: no. 2

BOREHOLE DIA. BELOW CASING: 6"

ELEVATION / DEPTH BOTTOM OF SCREEN: 25'

ELEVATION / DEPTH BOTTOM OF SAND PACK: 28'
TYPE OF BACKFILL BELOW OBSERVATION WELL: Monitoring well 05 MW 11 S I constructed below 05 MW 11 S in same borehole

ELEVATION / DEPTH OF HOLE: 70'

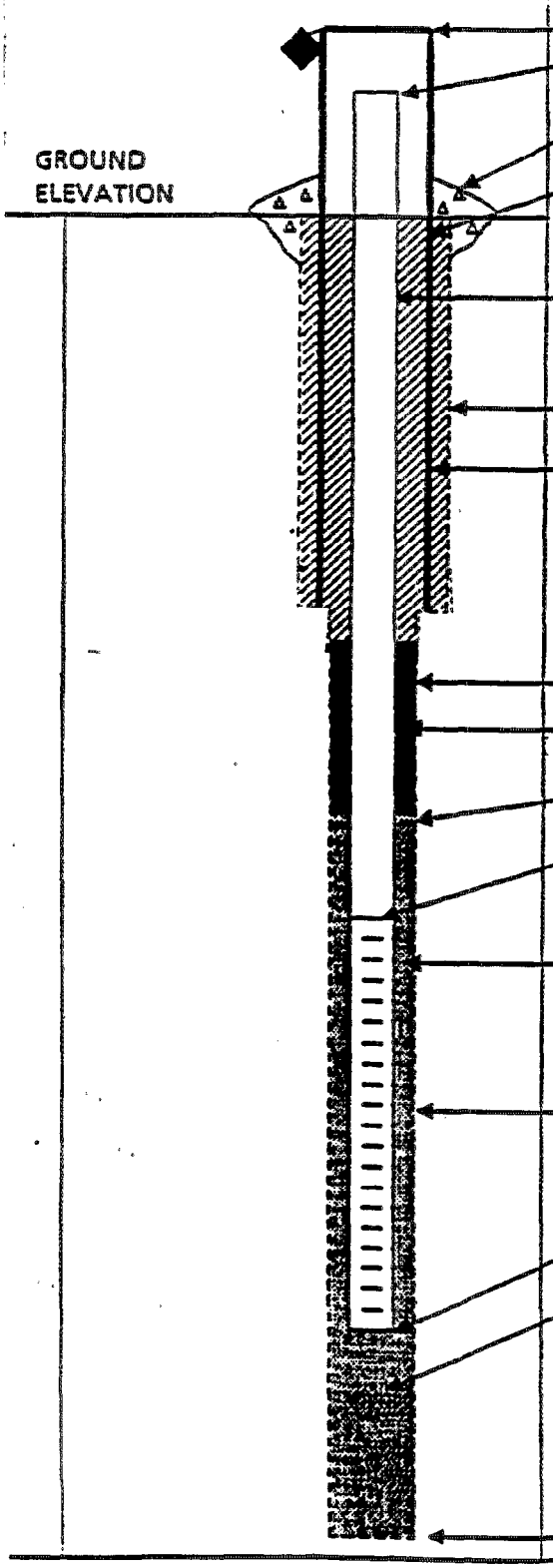
BROWN & ROOT ENVIRONMENTAL

MONITORING WELL SHEET

PROJECT NASJRB Willow Grove
PROJECT NO. 5466
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION site 5
BORING 05 MW11 SI
DATE 5/4/98

DRILLER Advanced
DRILLING METHOD air hammer
DEVELOPMENT METHOD submersible pump



ELEVATION OF TOP OF PERM. CASING :
ELEVATION OF TOP OF RISER PIPE:

TYPE OF SURFACE SEAL: cement

I.D. OF PERM. CASING:
TYPE OF SURFACE CASING: steel

RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC

BOREHOLE DIAMETER: 10"

PERM. CASING I.D. 6"
TYPE OF CASING & BACKFILL:
monitoring well 05 MW11 S constructed above 05 MW11 SI in same borehole

ELEVATION / DEPTH TOP OF SEAL: 28'
TYPE OF SEAL: bentonite

DEPTH TOP OF SAND PACK: 35'

ELEVATION/DEPTH TOP OF SCREEN: 40'
TYPE OF SCREEN: 0.02" slot size

TYPE OF SAND PACK: no. 2

BOREHOLE DIA. BELOW CASING: 6"

ELEVATION / DEPTH BOTTOM OF SCREEN: 50'

ELEVATION / DEPTH BOTTOM OF SAND PACK: 54'
TYPE OF BACKFILL BELOW OBSERVATION WELL: bentonite

ELEVATION / DEPTH OF HOLE: 70'

BROWN & ROOT ENVIRONMENTAL

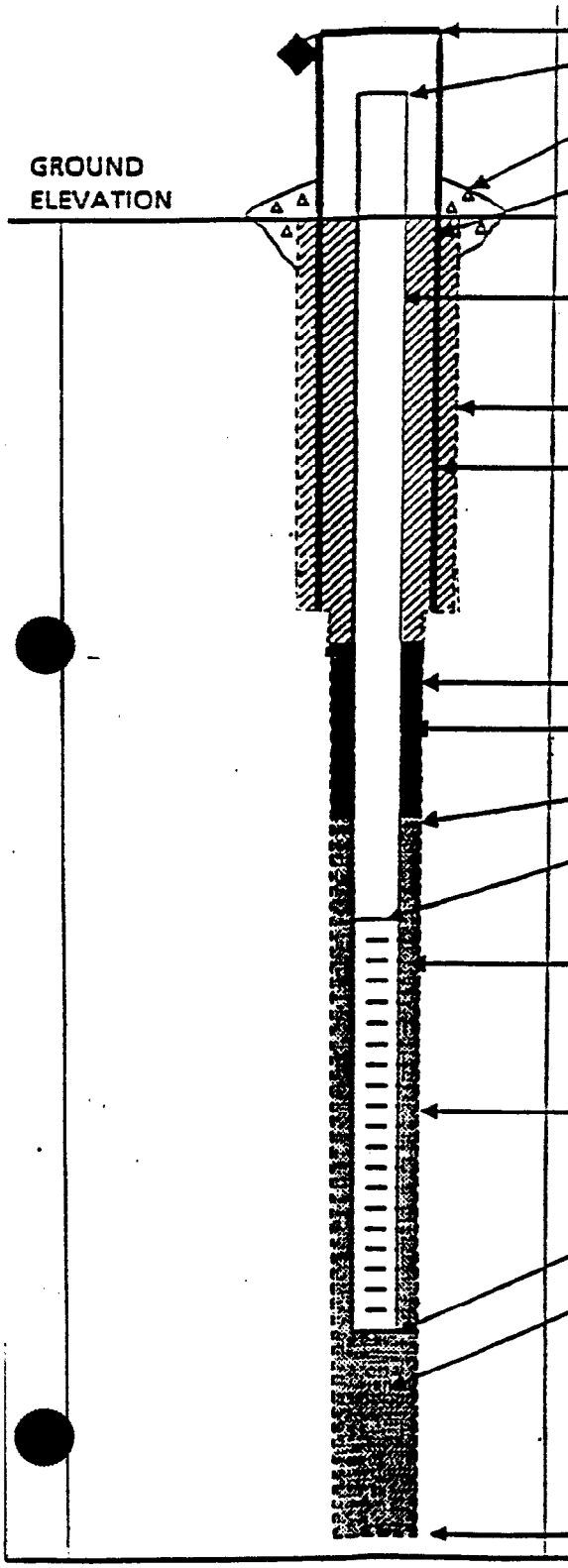
BORING NO. _____

MONITORING WELL SHEET

PROJECT NAS JRB Willow Grove
PROJECT NO. 5466
ELEVATION _____
FIELD GEOLOGIST D. Whalen

LOCATION Site 5
BORING 05 MW11 I
DATE 5-4-98

DRILLER Advanced
DRILLING METHOD air hammer
DEVELOPMENT METHOD submersible pump



ELEVATION OF TOP OF PERM. CASING : _____
ELEVATION OF TOP OF RISER PIPE: _____

TYPE OF SURFACE SEAL: cement

I.D. OF PERM. CASING: 6"
TYPE OF SURFACE CASING: steel

RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC

BOREHOLE DIAMETER: 10"

PERM. CASING I.D. 6"
TYPE OF CASING & BACKFILL: cement/bentonite grout

ELEVATION / DEPTH TOP OF SEAL: 123'
TYPE OF SEAL: bentonite

DEPTH TOP OF SAND PACK: 135'

ELEVATION/DEPTH TOP OF SCREEN: 139'
TYPE OF SCREEN: 0.02" slot size schedule 40 PVC

TYPE OF SAND PACK: no. 2

BOREHOLE DIA. BELOW CASING: 6"

ELEVATION / DEPTH BOTTOM OF SCREEN: 149'

ELEVATION / DEPTH BOTTOM OF SAND PACK: 150'
TYPE OF BACKFILL BELOW OBSERVATION WELL: N/A

ELEVATION / DEPTH OF HOLE: 150'

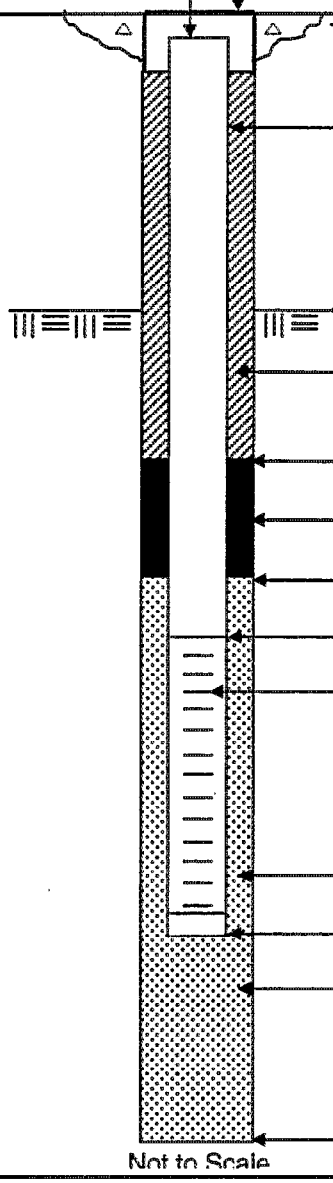
Tetra Tech NUS, Inc.

WELL No.: 05MW12I

MONITORING WELL SHEET

PROJECT:	NAJJRB WILLOW GROVE	DRILLING Co.:	RAAB DRILLING	BORING No.:	05MW12I
PROJECT No.:	N5466.1107	DRILLER:	JOE DIPASQUALE	DATE COMPLETED:	9/1/00
SITE:	FTAB, SITE 5	DRILLING METHOD:	AIR PERCUSSION	NORTHING:	
GEOLOGIST:	ROBERT GOOD	DEV. METHOD:	SUBMERSIBLE PUMP	EASTING:	

Ground Elevation =
Datum:



Elevation / Depth of Top of Riser: 1 +0.5'

Elevation / Height of Top of Surface Casing: 1 +1.0'

I.D. of Surface Casing: 6-INCH

Type of Surface Casing: STEEL

Type of Surface Seal:
6" STEEL CASING TO 28 FEET

I.D. of Riser: 2-INCH

Type of Riser: PVC

Borehole Diameter: 6-INCH

Elevation / Depth Top of Rock: 1 18'

Type of Backfill: CEMENT GROUT

Elevation / Depth of Seal: 1 24'

Type of Seal: BENTONITE

Elevation / Depth of Top of Filter Pack: 1 100'

Elevation / Depth of Top of Screen: 1 103.5'

Type of Screen: SLOTTED PVC

Slot Size x Length: 0.020-INCH

I.D. of Screen: 2-INCH

Type of Filter Pack: NO. 2 QTZ SAND

Elevation / Depth of Bottom of Screen: 1 113.5'

Elevation / Depth of Bottom of Filter Pack: 1 115.5'

Type of Backfill Below Well:
PURE BENTONITE CHIPS

Elevation / Total Depth of Borehole: 1 151'

Tetra Tech NUS, Inc.

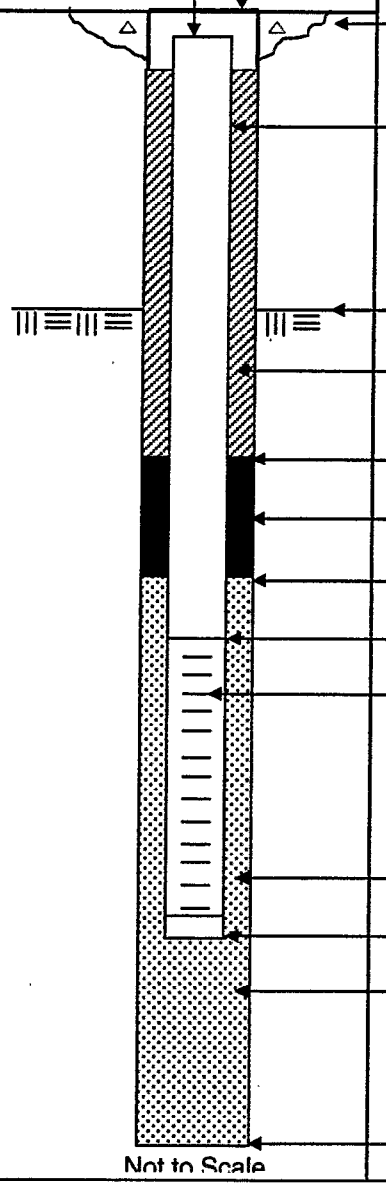
WELL No.: 05MW05I

MONITORING WELL SHEET

PROJECT:	NASJRB WILLOW-GROVE	DRILLING Co.:	RAAB DRILLING	BORING No.:	05MW05I
PROJECT No.:	N5466.1107	DRILLER:	JOE DIPASQUALE	DATE COMPLETED:	9/1/00
SITE:	FTAB, SITE 5	DRILLING METHOD:	AIR PERCUSSION	NORTHING:	
GEOLOGIST:	ROBERT GOOD	DEV. METHOD:	SUBMERSIBLE PUMP	EASTING:	

Ground Elevation =

Datum:



Not to Scale

Elevation / Depth of Top of Riser: 1 +0.5'

Elevation / Height of Top of Surface Casing: 1 +1.5'

I.D. of Surface Casing: 6-INCH

Type of Surface Casing: STEEL

Type of Surface Seal: CONCRETE

6" STEEL CASING TO 18 FEET

I.D. of Riser: 2-INCH

Type of Riser: PVC

Borehole Diameter: 6-INCH

Elevation / Depth Top of Rock: 1 12'

Type of Backfill: CEMENT GROUT

Elevation / Depth of Seal: 1 19.5'

Type of Seal: BENTONITE

Elevation / Depth of Top of Filter Pack: 1 185.5'

Elevation / Depth of Top of Screen: 1 189.5'

Type of Screen: SLOTTED PVC

Slot Size x Length: 0.020-INCH

I.D. of Screen: 2-INCH

Type of Filter Pack: NO. 2 QUARTZ SAND

Elevation / Depth of Bottom of Screen: 1 209.5'

Elevation / Depth of Bottom of Filter Pack: 1 215.5'

Type of Backfill Below Well: PURE BENTONITE CHIPS

Elevation / Total Depth of Borehole: 1 261'

Tetra Tech NUS, Inc.

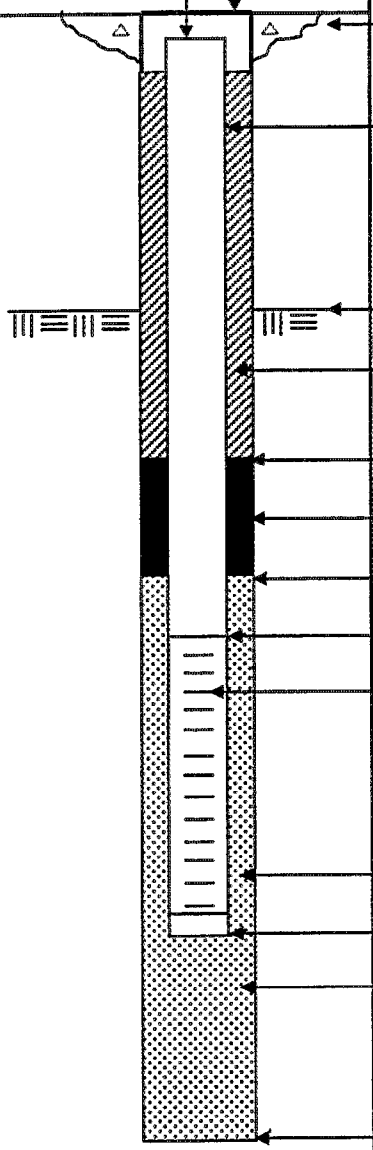
WELL No.: 05MW04I

MONITORING WELL SHEET

PROJECT:	NASJRB WILLOW GROVE	DRILLING Co.:	RAAS DRILLING	BORING No.:	05MW04I
PROJECT No.:	N5466 1107	DRILLER:	JOE DIPASQUALE	DATE COMPLETED:	9/1/00
SITE:	FTAB, SITE 5	DRILLING METHOD:	AIR PERCUSSION	NORTHING:	
GEOLOGIST:	ROBERT GOOD	DEV. METHOD:	SUBMERSIBLE PUMP	EASTING:	

Ground Elevation =

Datum:



Not to Scale

Elevation / Depth of Top of Riser: 1 + 1.5'

Elevation / Height of Top of Surface Casing: 1 + 2'

I.D. of Surface Casing: 6 - INCH

Type of Surface Casing: STEEL

Type of Surface Seal: 6" STEEL CASING TO 28 FEET

I.D. of Riser: 2 - INCH

Type of Riser: PVC

Borehole Diameter: 6 - INCH

Elevation / Depth Top of Rock: 1 16'

Type of Backfill: CEMENT GROUT

Elevation / Depth of Seal: 1

Type of Seal: BENTONITE

Elevation / Depth of Top of Filter Pack: 1 70'

Elevation / Depth of Top of Screen: 1 74.5'

Type of Screen: SLOTTED PVC

Slot Size x Length: 0.020 - INCH

I.D. of Screen: 2 - INCH

Type of Filter Pack: NO. 2 QUARTZ SAND

Elevation / Depth of Bottom of Screen: 1 84.5'

Elevation / Depth of Bottom of Filter Pack: 1 90.5'

Type of Backfill Below Well: PURE BENTONITE CHIPS

Elevation / Total Depth of Borehole: 1 150'

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Well: 05MW04I
Site: NASJRB WILLOW GROVE, SITE 5
Date Installed: 08/25/00
Date Developed: 08/31/00
Dev. Method: SUBMERSIBLE PUMP
Pump Type: GRUNFOS REDI-FLOW

Depth to Bottom (ft.): 84.5' (GS)
Static Water Level Before (ft.): 25.44' (TOC)
Static Water Level After (ft.): 25.44' (TOC)
Screen Length (ft.): 10'
Specific Capacity: 5.7 GPM/Ft
Casing ID (in.): 2"

Responsible Personnel: ROBERT GOOD
Drilling Co.: RAAB DRILLING
Project Name: NASJRB WILLOW GROVE
Project Number: 5466, CTO-277

Time	Pumping Rate (Gal/Min)	Cumulative Water Volume (Gal.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units ____)	Turbidity (NTU)	Remarks (odor, color, etc.) D.O. mg/L	PID ppm	
1500	2.0	0	25.44							
1503	2.0	6.0	25.77	18.1	5.78	.104	>1000	4.70	0.0	Turbid reddish-brown
1505	3.5	10.0	25.91	14.9	6.03	.216	>1000	5.84	0.0	Turbid Lt. brn.
1515	3.5	27.5	25.94	14.6	5.89	.195	870	7.54	0.0	— " —
1530	3.5	80.0	25.99	14.4	5.68	.152	245	7.36	0.0	— " —
1545	3.5	132.5	26.00	14.3	5.65	.138	164	7.47	0.0	— " —
1600	3.5	185.0	26.02	14.2	5.63	.129	107	7.03	0.0	— " —
1615	3.5	237.5	26.04	14.2	5.63	.126	78	5.65	0.0	Lt. brn tinted
1630	3.5	290.0	26.04	13.9	5.62	.124	61	6.53	0.0	— " —
1645	3.5	342.5	26.05	13.9	5.62	.122	48	6.32	0.0	
1700	3.5	395.0	26.04	13.9	5.63	.122	50	6.07	0.0	Almost clear

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Well: 05MW12I
Site: NASJRB WILLOW GROVE, SITE 5
Date Installed: 08/25/00
Date Developed: 09/01/00
Dev. Method: SUBMERSIBLE PUMP
Pump Type: GRUNDFOS REDI-FLOW

Depth to Bottom (ft.): 113.5 (GS)
Static Water Level Before (ft.): 26.66' (TOC)
Static Water Level After (ft.): 26.66' (TOC)
Screen Length (ft.): 10'
Specific Capacity: 6.5 GPM/Ft
Casing ID (in.): 2"

Responsible Personnel: ROBERT GOOD
Drilling Co.: RAAB DRILLING
Project Name: NASJRB WILLOW GROVE
Project Number: 5466, CTO-277

Time	Pumping Rate (Gal/Min)	Cumulative Water Volume (Gal.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units ____)	Turbidity (NTU)	D.O. mg/L	Remarks (odor, color, etc.)
1108	2.0	0							
1110	2.0	4.0	26.84	22.4	5.81	.125	>1000	9.02	V. Turbid gray-brn.
1120	4.0	24.0	27.07	16.5	5.89	.118	>1000	7.51	— " —
1130	4.0	64.0	27.14	15.8	5.62	.118	340	7.46	— " —
1140	4.0	104.0	27.17	15.6	5.46	.118	146	7.42	Turbid lt. gray-brn.
1155	4.0	164.0	27.21	15.7	5.42	.119	92	7.39	— " —
1210	4.0	224.0	27.24	15.7	5.42	.121	69	6.67	Sl. turbid lt. gray-brn
1225	4.0	284.0	27.25	15.7	5.41	.120	52	7.09	— " —
1240	4.0	344.0	27.26	15.5	5.48	.120	47	7.23	Sl. distinct gray-brn
1255	4.0	404.0	27.25	15.7	5.51	.120	65	6.92	— " —
1310	4.0	464.0	27.28	15.7	5.51	.120	41	6.75	
1320	4.0	504.0	27.28	15.4	5.53	.120	38	6.86	Almost Clear

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Well: OSMW05I
Site: NASJRB WILLOW GROVE, SITE 5
Date Installed: 08/25/00
Date Developed: 08/31/00
Dev. Method: SUBMERSIBLE PUMP
Pump Type: GRUNDFOS REDI-FLOW

Depth to Bottom (ft.): 209.5 (GS)
Static Water Level Before (ft.): 30.26 (TOC)
Static Water Level After (ft.): 57' & RISING
Screen Length (ft.): 20'
Specific Capacity: 0.0083 GPM/FT
Casing ID (in.): 2"

Responsible Personnel: ROBERT GOOD
Drilling Co.: RAAB DRILLING
Project Name: NASJRB WILLOW GROVE
Project Number: 5466, CTO-277

Time	Pumping Rate (Gal/Min)	Cumulative Water Volume (Gal.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units ____)	Turbidity (NTU)	Remarks (odor, color, etc.) D.O. (mg/L)	PID (ppm)	
1115		0								
1118	0.5	1.5	30.60	19.9	6.92	0.321	194	3.04	0.0	Lt. Brn Tint
1122	0.5	3.5	53.0	18.3	7.06	.372	30	2.49	0.0	" " "
1130	0.5	7.5	64.05	19.2	7.15	.390	82	2.21	0.0	Lt. Brn Tint
1135	0.5	10	70.20	18.6	7.09	.384	113	3.05	0.0	Adj flow gravel
1140	0.5	12.5	73.17	18.7	7.10	.381	72	2.44	0.0	" " " "
1150	0.5	17.5	82.38	18.1	7.31	.404	350	2.74	0.0	Cloudy, gray
1200	0.5	22.5	82.68	18.5	7.52	.392	545	3.30	0.0	"
1215	0.5	30	85.70	18.1	7.67	.376	450	2.05	0.0	Cloudy gray
1230	0.5	37.5	86.65	18.1	7.79	.364	490	2.42	0.0	
1245	0.5	45	89.37	17.9	7.81	.362	294	2.23	0.0	
1300	0.5	52.5	88.25	17.6	7.89	.358	245	1.97	0.0	
1315	0.5	60	89.27	17.5	7.94	.355	175	2.41	0.0	
1330	0.5	67.5	89.39	17.4	7.95	.353	125	2.11	0.0	Sl. Tinted gray
1345	0.5	75	89.15	17.6	7.97	.349	70	2.28	0.0	"
1400	0.5	82.5	88.96	18.2	8.00	.347	43	2.33	0.0	Almost clear.
1415	0.5	90	88.79	18.3	8.03	.346	25	2.12	0.0	"

APPENDIX D

SAMPLE COLLECTION LOGS

For sample collection logs prior to 1997 see Phase II Remedial Investigation Report Appendices (TtNUS, April 1998)

SAMPLE LOG SHEET

Page 1 of 1

☒ Monitoring Well Data
☐ Domestic Well Data
☐ Other _____

Case # _____

By R. Good

Project Site Name NASJRB - WILLOW GROVE Project Site Number CTO-277, JOB 5466
NUS Source No. 05MW11S Source Location SITE 5, MW-11S

	Purge Data				
Total Well Depth: 25' G.S.					
Well Casing Size & Depth: 2" PVC TO 20' G.S.; SCREEN TO 25' G.S.	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level: 8.26' TOIC	(SEE LOW FLOW PURGE DATA SHEET)				
One Casing Volume: N.A.					
Start Purge (hrs.): 1212					
End Purge (hrs.): 1257					
Total Purge Time (min.): 45 min					
Total Amount Purged ~~(gal.)~~ 15.75 L					
Monitor Reading: 0.0 ppm					
Purge Method: SUB. PUMP					
Sample Method: SUB. PUMP					
Depth Sampled: 23' G.S.					
Sample Date & Time: 5/28/98 1300	Sample Data				
	pH	S.C.	Temp. (°C)	Color & Turb[illegible]	
Sampled By: VINCE SHICHORA	5.56	129	— N.A. —	CLEAR, 0.95 NTU	

Signature(s):

Type of Sample
☒ Low Concentration
☐ High Concentration
☒ Grab
☐ Composite
☐ Grab - Composite

Observations / Notes:
LOW FLOW PURGE & SAMPLE
AVG. RATE = 350 ml/min

Analysis:	Preservative		Organic	Inorganic
3x 40 ml VOC	HCl	Traffic Report #	— NA. —	
1x 250 ml Cyanide	NaOH	Tag #	— NA. —	
1x 1 L Metals	HNO_3			
4x 1 L Sulf, Pb, Pest	—	AB #	FED EX 805368187426	
		Date Shipped	5/28/98	
		Time Shipped	1900	
		Lab	QUANTERRA	
		Volume	SEE ANALYSIS	

SAMPLE LOG SHEET

Page 1 of 1

☒ Monitoring Well Data
☐ Domestic Well Data
☐ Other _____

Case # _____

By R. Good

Project Site Name NASJRB - WILLOW GROVE Project Site Number CTO-277, JOB 5466
NUS Source No. OSMW11SI Source Location SITE 5, MW-11SI

	Purge Data				
Total Well Depth: 50' G.S.					
Well Casing Size & Depth: 2" PVC TO 40' G.S.; SCREEN TO 50' G.S.	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level: 8.34	(SEE LOW FLOW PURGE DATA SHEET)				
One Casing Volume: N.A.					
Start Purge (hrs.): 1340					
End Purge (hrs.): 1415					
Total Purge Time (min.): 35					
Total Amount Purged (~~gal.~~): 21.2 L					
Monitor Reading: 0.0 ppm					
Purge Method: SUB. PUMP.					
Sample Method: SUB. PUMP					
Depth Sampled: ~ 45' G.S.					
Sample Date & Time: 5/28/98 1415	Sample Data				
	pH	S.C.	Temp. (°C)	Color & Turbidity	
Sampled By: VINCE SHICKORA	5.57	134	17.41	CLEAR 1.45 NTU	

Signature(s):

Type of Sample
- ☒ Low Concentration
- ☐ High Concentration
- ☒ Grab
- ☐ Composite
- ☐ Grab - Composite

Observations / Notes:
LOW FLOW PURGE & SAMPLE
AVG RATE ≈ 606 ml/min.

Analysis:	Preservative		Organic	Inorganic
3 x 40 ml VOC	HCl	Traffic Report #	— NA —	
1 x 250 ml Cyanide	NaOH	Tag #	— NA —	
1 x 1 L Metals	HNO_3			
4 x 1L SVOC, PCB, PEST	—	AB #	FED EX 805368187426	
		Date Shipped	5/28/98	
		Time Shipped	1900	
		Lab	QUANTERRA	
		Volume	SEE ANALYSIS	

SAMPLE LOG SHEET

Page 1 of 1

☒ Monitoring Well Data
☐ Domestic Well Data
☒ Other QA/QC

Case #

By R. Good

Project Site Name NASJRB - WILLOW GROVE Project Site Number CTO-277, JOB 5466

NUS Source No. 05MW12SI Source Location SITE 5, MW-11SI

	Purge Data				
Total Well Depth:					
Well Casing Size & Depth:	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level:					
One Casing Volume:					
Start Purge (hrs.):					
End Purge (hrs.):					
Total Purge Time (min.):					
Total Amount Purged (gal.):					
Monitor Reading:					
Purge Method:					
Sample Method:					
Depth Sampled:					
Sample Date & Time: 5/28/98 1415 (1445)	Sample Data				
	pH	S.C.	Temp. (°C)	Color & Turbidity	
Sampled By: VINCE SHICKORA					

Signature(s):

Type of Sample

☒ Low Concentration
☐ High Concentration
☒ Grab
☐ Composite
☐ Grab - Composite

Observations / Notes:

FIELD DUPLICATE OF SAMPLE 05MW11SI .... ALL DATA THE SAME .... USE SAMPLE TIME OF 1445 ON CHAIN-OF-CUSTODY

Analysis:	Preservative		Organic	Inorganic
3 x 40 ml VOC	HCl	Traffic Report #	NA	
1 x 250 ml Cyanide	NaOH	Tag #	NA	
1 x 1L Metals	HNO_3			
4 x 1L SVOC, PCB, Pest	—	AB #	FED EX 8053 6818 7426	
		Date Shipped	~~1400~~ 5/28/98	
		Time Shipped	1400	
		Lab	QUANTERRA	
		Volume	SEE ANALYSIS	

SAMPLE LOG SHEET

Page 1 of 1

☒ Monitoring Well Data
☐ Domestic Well Data
☐ Other _____

Case # _____

By R. Good

Project Site Name NAS JRB - WILLOW GROVE Project Site Number CTO-277, JOB 5466
NUS Source No. OS MW11 I Source Location SITE 5, MW-11 I

	Purge Data				
Total Well Depth: 150' G.S.					
Well Casing Size & Depth: 2" PVC TO 140' G.S.; SCREEN TO 150' G.S.	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level: 24.69 TOIC	(SEE LOW FLOW PURGE DATA SHEET)				
One Casing Volume: N.A.					
Start Purge (hrs.): 1525					
End Purge (hrs.): 1600					
Total Purge Time (min.): 35					
Total Amount Purged ~~(gal.)~~ ~24.7 L					
Monitor Reading: 0.0 ppm					
Purge Method: SUB. PUMP					
Sample Method: SUB. PUMP					
Depth Sampled: ~ 145' G.S.					
Sample Date & Time: 5/28/98	Sample Data				
	pH	S.C.	Temp. (°C)	Color & Turbidity	
Sampled By: VINCE SHICKORA	6.95	419	~14.48	CLEAR 4.73 NTU	

Signature(s):

Type of Sample
☒ Low Concentration
☐ High Concentration
☒ Grab
☐ Composite
☐ Grab - Composite

Observations / Notes:
LOW FLOW PURGE & SAMPLE
AVG RATE ≈ 706 ml/min

Analysis:	Preservative		Organic	Inorganic
3 x 40 ml VOC	HCl	Traffic Report #	NA	
1 x 250 ml Cyanide	NaOH	Tag #	NA	
1 x 1L Metals	HNO_3			
4 x 1L SVOC, PCB, Pest.	—	AB #	FED EX 805368187426	
		Date Shipped	5/28/98	
		Time Shipped	1900	
		Lab	QUANTERRA	
		Volume	SEE ANALYSIS	

SAMPLE LOG SHEET

Page 1 of 1

☒ Monitoring Well Data
☐ Domestic Well Data
☒ Other QA/QC

Case # _____

By R. Good

Project Site Name NASJRB - WILLOW GROVE Project Site Number CTO-277, Job 5466
NUS Source No. 05 RB 05 28 Source Location (SEE BELOW)

	Purge Data				
Total Well Depth: N.A.					
Well Casing Size & Depth: N.A.	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level: N.A.		(N.A.)			
One Casing Volume: N.A.					
Start Purge (hrs.): N.A.					
End Purge (hrs.): N.A.					
Total Purge Time (min.): N.A.					
Total Amount Purged (gal.): N.A.					
Monitor Reading: N.A.					
Purge Method: N.A.					
Sample Method: SEE OBSERVATIONS					
Depth Sampled: N.A.					
Sample Date & Time: 5/28/98 1655	Sample Data				
	pH	S.C.	Temp. (°C)	Color & Turb	
Sampled By: VINCE SHICHORA			N.A.		

Signature(s):

Type of Sample
☒ Low Concentration
☐ High Concentration
☒ Grab
☐ Composite
☐ Grab - Composite

Observations / Notes:
CRITERION SCIENCES, REAGENT GRADE, DEIONIZED WATER THROUGH CLEAN ½" PE PUMP TUBING, YSI FLOW-THROUGH CELL & SONDE PROBES, ½" TEFLON LINED PE DISCHARGE TUBING INTO SAMPLE CONTAINERS.

RINSATE BLANK

Analysis:	Preservative		Organic	Inorganic
3 x 40 ml VOC	HCl	Traffic Report #	NA	
1 x 250 ml Cyanide	NaOH	Tag #	NA	
1 x 1L Metals	HNO_3			
4 x 1L SVOC, PCB, Pest	—	AB #	FED EX 805368187426	
		Date Shipped	5/28/98	
		Time Shipped	1800	
		Lab	QUANTERRA	
		Volume	SEE ANALYSIS	

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: NASJRB WILLOW GROVE
PROJECT NUMBER: CTO-277, JOB NO. 5466

WELL I.D.: 05MW11I
DATE: 5/28/98

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	Temp. (Celcius)	pH (S.U.)	Spec. Cond.	DO (mg/L)	O.R.P. ~~Sal.~~ mV ~~%~~	Turb. (NTU)	Comments
1525	24.93	600	14.97	6.46	384	3.87	146.8	29.8	
1530	24.95	900	14.34	6.69	451	4.63	29.5	>200	
1535	24.96	900	14.41	6.80	434	5.41	27.3	42.8	
1540	24.96	1100	14.49	6.87	425	4.62	24.9	19.9	
1545	25.00	1200	14.08	6.80	420	8.41	31.0	14.12	
1550	24.83	350	14.48	6.77	419	5.07	37.2	9.57	
1555	24.83	300	17.66	6.93	420	1.82	30.6	0	Temp. probe malfunction
1600	24.82	300	18.70	6.95	419	2.12	30.3	4.73	"
		(AVG = 706)							

SIGNATURE(S) [illegible] 5/28/98

PAGE 1 of 1

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: NASJRB- WILLOW GROVE
PROJECT NUMBER: CTO-277 JOB NO. 5466

WELL I.D.: 05MW11S
DATE: 5/28/98

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	Temp. (Celcius)	pH (S.U.)	Spec. Cond.	DO (mg/L)	O.R.P. ~~Sal.~~ mV ~~%~~	Turb. (NTU)	Comments
1212	8.26	450	14.97	5.75	—	6.43	—	25.2	
1217	8.26	450	14.21	5.54	—	5.96	—	—	
1222	8.27	400	17.81	5.53	—	5.68	—	—	Temp. Probe Malfunction
1227	8.27	225	20.22	5.55	137	5.42	—	11.2	
1232	8.27	300	23.82	5.55	135	4.76	159.5	5.65	
1237	8.27	400	23.20	5.57	135	4.85	159.3	3.68	
1242	8.27	275	21.91	5.55	133	4.84	165.0	1.98	
1247	8.27	200	23.85	5.57	133	4.83	167.6	1.54	
1252	8.27	400	21.53	5.56	130	5.26	169.7	1.21	
1257	8.27	400	20.70	5.56	129	4.93	171.9	0.95	
		(AVG = 350)							

SIGNATURE(S) [signature] 5/28/98

PAGE 1 of 1

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: NASJRB - WILLOW GROVE
PROJECT NUMBER: CTO-277, JOB NO. 5466

WELL I.D.: 05MW11SI
DATE: 5/28/98

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	Temp. (Celcius)	pH (S.U.)	Spec. Cond.	DO (mg/L)	O.R.P. ~~Sal.~~ mV ~~%~~	Turb. (NTU)	Comments
1340	8.48	500	14.90	5.50	133	6.67	148.5	0	
1345	8.48	1000	14.89	5.54	133	7.50	141.0	40.4	
1350	8.45	1000	15.01	5.59	133	7.98	188.9	27.2	Pass Temp. Probe Malfunction
1355	8.40	500	16.65	5.57	134	7.63	186.4	11.25	
1400	8.40	450	17.27	5.57	134	7.11	185.1	15.04	
1405	8.40	450	17.13	5.59	134	7.18	184.0	6.08	
1410	8.39	450	17.97	5.58	134	7.17	183.6	2.42	
1415	8.40	500	17.41	5.57	134	7.18	183.1	1.45	
		(AVG = 606)							

SIGNATURE(S) [illegible] 5/28/98

PAGE 1 of 1

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW01S 0900
Sample Location: 05MW01S
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Date: 9/25/00	Visual	Standard	mS/cm	°C	NTU	mg/l	ORP	W.L.
Time: 1045								
Method: whale pump	Clear	5.80	0.220	14.6	0	1.1	157	28.07

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	~~TBD~~ ORP	TBD
Date: 9/25/00								
Method: whale pump	0	5.76	0.272	13.8	0	3.2	88	
Monitor Reading (ppm): 0.0	1	5.78	0.241	13.7	0	0.9	73	29.35
Well Casing Diameter & Material	2	5.80	0.235	14.0	6	1.1	73	28.23
Type: 4" PVC	3	5.81	0.229	14.2	4	1.5	85	28.07
Total Well Depth (TD): 32.00	4	5.80	0.224	14.6	5	1.0	138	
Static Water Level (WL): 23.61	5	5.80	0.220	14.6	0	1.1	157	
One Casing Volume(gal/L): 5.48								
Start Purge (hrs): 0927								
End Purge (hrs): 1037								
Total Purge Time (min): 70								
Total Vol. Purged (gal/L): 31								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

32.00
23.61
8.39
0.653
2517
4195
5034
5.47867

Circle if Applicable:

MS/MSD

Duplicate ID No.: (0000)
05MW86D 0900

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page ___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW01SI 0900
Sample Location: 05MW01
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Date: 9/25/00	Visual	Standard	mS/cm	°C	NTU	mg/l	ORP	
Time: 1605								
Method: Whale Pump	Clear	6.20	0.237	13.1	0	0.6	199	

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD ORP	TBD
Date: 9/25/00								
Method: Whale Pump	0	6.45	0.254	13.3	0	3.2	184	
Monitor Reading (ppm): 23.00	1	6.21	0.236	13.1	0	0.8	200	
Well Casing Diameter & Material	2	6.18	0.236	13.1	0	0.6	183	
Type: 4" PVC	3	6.20	0.237	13.1	0	0.6	199	
Total Well Depth (TD): 85.00								
Static Water Level (WL): 23.81								
One Casing Volume(gal/L): 40								
Start Purge (hrs): ~~1346~~ 1400								
End Purge (hrs): 1603								
Total Purge Time (min): 123								
Total Vol. Purged (gal/L): 120								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

85.00
23.81
61.19
.653
18357
30595
36714
3 495707

Pump set at 80 feet

1630 Purging of the Hydrogen bubbler was begun

1655 Hydrogen sample 05MW01SI was collected by DW from the bubble Stripper

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW01I 0900
Sample Location: 05MW01I
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color Visual	pH Standard	S.C. mS/cm	Temp. °C	Turbidity NTU	DO mg/l	TBD ORP	TBD W.L.
Date: 9/2/00								
Time: 1120								
Method: Rediflow Pump	clear	7.30	0.269	14.4	0	5.2	89	124.30

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/25/00								
Method: Rediflow Pump	0	7.11	0.273	13.2	0	4.6	117	
Monitor Reading (ppm):	1	7.24	0.267	13.8	0	5.2	99	65.73
Well Casing Diameter & Material	2	7.31	0.269	14.1	0	5.3	93	101.75
Type: 2" PVC	3	7.30	0.269	14.4	0	5.2	89	124.30
Total Well Depth (TD): 135.00								
Static Water Level (WL): 24.62								
One Casing Volume(gal/L): 18.00								
Start Purge (hrs): 1015								
End Purge (hrs): 1117								
Total Purge Time (min): 62								
Total Vol. Purged (gal/L): 60								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

135.00
24.62
110.38
x .163
33114
66228
0 38
199194

pump was set at 130 purge rate 1 gpm

1230 Hydrogen Bubbler Hooked up and purging was begun

1255 Hydrogen Sample 05MW01I 0900 was collected

Circle if Applicable:

MS/MSD	Duplicate ID No.:	Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW02S 0900
Sample Location: 05MW02S
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Date: 9/18/00	Visual	Standard	mS/cm	°C	NTU	mg/l		
Time: 1420								
Method: GRUNDFOS SUB.	clear to the eye	5.29	0.106	14.3	24	7.3	249	26.55

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/18/00								
Method: GRUNDFOS SUBMERSIBLE	0	5.48	0.110	14.3	130	10.5	222	26.56
Monitor Reading (ppm): 0.0	1	5.42	0.109	14.4	69	8.0	230	26.55
Well Casing Diameter & Material	2	5.43	0.108	14.4	44	8.3	230	26.55
Type: 4" PVC	3	5.40	0.107	14.4	41	8.2	237	26.55
Total Well Depth (TD): 30.40	4	5.34	0.107	14.3	36	7.3	245	26.55
Static Water Level (WL): 25.71	5	5.29	0.106	14.3	24	7.3	249	26.55
One Casing Volume (gal/L): 3								
Start Purge (hrs): 1400								
End Purge (hrs): 1418								
Total Purge Time (min): 18								
Total Vol. Purged (gal/L): 15								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

30.40
25.71
4.69
.653
1407
2345
2714
2.96257

The pump was set at 28 feet with a flow rate of 1 gpm
No Hydrogen sample was collected due to whale pump problems

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Repurge for Hydrogen Sample

Page___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW02S 0900
Sample Location: 05MW02S
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color Visual	pH Standard	S.C. mS/cm	Temp. °C	Turbidity NTU	DO mg/l	TBD ORP	TBD W. L.
Date: 9/21/00								
Time: 0935								
Method: Whale Pump	clear	5.37	0.109	14.3	10	5.7	292	25.89

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/21/00								
Method: RediFlow pump	0	5.20	0.120	14.2	93	7.5	276	24.96
Monitor Reading (ppm): 0.0	1	5.20	0.108	14.2	40	5.6	300	35.76
Well Casing Diameter & Material	2	5.28	0.108	14.3	14	5.8	297	25.84
Type: 4" PVC	3	5.35	0.108	14.3	13	5.7	293	25.89
Total Well Depth (TD): 30.00	4	5.37	0.109	14.3	10	5.7	292	25.89
Static Water Level (WL): 24.81								
One Casing Volume(gal/L): 3.28								
Start Purge (hrs): 0840								
End Purge (hrs): 0855								
Total Purge Time (min): 15								
Total Vol. Purged (gal/L): 14								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

30.00
24.81
5.19
0.653
1557
2595
14
28907

0410 Hydrogen stripping started

0435 Hydrogen sample 05MW02S 0900 was collected by MW from the stripping bottle

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW03S0900
Sample Location: 05MW03S
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color Visual	pH Standard	S.C. mS/cm	Temp. °C	Turbidity NTU	DO mg/l	TBD ORP	TBD W.L
Date: 9/18/00								
Time: 1655								
Method: Rediflow Pump	Clear	5.31	0.099	17.1	0	9.9	260	25.60

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/18/00								
Method: Rediflow Pump	0	5.54	0.100	16.9	4	10.9	194	25.00
Monitor Reading (ppm): 0.0	1	5.39	0.100	17.0	12	9.8	242	25.52
Well Casing Diameter & Material	2	5.36	0.100	17.0	7	9.8	250	25.58
Type: 2" PVC	3	5.32	0.100	17.0	0	9.9	255	25.58
Total Well Depth (TD): 31.00	4	5.31	0.099	17.1	0	9.9	260	25.60
Static Water Level (WL): 24.96								
One Casing Volume(gal/L): 4.0								
Start Purge (hrs): 1635								
End Purge (hrs): 1653								
Total Purge Time (min): 18								
Total Vol. Purged (gal/L): 16								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

31.00
24.96
6.04
0.653
1812
2020
3624
3.94412

The pump was set at 28 feet with a flow rate of 1gpm

the whale pump broke so no hydrogen sample was collected

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Repurge For Hydrogen

Page___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW03S0900
Sample Location: 05MW03S
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color Visual	pH Standard	S.C. mS/cm	Temp. °C	Turbidity NTU	DO mg/l	TBD ORP	TBD W.L.
Date: 9/21/00								
Time: 1135								
Method: whale Pump	Clear	5.45	0.088	16.8	10	9.1	254	23.40

PURGE DATA:

Date: 9/21/00	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Method: whale Pump	0	5.70	0.087	16.8	13	9.4	237	22.85
Monitor Reading (ppm): 0.0	1	5.44	0.087	16.8	12	9.2	249	23.28
Well Casing Diameter & Material	2	5.45	0.088	16.8	12	9.2	251	23.40
Type: 4" PVC	3	5.45	0.088	16.8	10	9.1	254	
Total Well Depth (TD): 31.00								
Static Water Level (WL): 22.23								
One Casing Volume(gal/L): 5.73								
Start Purge (hrs): 1025								
End Purge (hrs): 1042								
Total Purge Time (min): 17								
Total Vol. Purged (gal/L): 20								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

31.00
22.23
8.77
.653
2631
4385
5262
5.72681

1110 Hydrogen sample 05MW03S was begun through the stripper

1135 Hydrogen sample 05MW03S0900 was collected by MW from the stripper

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW03I 0900
Sample Location: 05MW03I
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color Visual	pH Standard	S.C. mS/cm	Temp. °C	Turbidity NTU	DO mg/l	TBD ORP	TBD W.L
Date: 9/18/00								
Time: 1557								
Method: Rediflow Pump		6.03	0.170	13.9	0	5.0	206	29.05

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/18/00								
Method: Rediflow Pump	0	6.06	0.175	14.1	760	7.3	188	
Monitor Reading (ppm): 0.0	1	6.08	0.174	14.0	75	5.9	172	29.05
Well Casing Diameter & Material	2	6.07	0.165	14.0	26	5.3	181	
Type: 2" PVC	3	6.06	0.170	13.9	6	4.9	192	29.08
Total Well Depth (TD): 128.00	4	6.02	0.169	13.9	5	4.8	204	
Static Water Level (WL): 28.86	5	6.03	0.170	13.9	0	5.0	206	29.08
One Casing Volume(gal/L): 16.16								
Start Purge (hrs): 1505								
End Purge (hrs): 1555								
Total Purge Time (min): 50								
Total Vol. Purged (gal/L): 80								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

128.00
28.86
99.14
.163
29742
59484
9914
1613992

The pump was set at 123 feet with a flow Rate of 1.5 gpm
No hydrogen sample was collected due to whole pump problems

Circle if Applicable:

MS/MSD | Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Repurge For Hydrogen

Page___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW03I 0900
Sample Location: 05MW03I
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Date: 9/21/00	Visual	Standard	mS/cm	°C	NTU	mg/l	ORP	
Time: 1055								
Method: Whale Pump	clear	6.08	0.170	13.9	1	4.1	208	

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/21/00								
Method: Whale	0	7.08	0.175	13.9	220	4.8	257	
Monitor Reading (ppm): 0.0	1	6.11	0.173	14.0	64	4.2	207	
Well Casing Diameter & Material	2	6.10	0.172	14.0	11	4.1	204	
Type: 2" PVC	3	6.08	0.170	13.9	1	4.1	208	
Total Well Depth (TD): 128.00								
Static Water Level (WL): 27.90								
One Casing Volume(gal/L): 168.30								
Start Purge (hrs): 0940								
End Purge (hrs): 1009								
Total Purge Time (min): 29								
Total Vol. Purged (gal/L): 50								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

128.00
27.90
100.10
.163
30030
00060
0010

1030 Hydrogen Stripping was begun

1055 Hydrogen sample 05MW03I0900 was collected by MW from the stripping tube

Circle if Applicable:

MS/MSD	Duplicate ID No.:	Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW04S0900
Sample Location: 05MW04S
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Date: 9/21/00	Visual	Standard	mS/cm	°C	NTU	mg/l	ORP	W.L.
Time: 1315								
Method: Whale Pump	clear	5.23	0.106	13.3	0	8.5	304	

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/21/00								
Method: Whale Pump	0	5.25	0.106	13.5	0	8.4	284	24.04
Monitor Reading (ppm): 0.0	1	5.23	0.105	13.3	19	8.2	287	24.04
Well Casing Diameter & Material	2	5.20	0.105	13.3	6	8.5	300	24.04
Type: 4" PVC	3	5.23	0.106	13.4	0	8.5	301	24.04
Total Well Depth (TD): ~~30.00~~ 32.00	4	5.23	0.106	13.3	0	8.5	304	24.04
Static Water Level (WL): 23.63								
One Casing Volume(gal/L): ~~34.14~~	5.46 gal							
Start Purge (hrs): 1240								
End Purge (hrs): 1314								
Total Purge Time (min): 34								
Total Vol. Purged (gal/L): 27								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

30.00 − 23.63 = 6.37 × 0.653 = 4.11 × 3 = 12.33 × 3 = 37.02 = 5.46 gal

32.00 − 23.63 = 8.37 × 0.653 = 5.11 × 3 = 15.33 × 3 = 45.22 = 8.25 gal

1338 Hydrogen Stripping began
1403 Hydrogen sample 05MW04S0900 was collected by MW from the stripping column

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW04I0900
Sample Location: 05MW04E
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color Visual	pH Standard	S.C. mS/cm	Temp. °C	Turbidity NTU	DO mg/l	TBD ORP	TBD
Date: 9/21/00								
Time: 1225								
Method: Rediflow Pump	Lt Brown	5.95	0.146	12.9	56	6.40	208	

PURGE DATA:

Date: 9/21/00	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Method: Rediflow Pump	0	6.01	0.185	12.9	990	8.20	246	25.49
Monitor Reading (ppm): 0.0	1	6.04	0.182	12.9	440	6.80	215	
Well Casing Diameter & Material	2	6.02	0.172	12.9	190	6.00	204	
Type: 2" PVC	3	5.97	0.161	12.9	97	6.30	203	
Total Well Depth (TD): 85.00	4	5.97	0.154	12.9	47	6.80	207	
Static Water Level (WL): 25.29	5	5.95	0.146	12.9	56	6.40	208	
One Casing Volume(gal/L): 9.67								
Start Purge (hrs): 1150								
End Purge (hrs): 1222								
Total Purge Time (min): 32								
Total Vol. Purged (gal/L): 50								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
RCRA Metals	HNO_3	500 ml Poly	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

251.00
-25.29
125 71
0.163
37713
75226
2571
3.47073

85.00
25.29
5971
0.163
17913
35826
5971

1415 Hydrogen sample stripping was begun

1440 Hydrogen sample 05MW04I0900 was collected by MW from the hydrogen bubbler

Circle if Applicable?

MS/MSD	Duplicate ID No.:	Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page ___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW05S0900
Sample Location: 05MW05S
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

Date: 9/12/00	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Time: 1728	Visual	Standard	mS/cm	°C	NTU	mg/l		W. L.
Method: Whale Pump	clear	5.87	0.854	12.3	7	3.9	220	25.89

PURGE DATA:

Date: 9/12/00	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Method: whale pump	0	5.37	0.109	12.7	47	6.0	264	22.76
Monitor Reading (ppm): 0.0	1	5.77	0.121	12.9	96	4.0	249	24.66
Well Casing Diameter & Material	2	5.62	0.130	12.3	32	3.9	246	26.55
Type: 4" PVC	3	5.69	.134	12.1	22	4.2	249	30.20
Total Well Depth (TD): 40.00	4	5.87	.154	12.3	7	3.9	220	25.89
Static Water Level (WL): 21.00								
One Casing Volume(gal/L): 12.41								
Start Purge (hrs): 1450								
End Purge (hrs): 1720								
Total Purge Time (min): 150								
Total Vol. Purged (gal/L): 48								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

40.00
21.00
19.00
.653
5700
9500
11400
12.40700

The pump was set at 35 feet with a flow rate of 0.33 gallons.

1805 Hydrogen sample purging was begun

1830 Hydrogen sample 05MW05S0900 was collected by MW from the bubble stripping unit.

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

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Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW05I0900
Sample Location: 05MW05I
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Date: 9/22/00	Visual	Standard	mS/cm	°C	NTU	mg/l	ORP	
Time: 0955								
Method: Rediflow Pump	lt brown	8.01	0.371	15.15	130	0.6	144	

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/22/00								
Method: Rediflow Pump	0	7.10	0.455	12.1	2	5.1	129	
Monitor Reading (ppm): 0.0	1	8.05	0.418	13.1	550	0.9	138	
Well Casing Diameter & Material	2	7.96	0.384	14.4	410	0.8	137	
Type: 2" PVC	3	8.01	0.374	15.5	130	0.6	144	
Total Well Depth (TD): 215.00								
Static Water Level (WL): 38.52								
One Casing Volume(gal/L): 29.00								
Start Purge (hrs): 0830								
End Purge (hrs): 0953								
Total Purge Time (min): 83								
Total Vol. Purged (gal/L): 90								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
RCRA Metals	HNO_3	500ml Poly	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1
Dissolved RCRA Metals	HNO_3	250ml Poly	2

OBSERVATIONS / NOTES:

215.00
38.52
176.48
× 163
52944
105888
10648
28.76624

1110 Purging of the hydrogen was begun
1135 Sample 05MW05I was collected for Hydrogen.

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

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Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW06S0900
Sample Location: 05MW06S
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

Date: 9/13/00	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Time: 1510	Visual	Standard	mS/cm	°C	NTU	mg/l	ORP	W.L
Method: Whale Pump	Clear	5.36	0.141	13.4	0	5.9	264	23.16

PURGE DATA:

Date: 9/13/00	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Method: WHALE	0	5.34	0.157	13.5	47	6.7	256	23.08
Monitor Reading (ppm): 0.0	1	5.34	0.148	13.5	0	4.7	262	23.11
Well Casing Diameter & Material	2	5.36	0.143	13.4	0	5.4	263	23.12
Type: 4" PVC	3	5.31	0.141	13.2	0	5.6	268	23.14
Total Well Depth (TD): 37.50	4	5.36	0.141	13.4	0	5.9	264	23.16
Static Water Level (WL): 23.01								
One Casing Volume(gal/L): 8.15								
Start Purge (hrs): 1435								
End Purge (hrs): 1505								
Total Purge Time (min): 30								
Total Vol. Purged (gal/L): 30								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

37.50
23.01
14.49
.563
4341
8694
7245
8157

The pump was set at 32 feet with a flow rate of 1 gpm

1525 Hydrogen stripping was begun into the bubbler

1552 Hydrogen sample 05MW06S0900 was collected by MW but water had mixed with the sample so it wasn't sent.

Circle if Applicable:

MS/MSD

Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

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Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW06I0900
Sample Location: 05MW06I
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color Visual	pH Standard	S.C. mS/cm	Temp. °C	Turbidity NTU	DO mg/l	TBD ORP	TBD W.L.
Date: 9/13/00								
Time: 1418								
Method: Rediflow Pump	Clear	7.55	0.345	15.9	0	8.3	110	78.5

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/13/00								
Method: whale	0	9.86	0.371	13.3	0	10.0	29	22.16
Monitor Reading (ppm): 0.0	1	9.05	0.345	14.2	19	10.5	107	55.90
Well Casing Diameter & Material	2	7.55	0.345	15.9	0	8.3	110	78.5
Type: 4" PVC								
Total Well Depth (TD): 84.00								
Static Water Level (WL): 22.16								
One Casing Volume(gal/L): 40.38								
Start Purge (hrs): 1135								
End Purge (hrs): 1343								
Total Purge Time (min): 133								
Total Vol. Purged (gal/L): 95								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

84.00
22.16
61.84
.653
18552
30920
37104

Pump set at 80 feet
Purging completed after purging the well dry. at 1343.
1412 WL = 60.30 feet sample was collected

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

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Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW07S0900
Sample Location: 05MW07S
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color Visual	pH Standard	S.C. mS/cm	Temp. °C	Turbidity NTU	DO mg/l	TBD ORP	TBD W.L.
Date: 9/14/00								
Time: 1050								
Method: whale pump	clear	5.73	0.260	15.4	0	0.7	233	21.57

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/14/00								
Method: whale Pump	0	5.77	0.273	15.4	22	3.6	255	21.56
Monitor Reading (ppm): 0.0	1	5.76	0.257	15.4	5	0.7	255	21.57
Well Casing Diameter & Material	2	5.76	0.258	15.5	0	0.8	239	21.56
Type: 4" PVC	3	5.78	0.259	15.8	0	0.8	225	21.52
Total Well Depth (TD): 40.00	4	5.74	0.259	15.4	0	0.7	230	21.55
Static Water Level (WL): 21.42	5	5.73	0.260	15.4	0	0.7	233	21.57
One Casing Volume(gal/L): 10.5								
Start Purge (hrs): 0955								
End Purge (hrs): 1048								
Total Purge Time (min): 53								
Total Vol. Purged (gal/L): 53								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

40.00
-21.42
18.58
.563
5.574
11.480
29.00

10.46054 GALLONS/volume

The pump was set at 35 feet with a flow rate of 1gpm

1105 Hydrogen stripping was begun

1130 Hydrogen sample 05MW07S0900 was collected by MW from the hydrogen bubbler.

Circle if Applicable:

MS/MSD

Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

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Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW07I0900
Sample Location: 05MW07I
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

Date: 9/14/00	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Time: 1402	Visual	Standard	mS/cm	°C	NTU	mg/l	ORP	W.L.
Method: Redi flow Pump	Clear	6.84	0.307	14.3	0	5.8	152	24.51

PURGE DATA:

Date: 9/14/00	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Method: Redi flow Pump	0	7.02	0.331	14.6	36	6.0	183	24.00
Monitor Reading (ppm): 0.0	1	6.91	0.308	14.5	0	3.0	134	24.51
Well Casing Diameter & Material	2	6.85	0.305	14.4	0	6.4	142	24.51
Type: 4" PVC	3	6.88	0.305	14.4	0	5.7	149	24.51
Total Well Depth (TD): 84.00	4	6.84	0.307	14.3	0	5.8	152	24.51
Static Water Level (WL): 22.14								
One Casing Volume(gal/L): 40.39								
Start Purge (hrs): 1215								
End Purge (hrs): 1400								
Total Purge Time (min): 105								
Total Vol. Purged (gal/L): 165								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

84.00
22.14
61.86
x 0.653
40.39

The pump was set at 80 feet with a flow rate of 1.5 gpm

1440 Purging for the hydrogen sample was begun into the stripping unit.

1505 Hydrogen sample 05MW07I0900 was collected by MW from the bubbler unit

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW08S 0900
Sample Location: 05MW08S
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Date: 9/15/00	Visual	Standard	mS/cm	°C	NTU	mg/l	ORP	W.L.
Time: 1005								
Method: whale pump	clear	5.74	0.235	14.8	6	0.6	209	22.32

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/15/00								
Method: whale pump	0	6.82	0.499	13.8	91	3.8	167	22.60
Monitor Reading (ppm): 0.0	1	6.31	0.343	13.6	76	3.2	181	23.25
Well Casing Diameter & Material	2	5.92	0.250	14.1	2	2.9	181	22.55
Type: 2" PVC	3	5.79	0.242	14.3	2	1.3	202	22.58
Total Well Depth (TD): 36.00	4	5.78	0.239	14.4	2	0.8	205	22.48
Static Water Level (WL): 21.68	5	5.74	0.235	14.8	6	0.6	209	22.32
One Casing Volume(gal/L): 2.33								
Start Purge (hrs): 0900								
End Purge (hrs): 1003								
Total Purge Time (min): 63								
Total Vol. Purged (gal/L): 12								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

36.00
21.68
14.32
0.163
4296
8592
1432
2.33416

The pump was set at 31 feet with a flow rate of 0.28 gpm

1025 Purging for hydrogen was began into the hydrogen bubbler

1050 sample 05MW08S 0900 was collected by mw from the hydrogen bubbler

Circle if Applicable:

MS/MSD

Duplicate ID No.: 05MW80S 0900
Assigned time 1500

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

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Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW08SI0900
Sample Location: 05MW08SI
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

Date: 9/15/00	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Time: 1250	Visual	Standard	mS/cm	°C	NTU	mg/l	ORP	W.L
Method: whale pump	clear	6.36	0.305	13.2	0	0.7	147	22.48

PURGE DATA:

Date: 9/15/00	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Method: whale pump	0	6.04	0.259	13.4	340	4.6	147	22.40
Monitor Reading (ppm): 0.0	1	6.20	0.286	13.2	120	0.6	104	22.48
Well Casing Diameter & Material	2	6.26	0.293	13.2	12	0.6	130	22.48
Type: 2" PVC	3	6.31	0.297	13.2	5	0.6	140	22.48
Total Well Depth (TD): 65.00	4	6.34	0.303	13.2	4	0.7	142	22.48
Static Water Level (WL): 22.14	5	6.36	0.305	13.2	0	0.7	147	22.48
One Casing Volume(gal/L): 7.00								
Start Purge (hrs): 1210								
End Purge (hrs): 1249								
Total Purge Time (min): 39								
Total Vol. Purged (gal/L): 35								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

65.00
22.14
4286
× .1163
12858
25716
0286
6.98618

The pump was set at 60 feet with a flow Rate of 1 gpm

1328 purging of hydrogen was begun

1335 hydrogen sample 05MW08SI0900 was collected by MW from the hydrogen bubbler

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW08I0900
Sample Location: 05MW08I
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color Visual	pH Standard	S.C. mS/cm	Temp. °C	Turbidity NTU	DO mg/l	TBD ORP	TBD W.L.
Date: 9/15/00								
Time: 0925								
Method: Rediflow Pump		6.84	0.285	13.2	0	3.1	150	22.40

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/15/00								
Method: Rediflow pump	0	6.55	0.313	13.3	90	5.2	232	22.39
Monitor Reading (ppm): 0.0	1	6.83	0.286	13.2	1	3.1	154	22.40
Well Casing Diameter & Material	2	6.84	0.285	13.2	36	3.1	150	22.40
Type: 2" PVC	3	6.79	0.285	13.2	0	3.2	160	
Total Well Depth (TD): 99.00	4	6.84	0.285	13.2	0	3.1	150	
Static Water Level (WL): 22.30						1		
One Casing Volume(gal/L): 12.50								
Start Purge (hrs): 0835								
End Purge (hrs): 0923								
Total Purge Time (min): 48								
Total Vol. Purged (gal/L): 50								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

99.00
-22.30
76.70
x .163
12.50

The pump was set at 95 feet with a flow rate of 1gpm

1125 Hydrogen stripping was begun

1150 Hydrogen sample 05MW08I0900 was collected by MW from the hydrogen bubbler.

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW09S0900
Sample Location: 05MW09S
Sampled By:
C.O.C. No.: –
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Date: 9/26/00	Visual	Standard	mS/cm	°C	NTU	mg/l	ORP	
Time: 1025								
Method: Whale Pump	Lt Gray	5.39	0.174	13.1	30	0.7	228	

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	~~TBD~~ ORP	TBD
Date: 9/26/00								
Method: Whale Pump	0	5.82	0.184	13.1	31	5.4	237	
Monitor Reading (ppm): 0.0	1	5.52	0.176	13.3	33	2.8	252	
Well Casing Diameter & Material	2	5.45	0.171	13.4	44	1.4	244	
Type: 2" PVC	3	5.43	0.171	13.3	110	0.8	233	
Total Well Depth (TD): 34.00	4	5.42	0.173	13.2	26	0.8	229	
Static Water Level (WL): 21.37	5	5.39	0.174	13.1	30	0.7	228	
One Casing Volume(gal/L): 2.06								
Start Purge (hrs): 0955								
End Purge (hrs): 1024								
Total Purge Time (min): 29								
Total Vol. Purged (gal/L): 10								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

34.00
21.37
12.63
0.163
3789
7578
263
203869

Pump installed to
1100 Purging of the hydrogen bubbler was begun
1125 Sample 05MW09S0900 was collected through the bubbler for Hydrogen analysis

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW09SI 0900
Sample Location: 05MW09SI
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color Visual	pH Standard	S.C. mS/cm	Temp. °C	Turbidity NTU	DO mg/l	TBD	TBD
Date: 9/22/00								
Time: 1255								
Method: Whale Pump								

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/22/00								
Method: Whale Pump	0	6.18	0.231	13.3	0	2.1	190	
Monitor Reading (ppm): 0.0	1	6.27	0.263	13.6	1	0.4	172	
Well Casing Diameter & Material	2	6.21	0.263	13.3	0	0.5	174	
Type: 2" PVC	3	6.22	0.262	13.3	3	0.5	182	
Total Well Depth (TD): 74.00								
Static Water Level (WL): 22.15								
One Casing Volume(gal/L): 8.45								
Start Purge (hrs): 1220								
End Purge (hrs): 1250								
Total Purge Time (min): 30								
Total Vol. Purged (gal/L): 30								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

74.00
22.15
5185
163
15555
31110
5185
845155

1340 Hydrogen Stripping was begun

1405 Sample 05MW09SI 0900 from the hydrogen bubbler for hydrogen analysis

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

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Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW09I0900
Sample Location: 05MW09I
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

Date: 9/22/00	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Time: 1320	Visual	Standard	mS/cm	°C	NTU	mg/l	ORP	
Method: Rediflow Pump	clear	6.89	0.292	13.2	0	1.8	129	

PURGE DATA:

Date: 9/22/00	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	ORP ~~TBD~~	TBD
Method: Rediflow Pump	0	7.08	0.326	13.5	260	2.1	27	23.00
Monitor Reading (ppm): 0.0	1	6.95	0.296	13.3	0	2.9	111	
Well Casing Diameter & Material	2	6.70	0.292	13.3	0	1.5	165	
Type: 2" PVC	3	6.85	0.293	13.3	0	1.8	132	
Total Well Depth (TD): 106.00	4	6.88	0.292	13.2	0	1.9	124	
Static Water Level (WL): 22.75	5	6.89	0.292	13.2	0	1.8	129	
One Casing Volume(gal/L): 13.73								
Start Purge (hrs): 1208								
End Purge (hrs): 1315								
Total Purge Time (min): 67								
Total Vol. Purged (gal/L): 70								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

106.00
22.75
8425
.163
25275
50550
8425
3.73275

1440 Hydrogen Stripping was begun

1505 Hydrogen sample 05MW09I0900 was collected from the Hydrogen Bubbler.

Circle if Applicable:

MS/MSD	Duplicate ID No.: 05MW84D0900 Assigned For Hydrogen only time 1900

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW108 0900
Sample Location: 05MW108
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

Date: 9/15/00	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Time: 1430	Visual	Standard	mS/cm	°C	NTU	mg/l	ORP	w.L
Method: Whale Pump	clear	5.47	0.185	14.4	0	0.5	238	23.86

PURGE DATA:

Date: 9/15/00	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Method: Whale Pump	0	5.51	0.193	14.5	310	2.5	252	23.80
Monitor Reading (ppm): 0.0	1	5.43	0.187	14.3	510	0.5	247	23.86
Well Casing Diameter & Material	2	5.48	0.186	14.2	0	0.4	245	23.86
Type: 2" PVC	3	5.50	0.186	14.3	0	0.4	242	23.86
Total Well Depth (TD): 34.00	4	5.47	0.185	14.4	0	0.5	238	23.86
Static Water Level (WL): 23.33								
One Casing Volume(gal/L): 1.74								
Start Purge (hrs): 1400								
End Purge (hrs): 1428								
Total Purge Time (min): 28								
Total Vol. Purged (gal/L): 7								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

34.00
23.33
10.67
x.163
1.74

The pump was set at 28 feet with a flow rate of 0.25 gpm

1440 Purging of the hydrogen sample was begun

1505 Hydrogen sample 05MW108 0900 was collected by MW from the hydrogen bubbler

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

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Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW10SI0900
Sample Location: 05MW10SI
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color Visual	pH Standard	S.C. mS/cm	Temp. °C	Turbidity NTU	DO mg/l	TBD ORP	TBD W.L
Date: 9/18/00								
Time: 1015								
Method: whale pump	clear	6.50	0.313	13.4	0	1.2	126	25.08

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/18/00								
Method: whale pump	0	6.27	0.317	14.1	5	10.9	253	25.03
Monitor Reading (ppm): 0.0	1	6.45	0.314	13.3	3	0.7	209	25.60
Well Casing Diameter & Material	2	6.45	0.313	13.4	1	0.7	182	24.95
Type: 2" PVC	3	6.46	0.313	13.4	9	0.7	159	—
Total Well Depth (TD): 23.77	4	6.48	0.313	13.4	0	1.8	125	25.08
Static Water Level (WL): 44.00	5	6.50	0.313	13.4	0	1.2	126	25.08
One Casing Volume(gal/L): 1.14								
Start Purge (hrs): 0910								
End Purge (hrs): 1014								
Total Purge Time (min): 64								
Total Vol. Purged (gal/L): 56								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

44.00
25.77
70.23
0.163
21069
42138
7023
11.44744

1120 Hydrogen Sample 05MW10SI0900 was collected

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

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Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW10I0900
Sample Location: 05MW10I
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color Visual	pH Standard	S.C. mS/cm	Temp. °C	Turbidity NTU	DO mg/l	TBD ORP	TBD W.L
Date: 9/18/00								
Time: 1035								
Method: whale pump	Clear	7.27	0.288	13.3	0	2.8	102	24.46

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/18/00								
Method: whale pump	0	7.04	0.294	13.3	66	2.8	151	24.35
Monitor Reading (ppm): 0.0	1	7.01	0.287	13.3	18	3.6	130	24.38
Well Casing Diameter & Material	2	7.21	0.287	13.3	0	2.9	64	24.40
Type: 2" PVC	3	7.21	0.286	13.3	0	2.8	94	24.42
Total Well Depth (TD): 126.00	4	7.21	0.287	13.3	0	2.8	99	24.46
Static Water Level (WL): 24.03	5	7.27	0.288	13.3	0	2.8	102	24.46
One Casing Volume(gal/L): 16.72								
Start Purge (hrs): 0940								
End Purge (hrs): 1032								
Total Purge Time (min): 52								
Total Vol. Purged (gal/L): 85								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

126.00
24.03
101.97
x 0.163
30591
61182
10197
16721.11

1155 Hydrogen sample 05MW10I0900 was begun through the bubbler system

1225 Hydrogen sample 05MW10I0900 was collected from the hydrogen gas bubble

Circle if Applicable:

MS/MSD | Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

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Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW11S 0900
Sample Location: 05MW11S
Sampled By: CM & MW
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Date: 9/12/00	Visual	Standard	mS/cm	°C	NTU	mg/l	ORP	W.L.
Time: 0945								
Method: Whale Pump	Clear	5.45	0.198	14.5	1.0	6.4	295	10.91

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/12/00								
Method: Whale Pump	0	5.44	0.218	16.6	70	6.6	2.84	10.91
Monitor Reading (ppm): 0.0	1	5.44	0.202	14.8	50	6.4	290	10.91
Well Casing Diameter & Material	2	5.43	0.200	14.7	29	6.4	293	10.91
Type: 2" PVC	3	5.45	0.199	14.7	12	6.6	295	10.91
Total Well Depth (TD): 28.00	4	5.45	0.198	14.5	1.0	6.4	295	10.91
Static Water Level (WL): 10.91								
One Casing Volume(gal/L): 2.82								
Start Purge (hrs): 0805								
End Purge (hrs): 0818								
Total Purge Time (min): 13								
Total Vol. Purged (gal/L): 12								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

28.00
10.91
17.08
x.163
5.124
19.648
17.08
22.404

Pump set at 25 feet with a flowrate of 1gpm.

1140 Hydrogen purging was begun

1208 Hydrogen sample 05MW11S 0900 was collected by MW from the hydrogen bubbler

Circle if Applicable:

MS/MSD | Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW11SE0900
Sample Location: 05MW11SE
Sampled By: MW/CM
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Date: 9/12/00	Visual	Standard	mS/cm	°C	NTU	mg/l	ORP	W.L
Time: 1325								
Method: Whale Pump	Clear	5.53	0.195	13.4	0	5.6	263	11.19

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/12/00								
Method: Whale Pump	0	5.62	0.200	13.9	45	8.9	250	11.08
Monitor Reading (ppm): 0.0	1	5.58	0.196	14.5	0	5.5	249	11.02
Well Casing Diameter & Material	2	5.56	0.196	13.2	0	5.3	270	11.21
Type: 2" PVC	3	5.57	0.195	13.2	0	5.4	267	11.21
Total Well Depth (TD): 54'	4	5.53	0.195	13.4	0	5.6	263	11.19
Static Water Level (WL): 10.95								
One Casing Volume(gal/L): 7.02								
Start Purge (hrs): 1240								
End Purge (hrs): 1325								
Total Purge Time (min): 45								
Total Vol. Purged (gal/L): 28.5								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

54.00
- 10.95
43.05
× .163
12915
25830
4305
7.01715

The pump was set at 49 feet with a flow rate of 0.5 gpm.

1350 Purging of the hydrogen sample was begun

1415 Hydrogen sample 05MW11SE0900 was collected by MW from the stripping unite

Circle if Applicable:

MS/MSD | Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW11D0900
Sample Location: 05MW11I
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color	pH	S.C.	Temp.	Turbidity	DO	TBD	TBD
Date: 9/13/00								
Time: 0950	Visual	Standard	mS/cm	°C	NTU	mg/l	ORP	W.L.
Method: Rediflow pump	clear	7.66	0.357	13.1	0	0.8	-55	30.21

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/13/00								
Method: Rediflow Pump	0	6.77	0.447	13.0	43	3.0	219	30.03
Monitor Reading (ppm): 0.0	1	7.50	0.361	13.3	0	2.1	9	30.13
Well Casing Diameter & Material	2	7.67	0.357	13.1	0	0.8	-53	30.17
Type: 2" PVC	3	7.67	0.357	13.1	0	0.8	-59	30.20
Total Well Depth (TD): 149.00	4	7.66	0.357	13.1	0	0.8	-55	30.21
Static Water Level (WL): 28.92								
One Casing Volume(gal/L): 19.73								
Start Purge (hrs): 0845								
End Purge (hrs): 0948								
Total Purge Time (min): 63								
Total Vol. Purged (gal/L): 60								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

149.00
28.92
121.08
.163
36324
72648
12108
19.7360 4

The pump was set at 145 feet with a flow rate of 1 gpm

1040 purging of hydrogen into the stripper was begun

1105 Hydrogen sample 05MW11I was collected by MW from the hydrogen bubbler

Circle if Applicable:

MS/MSD | Duplicate ID No.:

Signature(s):

TBD: To Be Determined

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of___

Project Site Name: NASJRB Willow Grove
Project No.: CTO 277

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: 05MW12I0900
Sample Location: 05MW12
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color Visual	pH Standard	S.C. mS/cm	Temp. °C	Turbidity NTU	DO mg/l	TBD ORP	TBD W.L.
Date: 9/21/00								
Time: 1535								
Method: Redflow Pump		5.73	0.142	14.0	120	5.6	229	26.78

PURGE DATA:

	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
Date: 9/21/00								
Method: REDIFLOW PUMP	0	5.91	0.141	14.8	990	5.9	237	26.42
Monitor Reading (ppm): 0.0	1	5.78	0.137	14.3	430	5.4	212	26.55
Well Casing Diameter & Material	2	5.79	0.140	14.2	190	5.1	221	26.78
Type: 2" PVC	3	5.75	0.142	14.0	280	5.2	222	26.78
Total Well Depth (TD): 115.00	4	5.72	0.142	14.0	150	5.4	227	26.78
Static Water Level (WL): 26.39	5	5.73	0.142	14.0	120	5.6	229	26.78
One Casing Volume(gal/L): 14.44								
Start Purge (hrs): 1455								
End Purge (hrs): 1533								
Total Purge Time (min): 38								
Total Vol. Purged (gal/L): 80								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
TCL VOA	HCl	40 ML Glass Vial	3
Ferrous Iron / Alkalinity	4 C	250 ML Poly	1
Chloride, Sulfide, Nitrate, Nitrite	4 C	250 ML Poly	1
TOC	HCl	40 ML Glass Vial	2
Sulfide	NaOH/ Zn Ac	Liter Ploy	1
RCRA metals	HNO3	500 ml poly	1
Gas Fraction			
Nitrogen, Oxygen, Carbon Dioxide	4 C	40 ML Glass Vial	2
Methane, Ethane, Ethene	4 C	40 ML Glass Vial	2
Hydrogen	None	40 ML Glass Vial	1

OBSERVATIONS / NOTES:

115.00
26.39
88.61
0.163
26583
53166
8861
1444343

1620 Hydrogen bubble stripping was begun

1645 Hydrogen sample 05MW12I0900 was collected from the bubbler

Circle if Applicable:

MS/MSD	Duplicate ID No.: 05MW82D0900 with an assigned time of 0930

Signature(s):

TBD: To Be Determined

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Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: NASJRB Willow Grove
Project No.: CTO 277
Location: Willow Grove , PA
Personnel: MW/CM
Weather Conditions:
Measuring Device: Herron Water Level Indicato
Tidally Influenced: Yes ___ No ___
Remarks:

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Total Well Depth (feet)*	Water Level Indicator Readin (feet)*	Thickness of Free Produc (feet)*	Groundwater Elevation (feet)*	Comments
05-MW-01S	9/11/00	1227	364.11	32	24.73			
05-MW-01SI	9/11/00	1225	363.64	84.5	24.87			
05-MW-02S	9/11/00	1254	365.46	30	25.59			
05-MW-03S	9/11/00	1307	367.18	31	24.83			
05-MW-04S	9/11/00	1338	365.62	30	24.56			
05-MW-05S	9/11/00	1427	359.92	40	20.96			
05-MW-06S	9/11/00	1406	362.38	37.5	22.89			
05-MW-06SI	9/11/00	1404	361.08	84	22.46			
05-MW-07S	9/11/00	1415	360.73	26	21.32			
05-MW-07SI	9/11/00	1410	360.2	84	22.03			
05-MW-01SI	9/11/00	1233	363.99	135	25.42			
05-MW-03I	9/11/00	1305	367.35	128	28.77			
05-MW-08S	9/11/00	1401	360.88	36	21.80			
05-MW-08SI	9/11/00	1400	360.92	65	22.15			
05-MW-08I	9/11/00	1358	361.02	99	22.28			
05-MW-09S	9/11/00	1359	361.91	32	22.55			
05-MW-09SI	9/11/00	1353	361.74	74	22.92			
05-MW-09I	9/11/00	1355	362.11	106	23.46			
05-MW-10S	9/11/00	1436	362.54	32	23.30			
05-MW-10SI	9/11/00	1435	362.44	94	23.65			
05-MW-10I	9/11/00	1431	362.46	126	23.91			
05-MW-11S	9/11/00	1453	349.5	28	10.87			
05-MW-11SI	9/11/00	1452	349.51	54	10.92			
05-MW-11I	9/11/00	1450	348.96	150	28.92			
05-MW-04I	9/11/00	1324		150	26.20			

* All measurements to the nearest 0.01 foot

Page ____ of ____

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: NASJRB Willow Grove
Project No.: CTO 277
Location: Willow Grove , PA
Personnel: MW/CM
Weather Conditions:
Measuring Device: Herron Water Level Indicato
Tidally Influenced: Yes ___ No _X_
Remarks:

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Total Well Depth (feet)*	Water Level Indicator Readin (feet)*	Thickness of Free Produc (feet)*	Groundwater Elevation (feet)*	Comments
05-MW-05I	9/11/00	1424		261	38.89			
05-MW-12I	9/11/00	1343		151	27.30			
05-MW01D	9/11/00	1233		137	25.42			
05-MW-03I				130	28.77			

* All measurements to the nearest 0.01 foot

Page ____ of ____

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: NASJRB Willow Grove
Project No.: CTO 277
Location: Willow Grove , PA
Personnel: MW/CM
Weather Conditions:
Measuring Device: Herron Water Level Indicato
Tidally Influenced: Yes ___ No ___
Remarks:

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Total Well Depth (feet)*	Water Level Indicator Readin (feet)*	Thickness of Free Produc (feet)*	Groundwater Elevation (feet)*	Comments
05-MW-01S	9/11/00	1227	364.11	32	24.73		339.38	
05-MW-01SI	9/11/00	1225	363.64	84.5	24.87		338.77	
05-MW-02S	9/11/00	1254	365.46	30	25.59		339.87	
05-MW-03S	9/11/00	1307	367.18	31	24.83		342.35	
05-MW-04S	9/11/00	1338	365.62	30	24.56		341.06	
05-MW-05S	9/11/00	1427	359.92	40	20.96		338.96	
05-MW-06S	9/11/00	1406	362.38	37.5	22.89		339.49	
05-MW-06SI	9/11/00	1404	361.08	84	22.46		338.62	
05-MW-07S	9/11/00	1415	360.73	26	21.32		339.41	
05-MW-07SI	9/11/00	1410	360.2	84	22.03		338.17	
05-MW-01SI	9/11/00	1233	363.99	135	25.42		338.57	
05-MW-03I	9/11/00	1305	367.35	128	28.77		338.58	
05-MW-08S	9/11/00	1401	360.88	36	21.8		339.08	
05-MW-08SI	9/11/00	1400	360.92	65	22.15		338.77	
05-MW-08I	9/11/00	1358	361.02	99	22.28		338.74	
05-MW-09S	9/11/00	1354	361.91	32	22.55		339.36	
05-MW-09SI	9/11/00	1354	361.74	74	22.92		338.82	
05-MW-09I	9/11/00	1355	362.11	106	23.46		338.65	
05-MW-10S	9/11/00	1436	362.54	32	23.3		339.24	
05-MW-10SI	9/11/00	1435	362.44	94	23.65		338.79	
05-MW-10I	9/11/00	1431	362.46	126	23.91		338.55	
05-MW-11S	9/11/00	1453	349.5	28	10.87		338.63	
05-MW-11SI	9/11/00	1452	349.51	54	10.92		338.59	
05-MW-11I	9/11/00	1450	348.96	150	28.92		320.04	
05-MW-04I	9/11/00	1324	364.75	150	26.2		338.55	

* All measurements to the nearest 0.01 foot

Page ____ of ____

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: NASJRB Willow Grove
Project No.: CTO 277
Location: Willow Grove , PA
Personnel: MW/CM
Weather Conditions:
Measuring Device: Herron Water Level Indicato
Tidally Influenced: Yes ___ No _X_
Remarks:

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Total Well Depth (feet)*	Water Level Indicator Readin (feet)*	Thickness of Free Produc (feet)*	Groundwater Elevation (feet)*	Comments
05-MW-05I	9/11/00	1424	358.89	261	38.89		320.00	
05-MW-12I	9/11/00	1342	365.98	151	27.3		338.68	
05-MW-01I	9/11/00	1233	363.99	137	25.42		338.57	
05-MW-03I	9/11/00	1303	367.35	130	28.77		338.58	

* All measurements to the nearest 0.01 foot

Page ____ of ____

APPENDIX E

TEST PIT DOCUMENTATION

For test pit documentation prior to 1997 see Phase II Remedial Investigation Report Appendices (TtNUS, April 1998)

APPENDIX F

SURVEY DATA

For survey data prior to 1997 see Phase II Remedial Investigation Report Appendices (TtNUS, April 1998)

GTS Technologies, Inc.

Date: 7/9/98
File: NAS-WL3.XLS

Willow Grove - Monitoring Wells - Fire Training Area

Well #	Northing	Easting	Top of Steel Casing	Top of PVC Pipe	Top of Concrete
05MW11S	322960.99	2695255.62		349.50	
05MW11SI	322960.87	2695255.71		349.51	
05MW11S & SI	322960.89	2695255.38	349.71		348.33
05MW11I	322947.84	2695243.62	349.29	348.96	347.59

***** 4043-1 *****

DATE: OCT 18, 2000
TIME: 14:06:28

***** Distances, Coordinates and Elevations are in Feet *****

NORTHERN Limit 323,801.885
SOUTHERN Limit 323,380.946
EASTHERN Limit 2,695,537.616
WESTERN Limit 2,695,053.265

TRAV PT #	NORTH COORD	EAST COORD	GROUND ELEV	PT CODE
105	323,722.324	2,695,537.610	363.748	105
106	323,490.274	2,695,465.393	360.288	106
115	323,801.885	2,695,221.241	365.118	115

Instrument @ Pt No 106 106
0 0 1 on Pt No 105 105
Height of Instrument = 4.9 Feet
Ground Elev = 360.288 Feet
Elevation Adjustment Factor = 0 F/F

PT NO	HOR ANG	HOR DIST	VERT ANG	ROD HT	NORTH COORD	EAST COORD	PT ELEV	PT CODE
105	0 0 1	243.035	89 10 42	4.940	323,722.331	2,695,537.612	363.734	bs105
						Closure: .007 Feet Horiz		
						-.014 Feet Vert	(-.000058 F/F)	
1000	232 57 55	323.563	90 23 2	4.900	323,380.946	2,695,160.860	358.120	gs
1001	232 58 0	323.563	90 23 23	4.900	323,380.954	2,695,160.858	358.087	gs
1002	232 58 10	323.417	90 14 47	4.900	323,381.018	2,695,160.989	358.897	mw05MW05I
	Note: INNER							
1003	232 58 15	323.407	90 15 5	4.900	323,381.029	2,695,160.996	358.869	mw05MW05I
1004	233 2 10	323.259	90 7 20	4.900	323,381.425	2,695,161.011	359.598	mw05MW05I
	Note: OUTER							
1005	233 1 40	323.259	90 7 43	4.900	323,381.381	2,695,161.027	359.562	mw05MW05I
1006	359 44 33	113.198	88 52 12	4.900	323,598.509	2,695,498.544	362.521	gs
	Note: 05RC01							
1007	359 44 58	113.198	88 52 40	4.900	323,598.505	2,695,498.557	362.505	gs
**105	0 0 2	243.035	89 10 38	4.940	323,722.331	2,695,537.613	363.738	bs105
						Closure: .008 Feet Horiz		
						-.01 Feet Vert	(-.000041 F/F)	

----- WARNING -----
Points marked with leading *'s are APPROXIMATE and for checking purposes only!!

Instrument @ Pt No 105 105
359 59 59 on Pt No 106 106
Height of Instrument = 4.99 Feet
Ground Elev = 363.748 Feet
Elevation Adjustment Factor = 0 F/F

PT NO	HOR ANG	HOR DIST	VERT ANG	ROD HT	NORTH COORD	EAST COORD	PT ELEV	PT CODE
**106	359 59 59	243.040	90 53 40	4.640	323,490.262	2,695,465.389	360.304	bs106
					Closure: .013 Feet Horiz			
						.016 Feet Vert	(.000066 F/F)	
1008	108 15 10	123.595	89 30 39	4.900	323,794.166	2,695,437.039	364.893	gs
1009	108 15 43	123.546	89 30 48	4.900	323,794.153	2,695,437.091	364.887	gs
1010	108 23 30	123.241	88 59 40	4.900	323,794.203	2,695,437.501	366.001	mw05MW12I
	Note: INNER							
1011	108 23 59	123.241	88 59 48	4.900	323,794.217	2,695,437.511	365.996	mw05MW12I
1012	108 26 11	123.081	91 1 5	0.160	323,794.188	2,695,437.688	366.391	mw05MW12I
	Note: OUTER							
1013	108 26 26	123.081	91 1 10	0.160	323,794.195	2,695,437.693	366.388	mw05MW12I
**106	359 59 53	243.040	90 53 45	4.640	323,490.260	2,695,465.396	360.298	bs106
					Closure: .014 Feet Horiz			
						.01 Feet Vert	(.000041 F/F)	

Instrument @ Pt No 115 115
0 0 0 on Pt No 105 105
Height of Instrument = 4.99 Feet
Ground Elev = 365.118 Feet
Elevation Adjustment Factor = 0 F/F

PT NO	HOR ANG	HOR DIST	VERT ANG	ROD HT	NORTH COORD	EAST COORD	PT ELEV	PT CODE
**105	0 0 0	326.226	90 17 12	4.750	323,722.323	2,695,537.616	363.726	bs105
					Closure: .006 Feet Horiz			
						-.022 Feet Vert	(-.000067 F/F)	
1014	128 53 50	210.282	90 30 34	4.900	323,675.373	2,695,053.273	363.338	gs
1015	128 54 4	210.282	90 30 43	4.900	323,675.385	2,695,053.265	363.329	gs
1016	128 56 14	209.900	90 7 16	4.900	323,675.720	2,695,053.490	364.764	mw05MW04I
	Note: INNER							
1017	128 56 18	209.919	90 7 35	4.900	323,675.712	2,695,053.472	364.745	mw05MW04I
1018	128 56 45	209.740	89 57 59	4.900	323,675.842	2,695,053.599	365.331	mw05MW04I
	Note: OUTER							
1019	128 56 41	209.710	89 58 10	4.900	323,675.856	2,695,053.625	365.320	mw05MW04I
**105	359 59 59	326.226	90 17 12	4.750	323,722.324	2,695,537.616	363.726	bs105
					Closure: .006 Feet Horiz			
						-.022 Feet Vert	(-.000067 F/F)	

----- WARNING -----
Points marked with leading *'s are APPROXIMATE and for checking purposes only!!

CODE	DESCRIPTION
bb	Bottom of Bank
bc	Bottom of Curb
bd	Bottom of Ditch
bh	Bore Hole
[illegible]	Breakline
[illegible]	Baseline
[illegible]	Bench Mark
bs	Back Sight
bt	Buried Tank
bu	Bush/Shrub
bw	Bottom of Wall
cb	Corner of Building
ccnn.n	Center of Circle < Radius = nn.n >
ci	Corner of Inlet
cl	Center Line of Road
cm	Concrete Monument
co	Clean Out
cp	Center of Pipe
cr	Corner
cu	Curb
dc	Depressed Curb
dtXYZ	Deciduous Tree < XYZ = Size & Type >
ec	Edge of Concrete
ed	Edge of Paved Drive
eg	Edge of Gravel
el	Electric Line < Buried >
em	Edge of Macadam
epXYZ	Electric Pole < XYZ = Pole Name & No. > UTILITY CO. POLE ONLY
er	Edge of Road
es	Edge of Stream
et	Edge of Trees
ew	Edge of Walk
fh	Fire Hydrant
fp	Fence Post
gl	Gas Line
gr	Guide Rail
gv	Gas Valve
gs	Ground Shot
gw	Guy Wire
ip	Iron Pin
jb	Junction Box
jt	Joint
ld	Loop Detector
[illegible]	Light/Lamp Post
[illegible]	Mail Box
[illegible]	Manhole
pc	Property Corner
pl	Planter
pm	Parking Meter
ppXYZ	Post/Pole < XYZ = Label >
ps	Paint Stripe < Lane Line >
ptXYZ	Pine Tree < XYZ = Size & Type >
rr	Railroad
rsXYZ	Road Sign < XYZ = Label >
ru	Ruins
sb	Side of Building
sc	Signal Controller
sd	Sounding < Bottom of Stream/Lake/Pond etc. >
sf	Septic Field
sg	Traffic Signal
sh	Edge of Shoulder
spXYZ	Sign Post < XYZ = Label >
ss	Sanitary Sewer
st	Septic Tank
tb	Top of Bank
tc	Top of Curb
td	Top of Ditch
tk	Tank < Above Ground >
tl	Telephone Line < Buried >
tpXYZ	Telephone Pole < XYZ = Pole Name & No. > UTILITY CO. POLE ONLY
tw	Top of Wall
um	Utility Marker
upXYZ	Utility Pole < Private Utility Pole >
vpXYZ	Vent/Filler Pipe < XYZ = Label >
wa	Wall
wlXYZ	Wet Land < XYZ = Label >
wm	Water Meter
wv	Water Valve
ww	Water Well

①

REF # 3419-31

4043

NAS WILLOW GROVE

60° F

CLEAR / CLOUDY

10-11-00

F.C. π
TAK Φ

10-11-00

(2) (3)

	T@106		B: @105			
	H.I. = 4.90					
	Hz		HDIST	VERT	RED	DESC
D	00-00-00		243.03	+3.48	4.94	105 P.K. END
R	—		243.03	+3.48	"	
					4.90	SHOTS 1000 - 1007 ON CARD
	T@105		B.S. @106			
	H.I. = 4.99					
D	00-00-00		243.03	-3.79	4.64	106 P.K. END
R	—		243.04	-3.81	"	
					4.90	SHOTS 1008 - 1019 ON CARD
						*OMIT SHOTS 1008 - 1013
D	86-49-45		326.22	+1.31	4.90	115 ~~105A~~ P.K NAIL SET BETWEEN
R	173-39-31		326.22	+1.28	"	BLUE WELLS (15.5' APART)

86-49-45.5
326.22

WELLS 05MW037 & 05MW035

#115 N 323,801.885
E 2,695,221.241
LEVEL ELEV. 365.118

10-11-00

(4) (5)

115
T @ ~~105~~ A B.S. @ 105
H.I = 4.99

H4		HOIST	VERT	ROD		
D	00-00-00	326.22	-1.63	4.75	105	
R	-	326.22	-1.65	"	"	

SHOTS 1020-1025 ON CARD

10-11-00

⑥	+	↗	−	ELEV				
106	7.55	367.838		360.288	P.K.	FND		
105			4.10	363.738	P.K.	FND		
	5.37	369.108						
05MW12I OUTER			2.74	.37 366.368	MW		EVEN FS./BS.	
05MW12I INNER			3.13	.98 365.978	MW			
115			3.99	365.118	P.K	SET		
	3.81	368.928						
05MW04I OUTER			3.61	.32 365.318	MW			
05MW04I INNER			4.18	364.748 .75	MW			
	4.26	369.008						
⊙			3.89	365.118	115		PEG TEST UNEVEN FS./BS.	
	4.85	369.968						
			6.25	363.718	105			

10-11-00 (9)

(8)

	+	Π	−	<<<v					
106	3.93	364.218		360.288		P.K			
⊙			7.21	357.008					
	5.70	~~362.708~~ (-.01) 362.698							
OSMWOS I INNER			3.81	~~358.888~~ 358.89		MW			
OSMWOS I OUTER			3.10	~~359.598~~ 359.60 ~~359.608~~					
	3.41	363.018							
⊙			6.00	357.018					
	6.89	363.908							
P.O.B.			3.60	360.308 (360.283)		6.02 106	P.O.B.		

GTS Technologies, Inc.
Engineers • Geologists • Environmental Consultants

851 South 19th Street • Harrisburg, PA 17104
Telephone (717) 236-3006 • Fax (717) 233-0994

October 18, 2000

To Whom It May Concern:

The attached file "WL4" contains coordinates and elevations for three monitoring wells and one rock core sample located at the fire training area of the Willow Grove N.A.S.J.R.B. The coordinates are based as The Pennsylvania State Plane Coordinate System South Zone NAD 83. The elevations are based on NAVD 88.

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL LAND
THOMAS WARNER KIMMEL
SURVEYOR
No. 22855-E

Thomas Warner Kimmel
PA. P.L.S. #22855-E

Date: 10/18/2000
File: WL4.xls
GTS # 4043

Willow Grove - Monitoring Wells - Fire Training Area

Well #	Northing	Easting	Top of Steel Casing	Top of PVC Pipe	Top of Ground
05MW04I	323675.60	2695053.43	365.32	364.75	363.3
05MW05I	323381.18	2695160.94	359.60	358.89	358.1
05MW12I	323794.20	2695437.38	366.37	365.98	364.9

Willow Grove - Rock Cores - Fire Training Area

Sample #	Northing	Easting	Top of Ground
05RC01	323598.5	2695498.5	362.5

APPENDIX G

CHAIN-OF-CUSTODY FORMS

For chain-of-custody forms prior to 1997 see Phase II Remedial Investigation Report Appendices (TtNUS, April 1998)

Chain Custody Record

Quanterra

QUA-4124

Client	Project Manager	Date	Chain Of Custody Number
TETRA TECH NUS (BROWN & ROOT ENV.)	RUSS TURNER	5/28/98	30369
Address	**Telephone Number (Area Code)/Fax Number**	**Lab Number**	**Page 1 of 2**
600 CLARK AVE., SUITE 3	(610) 491-9688		
City / State / Zip Code	**Site Contact**		
KING OF PRUSSIA / PA / 19406-1433			
Project Name	**Carrier/Waybill Number**		
NASJRB - WILLOW GROVE, CTO-277			
Contract/Purchase Order/Quote No.			

Sample I.D. No. and Description	Date	Time	Sample Type	Total Volume	Containers Type	Containers No.	Preservative	Condition on Receipt	VOC	CYANIDE	TAL METALS	SVOC, PCB, PEST
05MW11S	5/28/98	1300	AQ	3 x 40 mL	40 mL	3	HCl		X			
"		"		1 x 250 mL	250 mL	1	NaOH			X		
"		"		1 x 1 L	1 L	1	HNO_3				X	
"		"		4 x 1 L	1 L	4	—					X
05MW11SI		1415		3 x 40 mL	40 mL	3	HCl		X			
"		"		1 x 250 mL	250 mL	1	NaOH			X		
"		"		1 x 1 L	1 L	1	HNO_3				X	
"		"		4 x 1 L	1 L	4	—					X
05MW12SI		1445		3 x 40 mL	40 mL	3	HCl		X			
"		"		1 x 250 mL	250 mL	1	NaOH			X		
"		"		1 x 1 L	1 L	1	HNO_3				X	
"		"		4 x 1 L	1 L	4	—					X
05MW11SI		1600		3 x 40 mL	40 mL	3	HCl		X			
"		"		1 x 250 mL	250 mL	1	NaOH			X		
"		"		1 x 1 L	1 L	1	HNO_3				X	
"		"		4 x 1 L	1 L	4	—					X

Special Instructions

Possible Hazard Identification: ☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal: ☐ Return To Client ☒ Disposal By Lab ☐ Archive For _____ Months

Turn Around Time Required: ☐ Normal ☐ Rush

QC Level: ☐ I. ☐ II. ☐ III.

Project Specific (Specify)

	Date	Time		Date	Time
1. Relinquished By	5/28/98	1900	1. Received By		
2. Relinquished By			2. Received By		
3. Relinquished By			3. Received By		

Comments

SHIPPED VIA FEDERAL EXPRESS AIRBILL NO. 805368187426

DISTRIBUTION: WHITE - Stays with Sample; CANARY - Returned to Client with Report; PINK - Field Copy

Chain Custody Record

Quanterra

QUA-4124

Client	Project Manager	Date	Chain Of Custody Number
TETRA TECH NUS (BROWN & ROOT ENV.)	RUSS TURNER	5/28/98	30368
Address	**Telephone Number (Area Code)/Fax Number**	**Lab Number**	**Page 2 of 2**
600 CLARK AVE, SUITE 3	(610) 491-9688		

City	State	Zip Code	Site Contact
KING OF PRUSSIA	PA	19406-1433	

Project Name: NASJRB - WILLOW GROVE, C70-277

Carrier/Waybill Number:

Contract/Purchase Order/Quote No.:

Sample I.D. No. and Description	Date	Time	Sample Type	Total Volume	Containers Type	Containers No.	Preservative	Condition on Receipt	VOC	CYANIDE	TAL METALS	SVOC, PCB, BEST
OERB0528	5/28/98	1655	AQ	3x40 mL	40 mL	3	HCl		X			
"	↓	"	↓	1x250 mL	250 mL	1	NaOH			X		
"		"		1x1L	1L	1	HNO_3				X	
"		"		4x1L	1L	4	—					X
OSTB0528	↓	1705	↓	2x40mL	40 mL	2	HCl		X			

Special Instructions:

Possible Hazard Identification: ☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal: ☐ Return To Client ☒ Disposal By Lab ☐ Archive For _____ Months

Turn Around Time Required: ☐ Normal ☐ Rush

QC Level: ☐ I. ☐ II. ☐ III.

Project Specific (Specify):

	Date	Time		Date	Time
1. Relinquished By: [signature]	5/28/98	1600	1. Received By		
2. Relinquished By			2. Received By		
3. Relinquished By			3. Received By		

Comments: SHIPPED VIA FEDERAL EXPRESS AIRBILL NO. 805368187426

DISTRIBUTION: WHITE - Stays with Sample; CANARY - Returned to Client with Report; PINK - Field Copy

CHAIN OF CUSTODY RECORD

PROJECT NO.:	SITE NAME:
CT-277	[illegible] Willow Grove

SAMPLERS (SIGNATURE): [illegible]

STATION NO.	DATE	TIME	COMP	GRAB	STATION LOCATION	NO. OF CONTAINERS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	REMARKS
	9/6/00	1100		✓	[illegible]	4	2	1	1				

RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
[illegible]	[illegible]				
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED FOR LABORATORY BY (SIGNATURE):	DATE / TIME:	REMARKS: [illegible]	

(0498)

[redacted]

Chain of Custody Record

SEVERN TRENT SERVICES

Severn Trent Laboratories, Inc.

STL-4124 (0700)

Client	Project Manager	Date	Chain of Custody Number
Tetra Tech NUS	Russ Turner	9/26/00	002634
Address	**Telephone Number (Area Code)/Fax Number**	**Lab Number**	**Page 1 of 1**
600 Clark Ave Suite 3	610 491 8688 491 9645		

City	State	Zip Code	Site Contact	Lab Contact
King of Prussia	PA	19406	Chuck Mayer	

Project Name and Location (State)	Carrier/Waybill Number
NAS JRB Willow Grove	8196 6647 2798

Contract/Purchase Order/Quote No: CTO 272 5466

Analysis (Attach list if more space is needed)

Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Air	Aqueous	Sed.	Soil		Unpres.	H2SO4	HNOS	HCl	NaOH	ZnAc/NaOH		VOA Vial HCl	Poly Short 2 Pkg		Special Instructions/ Conditions of Receipt
TB-092500	9/25/00	0700		✓							✓				2			Trip Blank provided by Lab
05MW01S0900	9/25/00	1045		✓							✓		✓		9	3		Do MS/MSD
05MW01I0900	9/25/00	1120		✓							✓		✓		3	1		
05MW01SI0900	9/25/00	1605		✓							✓		✓		3	1		
05MW86D0900	9/25/00	2000		✓							✓		✓		3	1		
05MW09S0900	9/26/00	1025		✓							✓		✓		3	1		

Possible Hazard Identification: ☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☒ Unknown

Sample Disposal: ☐ Return To Client ☒ Disposal By Lab ☐ Archive For _____ Months (A fee may be assessed if samples are retained longer than 3 months)

Turn Around Time Required: ☐ 24 Hours ☐ 48 Hours ☐ 7 Days ☐ 14 Days ☒ 21 Days ☐ Other_____

QC Requirements (Specify)

	Date	Time		Date	Time
1. Relinquished By: Chuck Mayer	9/26/00	1700	1. Received By		
2. Relinquished By			2. Received By		
3. Relinquished By			3. Received By		

Comments

DISTRIBUTION: WHITE - Stays with the Sample; CANARY - Returned to Client with Report; PINK - Field C

CHAIN-OF-CUSTODY RECORD

VAPORTECH Services, Inc.

1158 Pittsburgh Road • Suite 201 • Valencia, PA 16059
Tel: 724-898-2622 • Fax: 724-898-2633

Company Name: Tetra Tech NUS
Address: 600 Clark Ave Suite 3
City: King of Prussia **State:** PA **Zip:** 19406
Proj. Manager: Russ Turner
Proj. Location: NAS JRB Willow Grove
Proj. Number: CTO 277 5466
Phone #: 610 491 9688 **Fax #:** 610 491 9645

Sampler's signature : Charles Mizzen

Analysis Options: Enter letters in Requested Analysis columns below.

A	Light Hydrocarbons	F	BTEX
B	Permanent Gases Oxygen Carbon Dioxide Nitrogen	G	BTEX & C5 - C10
C	Methane	H	TPH (C4 -C12 range)
D	Methane, Ethane, Ethylene	I	Chlorinated Hydrocarbons
E	Hydrogen	J	624 Compound List

Light Hydrocarbons: Methane, Ethane, Ethylene, Propane, Propylene, iso-Butane, n-Butane
Permanent Gases: Carbon Dioxide, Oxygen, Nitrogen, Methane, Carbon Monoxide
BTEX: Benzene, Toluene, Ethyl Benzene, m & p -Xylene, o-Xylene
C5-C10: Pentane, Hexane, Heptane, Octane, Nonane, Decane
Chlorinated HC: 1,1-DCE, 1,1- DCA, Methylene Chloride, trans-1,2-DCE, cis-1,2-DCE, Chloroform 1,1,1-TCA, Carbon Tetrachloride, Trichloroethylene (TCE), Tetrachloroethylene (PCE)

Collection Date	Collection Time	Number of Containers	Sample Type	Sample Identification	Requested Analysis				(Other)	Remarks
9/25/00	1045	2	GW	05MW01S 0900	B	D				
9/25/00	1205	1	Gas	05MW01S 0900	E					
9/25/00	1120	2	GW	05MW01I 0900	B	D				
9/25/00	1255	1	Gas	05MW01I 0900	E					
9/25/00	1605	2	GW	05MW01SI 0900	B	D				
9/25/00	1655	1	Gas	05MW01SI 0900	E					
9/25/00	0000	2	GW	05MW86D 0900	B	D				
9/25/00	0000	1	Gas	05MW86D 0900	E					
9/26/00	1025	2	GW	05MW09S 0900	B	D				
9/26/00	1125	1	Gas	05MW09S 0900	E					

Results to :

Invoice to :

Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :
Charles Mizzen	Tetra Tech NUS	9/26/00	1700				
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :

WHITE COPY : Laboratory to return. YELLOW COPY : Laboratory PINK COPY : Submitter

Shipped via Federal Express Airbill No 8146 6647 2813

STL North Canton

CHAIN OF CUSTODY RECORD

601 Clark Ave Suite 5
King of Prussia PA 19406
610 491 9298 610 491 9645

Project Manager Russ Ivanc

PROJECT NO.:	SITE NAME:
CTS 277 S100	HASSRB Willow Grove

SAMPLERS (SIGNATURE):

STATION NO.	DATE	TIME	COMP	GRAB	STATION LOCATION	NO. OF CONTAINERS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	REMARKS
	9/25/96	1045		✓	05MW01S0900		6	2	2				RO MS/MSD limited volume for Alk, Cl, Sul, Nit, Nitrite, Ammonia
	[illegible]	1120		✓	05MW01I0900		2	1	1				
	[illegible]	1605		✓	05MW01S0900		2	1	1				
	[illegible]	2000		✓	05MW86D0900		2	1	1				

RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
	[illegible]				
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED FOR LABORATORY BY (SIGNATURE):	DATE / TIME:	REMARKS: Shipped via Federal Express Airbill No 9196 6647 2776	

(0498)

STL North Canton

Project Manager Russ Turner

CHAIN OF CUSTODY RECORD

PROJECT NO.: [illegible]

SITE NAME: [illegible]

SAMPLERS (SIGNATURE): [illegible]

STATION NO.	DATE	TIME	COMP	GRAB	STATION LOCATION	NO. OF CONTAINERS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	REMARKS
	[illegible]	[illegible]		✓	05MW05I 0400	4	1	1	2				
	[illegible]	[illegible]		✓	05MW98I 0400	4	1	1	2				
	[illegible]	[illegible]		✓	05MW04I 0400	11	1	1	2				
	[illegible]	[illegible]		✓	RS-072200	4	1	1	2				

RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
[illegible]	[illegible] 1930				
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED FOR LABORATORY BY (SIGNATURE):	DATE / TIME:	REMARKS: Shipped via Federal Express Airbill No. 8196 66 [illegible] 2754	

(0498)

CHAIN OF CUSTODY RECORD

PROJECT NO.:	SITE NAME:
CTO 277 5466	NASJRB [illegible]

SAMPLERS (SIGNATURE): [illegible]

STATION NO.	DATE	TIME	COMP	GRAB	STATION LOCATION	NO. OF CONTAINERS	[illegible]	TCL VOCs	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	REMARKS
	9/24/00	0900		✓	TB-092000	[illegible]	2							
	9/24/00	1225		✓	05MW04I0900	5	3	1	1					
	9/24/00	1215		✓	05MW04S0900	4	[illegible]	1						
	9/24/00	1235		✓	05MW12I0900	5	3	1	1					
	9/24/00	1750		✓	RB-092100	6	3	1		2				
	9/22/00	0955		✓	05MW05I0900	7	3	1	1		2	[illegible] 9/22/00		
	9/22/00	1255		✓	05MW09SI0900	4	[illegible]	1						
	9/22/00	1120		✓	05MW[illegible]I0900	4		1						
	9/22/00	1455		✓	RB-092200	4	[illegible]	1						
	9/22/00	0930			05MW22D0900	5	3	1	1					
	9/22/00	0955		✓	05MW05I0900F	2					2			

RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
[illegible]	9/24/00 1930				
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED FOR LABORATORY BY (SIGNATURE):	DATE / TIME:	REMARKS: Shipped via [illegible] Express Airbill No. 4196 4047 2743	

(0498)

CHAIN-OF-CUSTODY RECORD

VAPORTECH Services, Inc.

1158 Pittsburgh Road • Suite 201 • Valencia, PA 16059
Tel: 724-898-2622 • Fax: 724-898-2633

Company Name: Tetra Tech NUS
Address: 600 Clark Ave Suite 3
City: King of Prussia **State:** PA **Zip:** 19406
Proj. Manager: Russ Turner
Proj. Location: NAS JRB Willow Grove
Proj. Number: CTU 222 5466
Phone #: 610 491 9688 **Fax #:** 610 491 9645

Sampler's signature : [signature]

Analysis Options: Enter letters in Requested Analysis columns below.

A	Light Hydrocarbons	F	BTEX
B	Permanent Gases ox, nitrogen, carbon dioxide	G	BTEX & C5 - C10
C	Methane	H	TPH (C4 -C12 range)
D	Methane, Ethane, Ethylene	I	Chlorinated Hydrocarbons
E	Hydrogen	J	624 Compound List

Light Hydrocarbons: Methane, Ethane, Ethylene, Propane, Propylene, iso-Butane, n-Butane
Permanent Gases: Carbon Dioxide, Oxygen, Nitrogen, Methane, Carbon Monoxide
BTEX: Benzene, Toluene, Ethyl Benzene, m & p -Xylene, o-Xylene
C5-C10: Pentane, Hexane, Heptane, Octane, Nonane, Decane
Chlorinated HC: 1,1-DCE, 1,1- DCA, Methylene Chloride, trans-1,2-DCE, cis-1,2-DCE, Chloroform 1,1,1-TCA, Carbon Tetrachloride, Trichloroethylene (TCE), Tetrachloroethylene (PCE)

Collection Date	Collection Time	Number of Containers	Sample Type	Sample Identification	Requested Analysis				(Other)	Remarks
9/21/00	0935	1	Gas	05MW02S 0900	E					
9/21/00	1055	1	Gas	05MW03I 0900	E					
9/21/00	1135	1	Gas	05MW03S 0900	E					
9/21/00	1225	2	Aq	05MW04I 0900	B	D				
9/21/00	1440	1	Gas	05MW04I 0900	E					
9/21/00	1315	2	Aq	05MW04S 0900	B	D				
9/21/00	1403	1	Gas	05MW04S 0900	E					
9/21/00	1340	1	Gas	Ambient Air	E					
9/21/00	1535	2	Aq	05MW12I 0900	B	D				
9/21/00	1645	1	Gas	05MW12I 0900	E					
9/21/00	0930	2	Aq	05MW82D 0900	B	D				
9/22/00	0955	2	Aq	05MW05I 0900	B	D				

Results to :

Invoice to :

Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :
[signature]	TetraTech NUS	9/22/00	1430				
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :

WHITE COPY : Laboratory to return. YELLOW COPY : Laboratory PINK COPY : Submitter

Shipped via Federal Express AirBill 8146647 2965

CHAIN-OF-CUSTODY RECORD

VAPORTECH Services, Inc.

1158 Pittsburgh Road • Suite 201 • Valencia, PA 16059
Tel: 724-898-2622 • Fax: 724-898-2633

Company Name: Tetra Tech NUS
Address: 600 Clark Ave Suite 3
City: King of Prussia **State:** PA **Zip:** 19406
Proj. Manager: Russ Iwacc
Proj. Location: NASJRB Willow Grove
Proj. Number: 610 277 5466
Phone #: 610 491 9688 **Fax #:** 491 9645

Sampler's signature: [signature]

Analysis Options: Enter letters in Requested Analysis columns below.

A	Light Hydrocarbons	F	BTEX
B	Permanent Gases Oxygen Carbon Dioxide Nitrogen	G	BTEX & C5 - C10
C	Methane	H	TPH (C4 -C12 range)
D	Methane, Ethane, Ethylene	I	Chlorinated Hydrocarbons
E	Hydrogen	J	624 Compound List

Light Hydrocarbons: Methane, Ethane, Ethylene, Propane, Propylene, iso-Butane, n-Butane
Permanent Gases: Carbon Dioxide, Oxygen, Nitrogen, Methane, Carbon Monoxide
BTEX: Benzene, Toluene, Ethyl Benzene, m & p -Xylene, o-Xylene
C5-C10: Pentane, Hexane, Heptane, Octane, Nonane, Decane
Chlorinated HC: 1,1-DCE, 1,1- DCA, Methylene Chloride, trans-1,2-DCE, cis-1,2-DCE, Chloroform 1,1,1-TCA, Carbon Tetrachloride, Trichloroethylene (TCE), Tetrachloroethylene (PCE)

Collection Date	Time	Number of Containers	Sample Type	Sample Identification	Requested Analysis				(Other)	Remarks
9/22/00	1135	1	GAS	05MW05I 0700	E					
9/22/00	1255	2	AQ	05MW09SI 0900	B	D				
9/22/00	1405	1	GAS	05MW09SI 0900	E					
9/22/00	1505	1	GAS	05MW09I 0900	E					
9/22/00	1320	2	AQ	05MW09I 0900	B	D				
9/22/00	1700	1	GAS	05MW84D 0900	E					

Results to:

Invoice to:

Relinquished by:	Company:	Date:	Time:	Received by:	Company:	Date:	Time:
[signature]	Tetra Tech NUS	9/22/00	1930				
Relinquished by:	Company:	Date:	Time:	Received by:	Company:	Date:	Time:
Relinquished by:	Company:	Date:	Time:	Received by:	Company:	Date:	Time:

WHITE COPY : Laboratory to return. YELLOW COPY : Laboratory PINK COPY : Submitter

Shipped via Federal Express Airbill No 8796 66[illegible] 745

CHAIN OF CUSTODY RECORD

PROJECT NO.:	SITE NAME:
CTO 771 5460	NASJRB Willow Grove

SAMPLERS (SIGNATURE):

STATION NO.	DATE	TIME	COMP	GRAB	STATION LOCATION	NO. OF CONTAINERS	40 ml Vial HCl	TOC 250 ml Poly Amber	[illegible]				REMARKS
	9/24/00	1535		✓	05MW041 0600	4		1	1				
	9/24/00	1515		✓	05MW045 0600	4		1	1				
	9/24/00	1535		✓	05MW151 0600	4	2	1	1				
	9/24/00	0900		✓	05MW020 0600	4	2	1	1				
	9/21/00	1750		✓	EC 092100	4	2	1	1				

RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
	9/24/00 1530				
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED FOR LABORATORY BY (SIGNATURE):	DATE / TIME:	REMARKS: Shipped via Federal Express Airbill No. [illegible]	

(0498)

6

Chain of Custody Record

SEVERN TRENT SERVICES **Severn Trent Laboratories, Inc.**

STL-4124 (0700)

Client	Project Manager	Date	Chain of Custody Number
Tetra Tech NUS	Russ Turner	9/18/00	002637
Address	**Telephone Number (Area Code)/Fax Number**	**Lab Number**	
600 Clark Ave Suite 3	610 491 9658 610 491 9645		Page 1 of 1

City	State	Zip Code	Site Contact	Lab Contact
King of Prussia	PA	19406	Chuck Pirri	Ken Kozior

Project Name and Location (State)	Carrier/Waybill Number
NDSTAR Willow Grove	FedEx Airbill No 8196 6647 2700

Contract/Purchase Order/Quote No.: STO 227 5466

Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Matrix: Air	Aqueous	Sed.	Soil		Containers & Preservatives: Unpres.	H2SO4	HNO3	HCl	NaOH	ZnAc/NaOH		Analysis (Attach list if more space is needed): Nitric Acid HCl	Sulfuric Acid	Nitric Acid	Sulfuric Acid	Ferrous Iron								Special Instructions/ Conditions of Receipt
05MW01S 0900	9/18/00	1015		✓				✓			✓				2	1		1									
05MW01I 0900	9/18/00	1035		✓				✓			✓				2	1		1									
05MW02S 0900	9/18/00	1420		✓				✓			✓				2	1		1									
05MW03I 0900	9/18/00	1557		✓				✓			✓				2	1		1									
05MW03S 0900	9/18/00	1655		✓				✓			✓				2	1		1									
~~DUP 0918~~	~~9/18/00~~			✓				✓			✓																

Possible Hazard Identification: ☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☒ Unknown

Sample Disposal: ☐ Return To Client ☒ Disposal By Lab ☐ Archive For _____ Months (A fee may be assessed if samples are retained longer than 3 months)

Turn Around Time Required: ☐ 24 Hours ☐ 48 Hours ☐ 7 Days ☐ 14 Days ☒ 21 Days ☐ Other _____

QC Requirements (Specify):

Relinquished By	Date	Time	Received By	Date	Time
1. [signature]	9/18/00	1900	1.		
2.			2.		
3.			3.		

Comments:

DISTRIBUTION: WHITE - Stays with the Sample; CANARY - Returned to Client with Report; PINK - Field Co

CHAIN OF CUSTODY RECORD

PROJECT NO.:	SITE NAME:
CTO 277 [illegible]	NAS SIGB [illegible]

SAMPLERS (SIGNATURE): [illegible]

STATION NO.	DATE	TIME	COMP	GRAB	STATION LOCATION	NO. OF CON-TAINERS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	REMARKS
	9/19/00	1630		✓	TB-091900		2						
	9/19/00	1045		✓	05MW10SL0900			1					
	9/19/00	1035		✓	05MW10I0900	4		1					
	9/19/00	1420		✓	05MW02S0900	4		1					
	9/19/00	1557		✓	05MW03L0900	4		1					
	9/19/00	1155		✓	05MW03S0900	4		1					

RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
[illegible]	9/19/00 1[illegible]				
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED FOR LABORATORY BY (SIGNATURE):	DATE / TIME:	REMARKS: [illegible]	
				[illegible]	

(0498)

CHAIN-OF-CUSTODY RECORD

VAPORTECH Services, Inc.
1158 Pittsburgh Road • Suite 201 • Valencia, PA 16059
Tel: 724-898-2622 • Fax: 724-898-2633

Company Name: Tetra Tech NUS
Address: 600 Clark Ave Suite 3
City: King of Prussia **State:** PA **Zip:** 19406
Proj. Manager: Russ Turner
Proj. Location: NAS JRB Willow Grove
Proj. Number: 610 277 5466
Phone #: 610 491 9658 **Fax #:** 610 491 9645

Sampler's signature : [signature]

Analysis Options: Enter letters in Requested Analysis columns below.

A	Light Hydrocarbons	F	BTEX
B	Permanent Gases Oxygen Carbon Dioxide Nitrogen	G	BTEX & C5 - C10
C	Methane	H	TPH (C4 -C12 range)
D	Methane, Ethane, Ethylene	I	Chlorinated Hydrocarbons
E	Hydrogen	J	624 Compound List

Light Hydrocarbons: Methane, Ethane, Ethylene, Propane, Propylene, iso-Butane, n-Butane
Permanent Gases: Carbon Dioxide, Oxygen, Nitrogen, Methane, Carbon Monoxide
BTEX: Benzene, Toluene, Ethyl Benzene, m & p -Xylene, o-Xylene
C5-C10: Pentane, Hexane, Heptane, Octane, Nonane, Decane
Chlorinated HC: 1,1-DCE, 1,1- DCA, Methylene Chloride, trans-1,2-DCE, cis-1,2-DCE, Chloroform 1,1,1-TCA, Carbon Tetrachloride, Trichloroethylene (TCE), Tetrachloroethylene (PCE)

Collection Date	Collection Time	Number of Containers	Sample Type	Sample Identification	Requested Analysis (Others)					Remarks
9/18/00	1015	2	GW	05MW10SE 0900	B	D				
9/18/00	1120	1	Gas	05MW10SL 0900	E					
9/18/00	1035	2	GW	05MW10E 0900	B	D				
9/18/00	1225	1	Gas	05MW10L 0900	E					
9/18/00	1420	2	GW	05MW02S 0900	B	D				
9/18/00	1557	2	GW	05MW03E 0900	B	D				
9/18/00	1655	2	GW	05MW03S 0900	B	D				

Results to :

Invoice to :

Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :
[signature]	Tetra Tech NUS	9/19/00	1700				
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :

WHITE COPY : Laboratory to return. YELLOW COPY : Laboratory PINK COPY : Submitter

Shipped via FedEx Airbill No 6196 6647 2721

CHAIN-OF-CUSTODY RECORD

VAPORTECH Services, Inc.

1158 Pittsburgh Road • Suite 201 • Valencia, PA 16059
Tel: 724-898-2622 • Fax: 724-898-2633

Company Name: Tetra Tech NUS
Address: 600 Clark Ave Suite 3
City: King of Prussia **State:** PA **Zip:** 19406
Proj. Manager: Russ Turner
Proj. Location: NAS JRB Willow Grove
Proj. Number: CTO 277 5466
Phone #: 610 491 9688 **Fax #:** 610 491 9645

Sampler's signature :

Analysis Options: Enter letters in Requested Analysis columns below.

A	Light Hydrocarbons	F	BTEX
B	Permanent Gases O_2 CO_2 nitrogen	G	BTEX & C5 - C10
C	Methane	H	TPH (C4 -C12 range)
D	Methane, Ethane, Ethylene	I	Chlorinated Hydrocarbons
E	Hydrogen	J	624 Compound List

Light Hydrocarbons: Methane, Ethane, Ethylene, Propane, Propylene, iso-Butane, n-Butane
Permanent Gases: Carbon Dioxide, Oxygen, Nitrogen, Methane, Carbon Monoxide
BTEX: Benzene, Toluene, Ethyl Benzene, m & p -Xylene, o-Xylene
C5-C10: Pentane, Hexane, Heptane, Octane, Nonane, Decane
Chlorinated HC: 1,1-DCE, 1,1- DCA, Methylene Chloride, trans-1,2-DCE, cis-1,2-DCE, Chloroform 1,1,1-TCA, Carbon Tetrachloride, Trichloroethylene (TCE), Tetrachloroethylene (PCE)

Collection Date	Collection Time	Number of Containers	Sample Type	Sample Identification	Requested Analysis				(Other)	Remarks
9/14/00	0820	1	Gas	05MW06S 0900	E					
9/14/00	0970	1	Gas	05MW06I 0900	E					
9/14/00	1050	2	GW	05MW07S 0900	B	D				
9/14/00	1150	1	Gas	05MW07S 0900		E				
9/14/00	1401	2	GW	05MW07I 0900	B	D				
9/14/00	1505	1	Gas	05MW07I 0900		E				
9/15/00	0925	2	GW	05MW08I 0900	B	D				
9/15/00	1150	1	Gas	05MW08I 0900		E				
9/15/00	1005	2	GW	05MW08S 0900	B	D				
9/15/00	1050	1	Gas	05MW08S 0900		E				
9/15/00	1250	2	GW	05MW08SI 0900	B	D				
9/15/00	1335	1	Gas	05MW08SI 0900		E				

Results to :

Invoice to :

Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :
	Tetra Tech NUS	9/15/00	1800				
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :

WHITE COPY : Laboratory to return. **YELLOW COPY : Laboratory** **PINK COPY : Submitter**

Shipped via Federal Express Airbill No 8196 6647 662

CHAIN-OF-CUSTODY RECORD

VAPORTECH Services, Inc.

1158 Pittsburgh Road • Suite 201 • Valencia, PA 16059
Tel: 724-898-2622 • Fax: 724-898-2633

Company Name: Tetra Tech NUS
Address: 600 Clark Ave, Suite 3
City: King of Prussia **State:** PA **Zip:** 19406
Proj. Manager: Russ Turner
Proj. Location: NAS JRB Willow Grove
Proj. Number: 610 277 5466
Phone #: 610 491 9688 **Fax #:** 610 491 9645

Sampler's signature : [signature]

Analysis Options: Enter letters in Requested Analysis columns below.

A	Light Hydrocarbons	F	BTEX
B	Permanent Gases Oxygen Carbon dioxide Nitrogen	G	BTEX & C5 - C10
C	Methane	H	TPH (C4 -C12 range)
D	Methane, Ethane, Ethylene	I	Chlorinated Hydrocarbons
E	Hydrogen	J	624 Compound List

Light Hydrocarbons: Methane, Ethane, Ethylene, Propane, Propylene, iso-Butane, n-Butane
Permanent Gases: Carbon Dioxide, Oxygen, Nitrogen, Methane, Carbon Monoxide
BTEX: Benzene, Toluene, Ethyl Benzene, m & p -Xylene, o-Xylene
C5-C10: Pentane, Hexane, Heptane, Octane, Nonane, Decane
Chlorinated HC: 1,1-DCE, 1,1- DCA, Methylene Chloride, trans-1,2-DCE, cis-1,2-DCE, Chloroform 1,1,1-TCA, Carbon Tetrachloride, Trichloroethylene (TCE), Tetrachloroethylene (PCE)

Collection Date	Collection Time	Number of Containers	Sample Type	Sample Identification	Requested Analysis				(Other)	Remarks
9/15/00	1430	2	GW	05MW10S 0900	B	D				
9/15/00	1525	1	Gas	05MW10S 0900	E					
9/15/00	1700	1	Gas	05MW80D 0900	E					
9/15/00	1500	2	GW	05MW80D 0900	B	D				
9/15/00	1500	2	Aq	RB-091400	B	D				

Results to :

Invoice to :

Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :
[signature]	Tetra Tech NUS	9/15/00	1500				
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :

WHITE COPY : Laboratory to return. YELLOW COPY : Laboratory PINK COPY : Submitter

Sh[illegible]d via Federal Express Airbill No 8196 [illegible]17 2662 G-16

CHAIN OF CUSTODY RECORD

[illegible] TECH [illegible]
[illegible] Suite 3
[illegible] PA 19406
[illegible]

Project Name NAS JRB [illegible]
Project Number [illegible]

PROJECT NO.: [illegible] 5466

SITE NAME: NAS JRB [illegible]

SAMPLERS (SIGNATURE): [illegible]

STATION NO.	DATE	TIME	COMP	GRAB	STATION LOCATION	NO. OF CONTAINERS	[illegible]	[illegible]						REMARKS
	[illegible]	[illegible]		✓	TB-091400	2	2							
	[illegible]	[illegible]		✓	05MW07S 0900	12	9	3						05MW07S/MSD
	[illegible]	1402		✓	05MW07I [illegible]	4	3	1						
	[illegible]	1500		✓	[illegible]-091400	4	3	1						
	[illegible]	[illegible]		✓	05MW08T 0900	4	3	1						
	[illegible]	1005		✓	0[illegible]005 0900	4	3	1						
	[illegible]	1150		✓	[illegible]08ST 0900	4	3	1						
	[illegible]	1430		✓	[illegible]	[illegible]	3	1						
	[illegible]	1500		✓	05MW80D 0900	4	3	1						

RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
[illegible]	[illegible]				
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED FOR LABORATORY BY (SIGNATURE):	DATE / TIME:	REMARKS: Shipped via [illegible] Express Airbill No. 8196 0647 2651	

(0498)

CHAIN OF CUSTODY RECORD

PROJECT NO.:	SITE NAME:
[illegible]	[illegible]

SAMPLERS (SIGNATURE): [illegible]

STATION NO.	DATE	TIME	COMP	GRAB	STATION LOCATION	NO. OF CONTAINERS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	REMARKS
	[illegible]	[illegible]		✓	[illegible]	4	1	1	2				
	[illegible]	[illegible]		✓	[illegible]	4	1	1	2				
	[illegible]	[illegible]		✓	[illegible]	4	1	1	2				
	[illegible]	[illegible]		✓	[illegible]	4	1	1	2				
	[illegible]	[illegible]		✓	[illegible] 0400	4	1	1	2				

RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
[illegible]	[illegible] / 1000				
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED FOR LABORATORY BY (SIGNATURE):	DATE / TIME:	REMARKS: Shipped via [illegible] express [illegible]	

(0498)

Chain of Custody Record

SEVERN TRENT SERVICES

Severn Trent Laboratories, Inc.

STL-4124 (0700)

Client	Project Manager	Date	Chain of Custody Number
Tetra Tech NUS	Russ Turner	9/14/00	002638
Address	**Telephone Number (Area Code)/Fax Number**	**Lab Number**	
600 Clark Ave Suite 3	610 491 9688 610 491 9645		Page 1 of 1

City	State	Zip Code	Site Contact	Lab Contact
King of Prussia	PA	19406	Chuck Meyer	Ken Kuzior

Project Name and Location (State)	Carrier/Waybill Number
NDSTRB Willow Grove	Federal Express 8196 6047 2695

Contract/Purchase Order/Quote No.: CTO 277 5466

Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Matrix: Air	Aqueous	Sed.	Soil		Containers & Preservatives: Unpres.	H2SO4	HNOS	HCl	NaOH	ZnAc/NaOH		Analysis (Attach list if more space is needed): 250 ml Poly Alkalinity	Ferrous Iron	250 ml Poly Chloride, Sulfate	Nitrate, Nitrite	40 ml Vial HCl TOC								Special Instructions/ Conditions of Receipt
05MW07S 0900	9/14/00	1050		✓				✓			✓				3		3		6								Do MS/MSD
05MW07T 0900	9/14/00	1402		✓				✓			✓				1		1		2								
RB-091400	9/14/00	1500		✓				✓			✓				1		1		2								

Possible Hazard Identification: ☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☒ Unknown

Sample Disposal: ☐ Return To Client ☒ Disposal By Lab ☐ Archive For _____ Months (A fee may be assessed if samples are retained longer than 3 months)

Turn Around Time Required: ☐ 24 Hours ☐ 48 Hours ☐ 7 Days ☐ 14 Days ☒ 21 Days ☐ Other_____

QC Requirements (Specify):

	Date	Time		Date	Time
1. Relinquished By: [signature]	9/14/00	1800	1. Received By		
2. Relinquished By			2. Received By		
3. Relinquished By			3. Received By		

Comments

DISTRIBUTION: WHITE - Stays with the Sample; CANARY - Returned to Client with Report; PINK - Field Copy

Chain of Custody Record

STL-4124 (0700)

SEVERN TRENT SERVICES

Severn Trent Laboratories, Inc.

Client	Tetra Tech NUS
Project Manager	Russ Turner
Date	9/12/00
Chain of Custody Number	002630
Address	600 Clark Ave Suite 3
Telephone Number (Area Code)/Fax Number	610 491 9688 610 491 9645
Lab Number	
Page 1 of 1	
City	King of Prussia
State	PA
Zip Code	19406
Site Contact	Chuck Meyer
Lab Contact	Kim Kubior
Project Name and Location (State)	NASJRB Willow Grove PA
Carrier/Waybill Number	8196 6047 2637
Contract/Purchase Order/Quote No.	CTO 229 5466

Analysis (Attach list if more space is needed)

Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Air	Aqueous	Sed.	Soil	Unpres.	H2SO4	HNO3	HCl	NaOH	ZnAc/NaOH	250 ml Poly Nitrate, Sulfate	Nitrate, Sulfate	250 ml Poly Bicarbonate	Ferrous Sulfate	40 ml Vial HCl Frz								Special Instructions/ Conditions of Receipt
OS MW 11S 0900	9/12/00	0945		X			X			X			1		1		1								
OS MW 11SE 0900	9/12/00	1225		X			X			X			1		1		1								
OS MW 05S 0900	9/12/00	1722		X			X			X			1		1		1								
~~[illegible]~~ RB-091200	9/12/00	1530		X			X			X			1		1		1								

Possible Hazard Identification

☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☒ Unknown

Sample Disposal

☐ Return To Client ☒ Disposal By Lab ☐ Archive For _____ Months (A fee may be assessed if samples are retained longer than 3 months)

Turn Around Time Required

☐ 24 Hours ☐ 48 Hours ☐ 7 Days ☐ 14 Days ☒ 21 Days ☐ Other_____

QC Requirements (Specify)

	Date	Time		Date	Time
1. Relinquished By	9/12/00	2000	1. Received By		
2. Relinquished By			2. Received By		
3. Relinquished By			3. Received By		

Comments

DISTRIBUTION: WHITE - Stays with the Sample; CANARY - Returned to Client with Report; PINK - Field

Chain of Custody Record

SEVERN TRENT SERVICES

Severn Trent Laboratories, Inc.

STL-4124 (0700)

Client: Tetra Tech NUS	Project Manager: Russ Turner	Date: 9/13/00	Chain of Custody Number: 002631
Address: 600 Clark Ave Suite 3	Telephone Number (Area Code)/Fax Number: 610 491 9655 610 491 9645	Lab Number:	Page 1 of 1
City: King of Prussia; State: PA; Zip Code: 19406	Site Contact: Chuck Miller	Lab Contact: Ken Kuzier	
Project Name and Location (State): NAS JRB Willow Grove	Carrier/Waybill Number: 5196 6647 2630		
Contract/Purchase Order/Quote No.: CTU 277 5466			

Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Air	Aqueous	Sed.	Soil		Unpres.	H2SO4	HNOS	HCl	NaOH	ZnAc/NaOH		Sewer Pol. Alkalinity	Filtered Sewer Pol.	Sewer Pol. Cyanide, Sulfide	Alkalinity, Nitrate, Nitrite	4-Nitrophenol								Special Instructions/ Conditions of Receipt
05MW11I 0900	9/13/00	0950		✓				✓			✓				1		1		2								
05MW06I 0900	9/13/00	1418		✓				✓			✓				1		1		2								
05MW06S 0900	9/13/00	1510		✓				✓			✓				1		1		2								

Possible Hazard Identification: ☒ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal: ☐ Return To Client ☒ Disposal By Lab ☐ Archive For _____ Months (A fee may be assessed if samples are retained longer than 3 months)

Turn Around Time Required: ☐ 24 Hours ☐ 48 Hours ☐ 7 Days ☐ 14 Days ☒ 21 Days ☐ Other_____

QC Requirements (Specify):

Relinquished By	Date	Time	Received By	Date	Time
1. [signature]	9/13/00	1830	1.		
2.			2.		
3.			3.		

Comments:

DISTRIBUTION: WHITE - Stays with the Sample; CANARY - Returned to Client with Report; PINK - Field Copy

[redacted]

Chain of Custody Record

SEVERN TRENT SERVICES

Severn Trent Laboratories, Inc.

STL-4124 (0700)

Client	Project Manager	Date	Chain of Custody Number
Tetra Tech NUS	Russ Tomsic	9/12/00	002629
Address	**Telephone Number (Area Code)/Fax Number**	**Lab Number**	**Page 1 of 1**
400 Clark Rd. Suite 3	610 491 9658 610 491 9645		
City / State / Zip Code	**Site Contact / Lab Contact**		
King of Prussia PA 19406	Chuck Stoner / Vanessa Pollot		
Project Name and Location (State)	**Carrier/Waybill Number**		
NASJRB Willow Grove	8196 6642 2629		
Contract/Purchase Order/Quote No.			
CTO 277 5466			

Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Air	Aqueous	Sed.	Soil		Unpres.	H2SO4	HNOS	HCl	NaOH	ZnAc/ NaOH		Hexavalent Chrom	Total Poly Aromatic Hydrocarbons	Special Instructions/ Conditions of Receipt
OS MW11S 0900	9/12/00	0945		✓											3	1	
OS MW11S 0900	9/12/00	1225		✓											3	1	
OS MW05S 0900	9/12/00	1722		✓											3	1	
RB-091200	9/12/00	1830		✓											3	1	
TB-091200	9/12/00	0630		✓											3		
OS MW11I 0900	9/12/00	0930		✓											3	1	
OS MW06I 0900	9/12/00	1918		✓											3	1	
OS MW06S 0900	9/12/00	1510		✓											3	1	

Possible Hazard Identification

☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☒ Unknown

Sample Disposal

☐ Return To Client ☒ Disposal By Lab ☐ Archive For _____ Months (A fee may be assessed if samples are retained longer than 3 months)

Turn Around Time Required

☐ 24 Hours ☐ 48 Hours ☐ 7 Days ☐ 14 Days ☒ 21 Days ☐ Other _____

QC Requirements (Specify)

	Date	Time		Date	Time
1. Relinquished By	9/12/00	1830	1. Received By		
2. Relinquished By			2. Received By		
3. Relinquished By			3. Received By		

Comments

DISTRIB[illegible]: WHITE - Stays with the Sample; CANARY - Returned to Client with Report; PINK - Field C[illegible]

CHAIN-OF-CUSTODY RECORD

VAPORTECH Services, Inc.

1158 Pittsburgh Road • Suite 201 • Valencia, PA 16059
Tel: 724-898-2622 • Fax: 724-898-2633

Company Name: Tetra Tech NUS
Address: 600 Clark Ave Suite 3
City: King of Prussia **State:** PA **Zip:** 19406
Proj. Manager: Russ Turner
Proj. Location: NAS JRB Willow Grove
Proj. Number: CTO 222 5466
Phone #: 610 491 9655 **Fax #:** 610 491 9645

Sampler's signature : [signature]

Analysis Options: Enter letters in Requested Analysis columns below.

A	Light Hydrocarbons	F	BTEX
B	Permanent Gases Carbon Dioxide Oxygen, Nitrogen	G	BTEX & C5 - C10
C	Methane	H	TPH (C4 -C12 range)
D	Methane, Ethane, Ethylene	I	Chlorinated Hydrocarbons
E	Hydrogen	J	624 Compound List

Light Hydrocarbons: Methane, Ethane, Ethylene, Propane, Propylene, iso-Butane, n-Butane
Permanent Gases: Carbon Dioxide, Oxygen, Nitrogen, Methane, Carbon Monoxide
BTEX: Benzene, Toluene, Ethyl Benzene, m & p -Xylene, o-Xylene
C5-C10: Pentane, Hexane, Heptane, Octane, Nonane, Decane
Chlorinated HC: 1,1-DCE, 1,1- DCA, Methylene Chloride, trans-1,2-DCE, cis-1,2-DCE, Chloroform 1,1,1-TCA, Carbon Tetrachloride, Trichloroethylene (TCE), Tetrachloroethylene (PCE)

Collection Date	Collection Time	Number of Containers	Sample Type	Sample Identification	Requested Analysis (Other)					Remarks
9/12/00	0945	2	GW	05MW11S0900	B	D				
9/12/00	1208	1	GW	05MW11S0900			E			
9/12/00	1325	2	GW	05MW11SI0900	B	D				
9/12/00	1415	1	GW	05MW11SI0900			E			
9/12/00	1222	2	GW	05MW05S0900	B	D				
9/12/00	1530	1	GW	05MW05S0900			E			
9/13/00	0900	2	GW	05MW11I0900	B	D				
9/13/00	1105	1	GW	05MW11I0900			E			
9/13/00	1415	2	GW	05MW06I0900	B	D				
9/13/00	1510	2	GW	05MW06S0900	B	D				

Results to :

Invoice to :

Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :
[signature]	Tetra Tech NUS	9/13/00	1830				
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :

WHITE COPY : Laboratory to return YELLOW COPY : Laboratory PINK COPY : Submitter

shipped via Fed Ex Airbill #0

Bottle Order
PM: BORTOT

CHAIN OF CUSTODY

STL-Pittsburgh
450 William Pitt Way
Pittsburgh, PA 15238
(412) 820-8380
Fax - (412) 820-2080

Sign and return all Chain-of-Custody forms with sampling kit.

Client Code: 00375241	Quote/Sar No.: 35100	Due Date: 9/11/00

Co. Name: Tetra Tech NUS Site/Project: NASJRB Willow Grove	Ship to: Tetra Tech, NUS 600 Clark Avenue, Suite 3 King of Prussia, PA 19406-1433 Attn: Russ Turner

Comments:

Cooler No.:	*(Please return all coolers to the above address.)*					
				No of Trip Blanks: 7 sets		

Matrix	No. of Sets	No. per Set	Total No. of Bottles	Bottle Size	Bottle Type	Preservative	Parameter
Water	40	3	120	40 ml	clear	HCl	TCL Volatile Organics - OLMO 4.2
	40	1	40	250ml	Poly	HNO3	Metals – Iron only method 6010B
	4	1	4	500ml	Poly	HNO3	RCRA Metals – Method 6010B, 7470A
	40	1	40	250ml	poly	none	Anions (Chloride, Sulfate, Nitrate, Nitrite) 300A NC
	40	2	80	40 ml	Clear	HCl	TOC Method 415.1 NC
	40	1	40	1 liter	Poly	NaOHZnOAc	Sulfide Method 376.1
	40	1	40	250 ml	Poly	[redacted]	Alkalinity Method 310 [illegible] NC

Preservative Lot No.

HCl _____ NaOH _____ H_2SO_4 _____ HNO_3 _____

ZnAc/NaOH_____ Other (specify) _____

Packaged by: (Signature)	Date	Shipment method:	Comments:
Received by: (Signature)	Date		
Received at Laboratory by: (Signature)	Date		

APPENDIX H

SLUG TEST RESULTS

For slug test results prior to 1997 see Phase II Remedial Investigation Report Appendices (TtNUS, April 1998)

APPENDIX I

RISK ASSESSMENT DOCUMENTATION

For risk assessment documentation prior to 1997 see Phase II Remedial Investigation Report Appendices (TtNUS, April 1998)

APPENDIX J

GROUNDWATER SAMPLING ENDPOINT TURBIDITY VALUES

For groundwater sampling endpoint turbidity values prior to 1997
see Phase II Remedial Investigation Report
Appendices (TtNUS, April 1998)

APPENDIX K

DEDICATED LOW FLOW PUMP SPECIFICATIONS

For dedicated low flow pump specifications prior to 1997
see Phase II Remedial Investigation Report
Appendices (TtNUS, April 1998)

APPENDIX L

WASTE DISPOSAL RECORDS

For waste disposal records prior to 1997 see Phase II Remedial Investigation Report Appendices (TtNUS, April 1998)

APPENDIX M

ECOLOGICAL RISK ASSESSMENT TOXICITY PROFILES

For ecological risk assessment toxicity profiles prior to 1997
see Phase II Remedial Investigation Report
Appendices (TtNUS, April 1998)

APPENDIX N

RESPONSE TO U.S. EPA REGION III COMMENTS ON DRAFT PHASE II REMEDIAL INVESTIGATION REPORT

DEPARTMENT OF THE NAVY
NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
10 INDUSTRIAL HIGHWAY
MAIL STOP, #82
LESTER, PA 19113-2090

IN REPLY REFER TO

5090
Code 09TB/JC

09 JAN 2001

Ms. Lisa Bradford
U.S. Environmental Protection Agency, Region III
Federal Facilities Section
1650 Arch Street
Philadelphia, PA 19103-2029

Dear Ms. Bradford:

SUBJ: NAVY'S RESPONSES TO USEPA REGION III COMMENTS ON DRAFT PHASE II REMEDIAL INVESTIGATION (RI) REPORT DATED APRIL 1998; NAVAL AIR STATION JOINT RESERVE BASE (NASJRB) WILLOW GROVE, PA

The Navy had issued a Draft Phase II RI Report in April 1998 for which comments were requested. At a technical meeting held at Northern Division, NAVFAC offices in Lester, PA in April 1999, representatives from the USEPA Region III office and Pennsylvania Department of Environmental Protection (PADEP) offered several comments and recommendations that the Navy took as Action Items.

Since that meeting, the Navy has been addressing each of the Action Items and is now forwarding enclosures (1) and (2) that basically serve as the Navy's responses to regulator comments on the Draft Phase II RI Report. Enclosure (1) contains nine attachments that address specific Action Items. Enclosure (2) is being re-issued and are the Navy's responses to comments submitted by the USEPA Region III's toxicologist that was assigned to this project at that time.

If found to be acceptable, the Navy will incorporate the information contained in enclosures (1) and (2) into Final versions of the Phase II RI Report. As explained at our last meeting held at the USEPA Region III offices on December 5, 2000, the Navy will finalize a separate Phase II RI Report for each individual site rather than a four-site package as was done for the Draft Report.

The Navy would like to request that enclosures (1) and (2) be reviewed and that the regulators be prepared to discuss each of the Action Items at our next technical meeting that has been scheduled for Wednesday, February 7, 2001 at Building 1 located at NASJRB Willow Grove.

If you have any questions regarding the enclosures, please give me a call at (610) 595-0567, extension 163.

Sincerely,

JAMES L. COLTER
Remedial Project Manager
by Direction of the
Commanding Officer

Enclosures: (1) Nine Attachments Addressing Specific Action Items
(2) Navy Responses to EPA Toxicological Comments on Draft Phase II RI Report

Copy to:
PADEP, April Flipse
NASJRB Willow Grove, Jim Edmond
Tetra Tech NUS, Russ Turner

STATUS OF NAVY ACTION ITEMS FROM TECHNICAL MEETING HELD ON 14 APRIL 1999

13 October 1999
4 January 2001 (Revision 1)

SITE 5 REMEDIAL INVESTIGATION:

ITEM 1: The Navy will generate a map that shows IR Sites 2, 3, and 5 and the surrounding area. The map should include building numbers, location of wells and water level readings.

RESPONSE: See Attachment (1) that includes three figures. Figure 1 shows the locations of all monitoring wells installed at Sites 2, 3 and 5 on a USGS Quadrangle. Figure 2 shows the same monitoring well locations on an aerial photo background. Figure 3 shows the potential locations for additional monitoring wells at Site 5.

ITEM 2: What are the effects of the geologic structure on the groundwater flow patterns at SITE 5? How are the dip and bedding planes influencing contaminant movement?

RESPONSE: See Attachment (2). Upon acceptance, this information will be made part of the Final RI for Site 5.

ITEM 3: The Navy will propose a plan to further characterize the groundwater in the area west of well cluster 11 at Site 5.

RESPONSE: Attachment (3) is the Navy's Remedial Investigation Workplan Addendum for Site Investigations at Site 5. This letter workplan was submitted for review on 26 May 2000 and no adverse comments were received.

Implementation of the workplan was completed in the Fall 2000. Attachment (4) is being submitted that is a compilation of the recently collected analytical data. The Navy is currently evaluating this data. The Navy's evaluation consists of using a GIS-based software program (EVS) that analyzes and portrays the data in a three-dimensional view. This effort is not yet completed but should be in the next couple of weeks. The Navy is expecting to be able to present this analysis at the upcoming technical meeting scheduled for February 7, 2001. At this meeting, the Navy will also discuss it's recommendations and conclusions for Site 5. If accepted, these recommendations and conclusions will be made part of the Navy's Final RI for Site 5.

ITEM 4: Navy is to approach Horsham Township Water District about conducting a Pump Test on municipal well #26 in order to assess the impacts, if any, that this well may have on groundwater near Site 5.

RESPONSE: Ralph McQuaid (Horsham Township Water District) was contacted on 7 June 1999. Water demand over the summer was high and other maintenance activities on other wells made running Well #26 more imperative. Fore these reasons, the District was reluctant to shut down the well. Mr. McQuaid suggested that a pump test on Well #26 may be possible in the Fall when demand is typically lower, the other maintenance work would be completed and construction of a new well (Well #40) in the same vicinity as Well #26 would also be completed and could be used to supplement water when #26 is shut down.

Russ Turner will follow up with Mr. McQuaid regarding the status of the above and the possibility of performing the pump test on Well #26 in the near future. This follow up was conducted on 13 October 1999 and it was suggested that the shutdown for Well #26 could take place after the first of the year when the water demand has been historically at its lowest.

The actual shutdown, and subsequent pump test for Horsham Well #26 was conducted during the week beginning 17 January 2000 and was concluded during the week of 22 February 2000. The collected data has been evaluated by the USGS and was presented to the members of Willow Grove's RAB on 7 June 2000. A copy of that presentation is enclosed and discussions regarding Well #26 begins on Page 5 of Attachment (5).

SITE 5 REMEDIAL INVESTIGATION (Continued):

ITEM 5: Navy will review EPIC photos for all of NASJRB Willow Grove received from EPA on 15 April 1999. The Navy will review the photos to see if there are other possible sources in the vicinity of the IR Sites.

RESPONSE: The Navy's review of the EPIC photos was completed for IR Site 5 ONLY in October 2000. The results of this analysis are presented in Attachment (6). Upon approval, the information will be made part of the Final RI for Site 5.

Subsequent conclusions for the other IR Sites will be made part of the Final RI's for each individual site.

ITEM 6: Navy will consider using USGS to investigate weathered bedrock layer as a source of continuing groundwater contamination. This will involve taking cores of the shallow bedrock layer and eluting any VOCs from the core.

RESPONSE: The Navy conducted the coring of the weathered bedrock during the week of 4 September 2000. The analytical results from that effort are presented in Attachment (7). A discussion of the rock core procedures and the results of the lab analysis will be part of the agenda for the next scheduled meeting of Willow Grove's RAB that is to be held on December 6, 2000.

ITEM 7: The Navy will consider whether a soil removal project is warranted either to remove as a source of groundwater contamination or to reduce Eco/human health risk.

RESPONSE: This evaluation will be made part of the Feasibility Study for Site 5 which is currently being developed. The FS will be forwarded concurrently with the submission of the Final RI for Site 5 or shortly thereafter.

LOW-FLOW SAMPLING PROCEDURES:

ITEM 1: EPA expressed concerns that the Low-Flow sampling protocols may not have been followed resulting in a question regarding usability of the analytical data. The following action items resulted:

- Review field logs to determine if protocols were followed
- Examine historical data and compare with the data in question
- Determine if the conceptual site model changes if the concentrations were higher (Assumption: the highest level ever detected or 2 times the latest concentration)
- Determine if multiple fractures present within the screened interval

RESPONSE: Tetra Tech NUS's responses to the first three bullets listed above are shown on Attachment (8). Discussions regarding the last bullet are shown on Attachment (9). If found to be acceptable, the Navy will include this information into the Final RI Report for each IR Site.

ITEM 2: The Navy will look at the effect the suspect data may have on the human health risk assessments.

RESPONSE: Tetra Tech NUS's review of the effects, if any, that the suspect data may have on the human health risk assessments conducted at each of the IR Sites is included in Attachment (8) which discusses data quality issues. If the discussions included in Attachment (8) are found to be acceptable, the Navy will include the information into the Final RI Reports for each IR Site.

From: Kevin C. Kilmartin
To: Russ Turner

Date: July 7, 1999

Re: NASJRB WILLOW GROVE: Analysis of Screened Intervals and Fracture Zones for Monitoring Wells Installed During the Phase II RI

TtNUS was tasked to determine whether any of the screened monitoring wells installed during the Phase II RI were completed in such a manner that the vertical position of the well pump could affect the analytical results when sampling the well under low-flow sampling procedures. In order for the vertical position of the pump to influence the sampling results, the groundwater for that well must be migrating or flowing from multiple, hydraulically isolated fractures that are spaced widely enough that the groundwater from one fracture could be preferentially sampled over the groundwater from the other fracture(s).

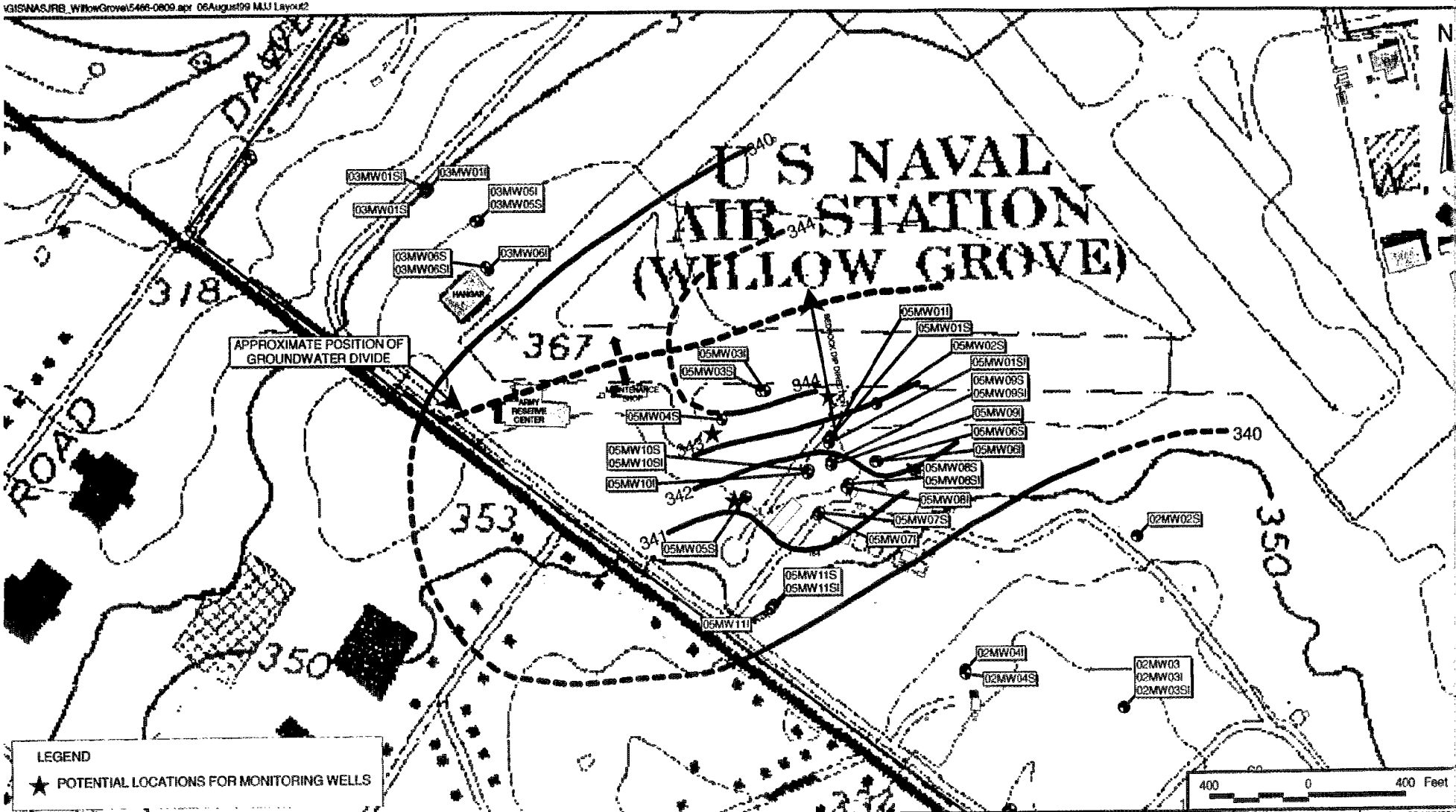
A top priority of the borehole retrofitting program was to construct the monitoring wells to obtain groundwater from only one groundwater zone and to not interconnect different groundwater zones. To reach this goal, all boreholes were geophysically logged (including borehole flowmeters), and the potential construction plans were reviewed and discussed with the USGS. The resultant individual well plans were then presented to EPA prior to the construction of the wells. I have reviewed the borehole geophysical logs and the well construction details to reconfirm that the monitoring wells were properly constructed as originally scoped and are obtaining groundwater from only one zone. Therefore, the exact vertical position of the pump within the well screen should not matter, because water can only enter the well through the screen, and all the water entering the screen is from the same zone. Some of my observations that led to this conclusion include:

- The vast majority of wells are screened across only one fracture. Therefore, the groundwater can only be entering the screen through that fracture.

- Some wells are screened across a fracture zone, or a series of smaller fractures rather than one distinct larger fracture. These fractures (typically two or three fractures within a five-foot interval) are very closely spaced vertically (generally on the order of one or two feet), and there was no lithologic indications of confining layers between these fractures. Fractures that are spaced so closely vertically are almost certainly hydraulically interconnected; it would be very unusual for these fractures to be hydraulically isolated from each other. In fact, due to the presence of high-angle vertical fractures (from the television survey), some of these "fracture zones" may be the same fracture intercepted on opposite sides of the borehole walls.

- The flowmeter was carefully considered for each well construction. Screens were extended across multiple fractures only if there was no evidence of intraborehole flow between the respective fractures. In fact, some screens were constructed specifically to monitor one fracture(s) but not the other(s) because of evidence of intraborehole flow.

\GIS\NASJRB_WillowGrove\5466-0809.apr 06August99 MJJ Layout2



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

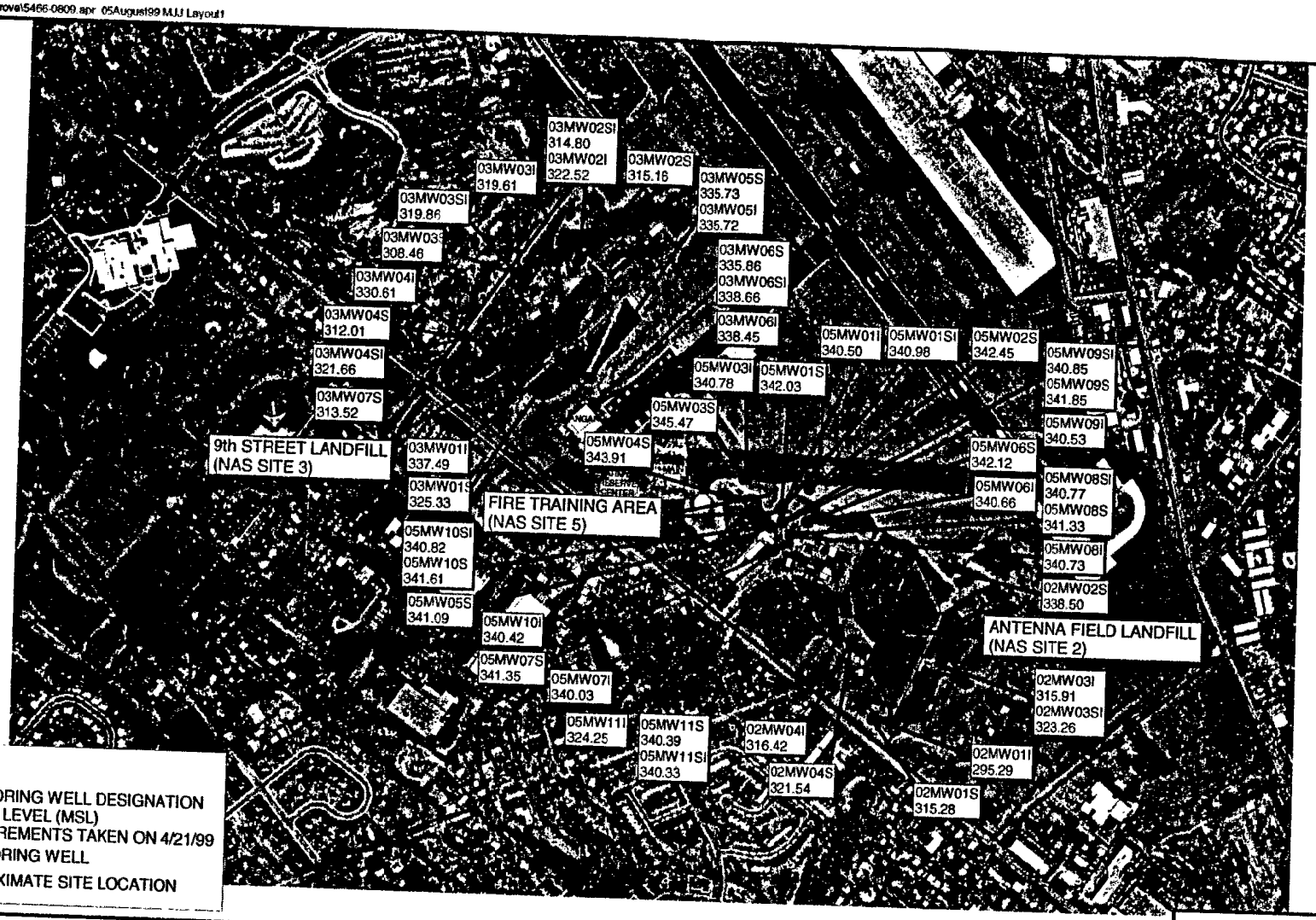
DRAWN BY: MJJ — DATE: 06August99
CHECKED BY — DATE
COST/SCHEDULE AREA
SCALE: AS NOTED

Tetra Tech NUS, Inc.

SITES 5 FIRE TRAINING AREA
HYDROLOGICAL FEATURES
NASJRB WILLOW GROVE
WILLOW GROVE, PA

CONTRACT NUMBER: 5466
OWNER NUMBER
APPROVED BY — DATE
APPROVED BY — DATE
DRAWING NO. FIGURE 2

P:\GIS\NASJRB_WillowGrove\5466-0809.apr 05August99 MJJ Layout1



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

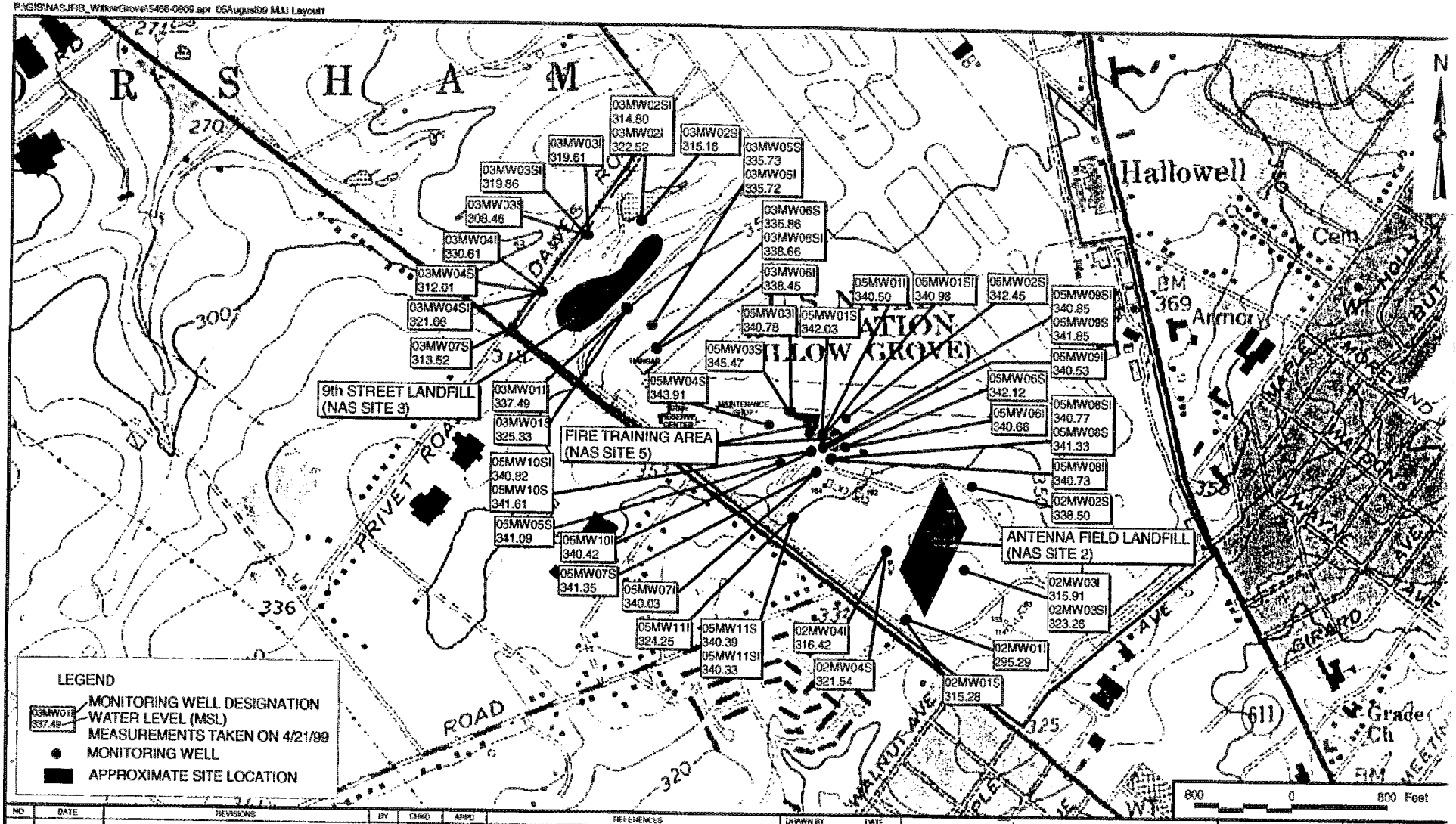
DRAWN BY: MJJ — DATE: 03August99
CHECKED BY — DATE
COST/SCHEDULE AREA
SCALE: AS NOTED

Tetra Tech NUS, Inc.

INSTALLATION RESTORATION
SITES 2, 3 AND 5 COMBINED AREA
NASJRB WILLOW GROVE
WILLOW GROVE, PA

CONTRACT NUMBER: 5466
OWNER NUMBER: —
APPROVED BY: — DATE: —
APPROVED BY: — DATE: —
DRAWING NO: FIGURE 1
REV: 0

P:\GIS\NASJRB_WillowGrove\5466-0609.apr 05August99 MJJ Layout1



NO	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY MJJ DATE 05August99
CHECKED BY DATE
COST/SCHEDULE-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

INSTALLATION RESTORATION
SITES 2, 3 AND 5 COMBINED AREA
NASJRB WILLOW GROVE
WILLOW GROVE, PA

CONTRACT NUMBER 5466
OWNER NUMBER
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO FIGURE 1
REV 0

(1) An Evaluation of the Effects of Geologic Structure on Groundwater Plume Migration at Site 5

and

(2) A Recommendation for a New Monitoring Well Location To Address the Hydrogeological Data Gap in the Southwestern Portion of the Site

NASJRB Willow Grove

1.0 An Evaluation of the Effects of Geologic Structure on Groundwater Plume Migration at Site 5

1.1 Background

TtNUS was tasked to investigate the effects of the geologic structure on the groundwater flow and plume migration at Site 5, the Fire Training Area. Specifically, EPA asked if the dip of the sedimentary bedrock units (to the northwest) caused either the dissolved-phase groundwater plume or a separate-phase DNAPL to migrate from the source area located near monitoring well cluster location 05MW01 to the northwest toward monitoring well cluster 05MW03, where approximately 50 ug/L of various chlorinated solvents were detected in the intermediate well but none were detected in the shallow (water table) well. The intermediate well (05MW03I) is screened just above a very fine-grained claystone unit. TtNUS had earlier concluded that the solvents detected in 05MW03I were not part of the main plume that has been delineated at Site 5.

1.2 Discussion

The hydrogeologic cross-section (Figure 1) indicates that monitoring well cluster location 05MW03 is hydraulically upgradient from the source area for chlorinated solvents that is located near monitoring well cluster location 05MW01. Figure 1 also indicates that the shallow groundwater at 05MW03 does not contain any chlorinated solvents, which indicates that this well cluster is not located within the source area of the solvents. Therefore, the occurrence of the solvents in monitoring well 05MW03I may be due to either:

- An unknown source located hydraulically upgradient from 05MW03, with the solvents migrating as a dissolved phase with the groundwater along the hydraulic gradient, and to deeper depths due to the downward-oriented vertical gradient; or

- The known source (the VOCs in the soils) located near 05MW01, with the solvents migrating to deeper depths down the geologic dip of the bedrock (but against the hydraulically gradient) to 05MW03.

TtNUS believes the data indicate that the source of the solvents in 05MW03I is an unknown source located hydraulically upgradient from that monitoring well location. The following discussions are presented in support of this hypothesis:

- The siltstones and claystone encountered in the subsurface near the source area (at 05MW01) do not appear to function as effective semi-confining layers to the depths at which they are encountered. Investigations at other base sites (Site 1 and Site 3) where confining conditions were encountered suggest that it is the cumulative effect of multiple fine-grained units that ultimately create the confining conditions at greater depths rather than any particular bed creating the confining conditions at any (including shallow) particular depth. This hypothesis is supported at Site 5 by the observation that upward groundwater flow was noted on the thermal-pulse flow log from the bottom of the 05MW03I borehole (from below the bottom claystone unit) prior the retrofitting of the open borehole with the monitoring well.

ATTACHMENT (2)

The geologic structure (bedrock dip) does not appear to influence the groundwater flow patterns to the total depth of the hydrogeologic investigation at Site 5. As depicted in Figure 1, both the groundwater and the dissolved-phase groundwater plume are migrating in a generally southward direction, while the dip of the bedrock is to the northwest. The hydrogeologic data are indicative of an unconfined groundwater flow system. Specifically:

- There are no major changes in the hydraulic head values across the potential semi-confining layers. The vertical gradients are relatively low and are oriented downward. Higher vertical gradients and more pronounced deflections in the groundwater flow patterns would normally be expected at the bed boundaries if the finer-grained layers were functioning as effective semi-confining units.

- Monitoring wells screened below the potential semi-confining layers contain chlorinated solvents, indicating that the geologic layers are not effectively retarding the migration of these chemicals. The gradational changes in chemical concentrations with depth appear to reflect typical attenuation/dilution processes rather than sharp changes across lithologic and hydrogeologic boundaries.

- The concentrations of the solvents at the source area do not suggest the presence of a DNAPL. An examination of the historical analytical data reveals that no compound approaches even one percent of its solubility in groundwater; the highest recorded concentration is for 1,1,1-TCA (2800 ug/L in 1991). Even if the siltstones and claystone functioned as effective semi-confining layers, the presence of a DNAPL would be required for the solvents to migrate to the northwest (down the bedrock structural dip and against the hydraulic gradient) rather than in a dissolved-phase plume migrating with the groundwater along the hydraulic gradient.

It is noted that monitoring well cluster 05MW03 is not located directly downdip from the source area located near well cluster 05MW01. As can be seen on Figure 2, well 05MW03I was installed about 38° west of true dip. Well 05MW03I was placed directly downdip from the source area based on the regional geology and the limited site-specific subsurface information that was available prior to the drilling of the borehole. The site-specific strike and dip directions were subsequently determined through the correlation of the subsurface geophysical logs at the conclusion of the drilling program. Therefore, it is possible that DNAPL could have migrated directly downdip, with the concentrations at 05MW03I representing the edge of a dissolved plume that is migrating downgradient (and updip) after migrating upgradient (but downdip) as a DNAPL, although as discussed above, the hydrogeological evidence does not indicate the likely presence of DNAPL in this area. To completely confirm this hypothesis, a borehole could be installed downdip from 05MW01 and near the runway (see Figure 2). Based on a rate of dip of 7°, the top of the finer-grained units encountered in 05MW01 at subsurface depths of 0 feet, 82 feet, and 106 feet (which is the unit that 05MW03I is screened above) would be encountered at the new location at subsurface depths of 32 feet, 114 feet, and 138 feet, respectively.

1.3 Other Potential Source Areas

Monitoring well location 05MW03 is located near the runway. The runway basically lies along a topographic high or ridge that bisects the base, and multiple hydrogeologic investigations have indicated that this ridge is both a surface water and a groundwater divide. Therefore, if the source of the solvents detected in 05MW03I is from an upgradient location (since there are no detections in 05MW03S) the potential sources should be limited to the area generally between the runway and the 05MW03 monitoring well cluster location. The nearest structure in this vicinity is part of the Army Reserve complex and is reportedly a maintenance-type facility.

The Army Reserve complex has also been identified as a potential source of the chlorinated solvent detected in the groundwater at the adjacent Site 3 (9th Street Landfill). The buildings at this complex either straddle or are located on either side of the groundwater divide (Figure 2). It is interesting to note, however, that a common source located on the complex could not account for both the Site 3 groundwater plume and the

solvents detected at Site 5 well 05MW03I because of the chemical dissimilarity of the detections (only PCE was detected at Site 3 while many different solvents were detected at Site 5). It is still possible, however, that two different sources could be located on the Army Reserve complex, with the sources located on opposite sides of the groundwater divide.

2.0 A Recommendation for a New Monitoring Well Location to Address the Hydrogeological Data Gap in the Southwestern Portion of the Site

2.1 Background

TtNUS was tasked to recommend a drilling location for an additional monitoring well cluster in the southwestern portion of the site designed to fill a data gap noted by EPA. The available data indicate that there is a component of groundwater flow in that direction and that the groundwater quality has been impacted immediately to the southwest of the source area (at monitoring well cluster 05MW10), but there are limited monitoring wells downgradient of 05MW07 from which to obtain water quality data. The only existing monitoring wells in that quadrant are the shallow wells 05MW05S (40 feet deep) and 05MW04S (30 feet deep).

2.2 Potential Well Locations

An intermediate monitoring well clustered with existing well 05MW05S would close the data gap to the southwest. A well in this location would provide additional hydraulic head and water quality data in a direction potentially downgradient from the source area near 05MW01 and downgradient from the impacted groundwater at 05MW10. Monitoring well 05MW05S has been sampled during both phases of the RI and has never had a positive detection of any VOC, but it is possible that the groundwater plume could be migrated through this area at some depth below the total depth of the shallow well. Due to the rather steep vertical hydraulic gradient at Site 5 (Figure 1), the new monitoring well should be installed at a depth of approximately 250 feet.

A second potential well location would involve the installation of an intermediate monitoring well clustered with existing well 05MW04S. Although this location is actually slightly northwest (rather than southwest) of the source area, the hydraulic head data collected during the Phase II RI did indicate a component of groundwater flow in this direction in the intermediate groundwater zone (because of a lower hydraulic head in monitoring well 05MW03I). Alternatively, the lower hydraulic heads could have resulted from the southward migration of the water level divide to a position just south of the 05MW03 location. Subsequent water level measurement rounds conducted after the RI have not found this same pattern. In these later rounds, the hydraulic head measured in 05MW03I is consistently higher than the head measured in the other intermediate wells, creating the south-to-southwest pattern of groundwater flow. An intermediate well installed to approximately the same depth as 05MW03I (128 feet) would provide useful hydraulic head data and possibly provide information helpful to the evaluation of the potential for an additional source area in this vicinity, as discussed above in Section 1.

DEPARTMENT OF THE NAVY

NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
10 INDUSTRIAL HIGHWAY
MAIL STOP, #82
LESTER, PA 19113-2090

IN REPLY REFER TO

5090
Code 09TB/JC

26 MAY 2000

MEMORANDUM

FOR THE MEMBERS OF THE RESTORATION ADVISORY BOARD (RAB) FOR THE INSTALLATION RESTORATION PROGRAM AT NAVAL AIR STATION JOINT RESERVE BASE (NASJRB) WILLOW GROVE, PENNSYLVANIA

The Navy is enclosing a Workplan to conduct additional environmental investigations at Installation Restoration (IR) Site 5 - Fire Training Area, located at NASJRB Willow Grove, for your review and information.

Development of this workplan was in response to comments and requests made by the U.S. Environmental Protection Agency, Region 3 regarding the Navy's Draft Phase 2 Remedial Investigation Report, dated April 1998.

It is anticipated that upon completion of this supplemental fieldwork effort, the Navy will have enough information to adequately characterize the nature and extent of groundwater contamination at Site 5 and can then proceed with development of a Feasibility Study to evaluate potential groundwater remedies.

Due to funding availability, the Navy will be able to begin implementation of the enclosed workplan during the week of June 19, 2000. Therefore, any comments regarding the workplan should be submitted as soon as possible so that relevant comments can be incorporated.

If you have any questions or would like to discuss the enclosed document further, please give me a call at (610) 595-0567, extension 163.

Sincerely,

JAMES L. COLTER
Remedial Project Manager
By direction of the
Commanding Officer

Enclosure: (1) Remedial Investigation Workplan Addendum for Site 5

ATTACHMENT (3)

Distribution:

U.S. EPA Region III, Lisa Bradford (3 copies)
PADEP, April Flipse/Pam Reigh (2 copies)
NASJRB Willow Grove, Jim Edmond (3 copies)
Community Co-Chair, Liz Gemmill (3 copies)
Restoration Advisory Board, Community Members Mailing List (1 copy each)

ADDENDUM REMEDIAL INVESTIGATION WORK PLAN
FOR SITE INVESTIGATIONS AT SITE 5 - FIRE TRAINING AREA

PHASE II REMEDIAL INVESTIGATION
NASJRB WILLOW GROVE, PENNSYLVANIA

INTRODUCTION

Tetra tech NUS (Tt NUS) has prepared this Work Plan for environmental site investigation on NASJRB Willow Grove property in the vicinity of Site 5 - Fire Training Area. These investigations are planned in response to comments/requests from the Environmental Protection Agency (EPA). EPA comments/requests are based on review of the draft Phase 2 Remedial Investigation (RI) Report for NASJRB Willow Grove Pennsylvania (Brown & Root Environmental, April 1998) and subsequent hydrogeological investigations and reports prepared for the Site 5 vicinity. The Navy has requested Tt NUS to perform additional remedial investigation at Site 5 under Contract Task Order No. 277 under Contract N62472-90-D-1298, Comprehensive Long - Term Environmental Action-Navy (CLEAN).

SUMMARY OF PREVIOUS REMEDIAL INVESTIGATIONS

Findings from the Phase II RI Report (draft) for NASJRB Willow Grove, Pennsylvania continue under review by the regulatory agencies. The findings appear to demonstrate that no off-post groundwater impact from past practices at or near Site 5 - Fire Training area has occurred. The EPA has (informally) questioned this conclusion.

To help determine if there is any potential for contaminated groundwater to migrate off-base, the Navy performed two water level studies in monitoring wells to the southwest of Site 5. Monitoring wells monitored included 05MW11S, 05MW11SI, 05MW11I, 05MW07S, and 05MW07I. See Figure 1 for a map of this area. Monitoring wells 05MW11S, 05MW11SI and 05MW11I were installed as near as possible to the facility boundary in a direct line between the nearest off-station municipal groundwater supply well and the former fire training and drum storage area. Monitoring wells 05MW07S, and 05MW07I are also along the approximate line between the nearest off-station municipal groundwater supply well and the former fire training and drum storage area, but are located closer to Site 5 (Figure 1). The second water level monitoring study involved a

groundwater recovery test resulting from a planned shutdown of the nearest municipal groundwater supply well (Number 26), owned by the Horsham Township Water Authority. Horsham production well No. 26 (H-26) is located approximately 1,500 feet southwest of monitoring wells 05MW11 (Figure 2). Water levels in wells both on and off of the Air Station were monitored for one week before the H-26 pump shutdown, the week of the H-26 pump shutdown, and for one week after the H-26 pump shutdown.

The results of the water level monitoring tests indicate that H-26 does have some influence on movement of groundwater in the vicinity of the known solvent plume at Site 5. Although groundwater originating at or flowing through Site 5 ultimately will reach the vicinity of H-26, the analytical data indicate that the plume may have reached steady-state conditions and does not leave the base property due to dilution and dispersion processes.

BACKGROUND

Tt NUS was assigned to address several perceived data gaps resulting from the regulatory review of the draft Phase II RI. These tasks include the following:

- Tt NUS was assigned to investigate the effects of the geologic structure on the groundwater flow and plume migration at Site 5. EPA questioned if the dip of the sedimentary bedrock units (to the northwest) caused either the dissolved-phase groundwater plume or a separate-phase DNAPL to migrate from the source area located near monitoring well cluster location 05MW01 to the northwest toward monitoring well cluster 05MW03, where approximately 50 ug/L of various chlorinated solvents were detected in the intermediate well but none were detected in the shallow (water table) well. The intermediate well (05MW03I) is screened just above a very fine-grained claystone unit. Tt NUS had earlier concluded that the solvents detected in 05MW03I were not part of the main plume that has been delineated at Site 5. An additional monitoring well is considered necessary to address EPA queries.

- Tt NUS was also assigned to recommend drilling locations for additional monitoring wells in the southwestern portion of the site to fill a gap noted by EPA in the existing solvent plume delineation. The available data indicate that there is a component of groundwater flow to the southwest and that the groundwater quality has been impacted immediately to the southwest of the source area (at monitoring well cluster 05MW10). EPA stated that there are insufficient monitoring wells downgradient of 05MW07 from which to obtain water quality data to accurately map the full extent of the plume. The only existing monitoring wells in that

quadrant are the shallow wells 05MW05S (40 feet deep) and 05MW04S (30 feet deep). Additional monitoring wells are considered necessary to allay concerns voiced by EPA.

- Tt NUS was assigned to investigate the possibility that bedrock in the vicinity of the solvent plume source area (near cluster 05MW01) is impregnated with chlorinated solvents and acting as a continuing solvent source.

SUMMARY OF PLANNED FIELD INVESTIGATIONS

The objective of this study is to conduct an environmental investigation of bedrock and groundwater quality on Navy property near Site 5 in order to fill data gaps identified by regulatory community members. Information will be used to more accurately delineate the current nature and extent of the known contaminant plume near the former fire training area on Navy property. All field activities will be governed by the Work Plan, and Health and Safety Plan (Brown & Root Environmental 1997) and Addenda prepared for phase II remedial activities at NASJRB Willow Grove, Horsham Township, Pennsylvania.

Rock Core Investigation

One rock core will be obtained from the assumed historical solvent plume source area near 05MW01 (see Figure 3 for the approximate location of the planned coring). The actual boring location will be marked in the field. The drilling subcontractor will obtain a 2 inch diameter core sample from the bottom of soil/fill to an approximate depth of 25 feet below ground surface. The soil/rock core will be transferred to clean polyethylene sheeting for immediate photo record, examination, and handling/sampling by USGS. Samples will be obtained at a minimum of 5 foot intervals, and at major fractures. USGS will supply equipment to cut samples from the rock core and crush the samples. At each sample interval, USGS will obtain six slices (approximately 2 inches of length) from the rock core. Two of the slices will be crushed and placed in sealed vials; two will be crushed and placed in vials with methanol; and two will be placed in airtight glass/ teflon containers for possible future analysis. Rock core samples will be analyzed at the USGS National Laboratory. The crushed rock core sample placed in vials will be analyzed using a water extraction procedure developed by USGS. The water and methanol extract solutions from the crushed rock core samples will be analyzed for VOC's using EPA approved methods. Appendix A is a copy of a field verification study of TCE in fractured bedrock developed by Beth Parker (see Appendix A).

Monitoring Well Installation

Figure 1 shows the proposed locations for additional monitoring wells. Actual locations will be marked in the field before drilling activities begin. After boreholes are installed, USGS will perform geophysical analyses on the open borehole. The Tetra Tech NUS lead geologist and the USGS geophysicist will confer to make recommendations for monitoring well construction in each borehole based on known features.

To investigate the effects of the geologic structure on the groundwater flow and potential plume migration against groundwater flow gradient at Site 5, a borehole (05MW12) will be installed downdip (north of) 05MW01 near the runway (see Figure 1). Based on a rate of dip of 7°, the top of the finer-grained units encountered in 05MW01 at subsurface depths of 0 feet, 82 feet, and 106 feet (which is the unit that 05MW03I is screened above) would be encountered at the new location at subsurface depths of 32 feet, 114 feet, and 138 feet, respectively.

A new intermediate monitoring well (05MW05I) clustered with existing well 05MW05S will be installed to close the data gap in the measured plume extent to the southwest. A well in this location will provide additional hydraulic head and water quality data in a direction potentially downgradient from the source area near 05MW01 and downgradient from the impacted groundwater at 05MW10. Monitoring well 05MW05S has been sampled during both phases of the RI and has never had a positive detection of any VOC, but it is possible that the groundwater plume could have migrated through this area at some depth below the total depth of the shallow well. Due to the rather steep vertical hydraulic gradient at Site 5 the new monitoring well should be installed at a depth of approximately 250 feet.

A third new monitoring well (05MW04I) will be installed clustered with existing well 05MW04S. Although this location is actually slightly northwest (rather than southwest) of the source area, the hydraulic head data collected during the Phase II RI did indicate a component of groundwater flow in this direction in the intermediate groundwater zone (because of a lower hydraulic head in monitoring well 05MW03I). Alternatively, the lower hydraulic heads could have resulted from the southward migration of the water level divide to a position just south of the 05MW03 location. Subsequent water level measurement rounds conducted after the RI have not found this same pattern. An intermediate well installed to approximately the same depth as 05MW03I (128 feet) would provide useful hydraulic head data and possibly provide information helpful to the evaluation of the potential for an additional source area in this vicinity.

Survey

The horizontal locations and the elevations (at the top of casing for monitoring wells) relative to mean sea level for the three monitoring wells and one rock coring will be measured and recorded by a land surveyor licensed in the Commonwealth of Pennsylvania.

Monitoring Well Water Level Measurements

All Site 5 monitor wells will be gauged to determine piezometric elevations, groundwater flow direction, and gradient.

Groundwater Sampling

Groundwater samples from all Site 5 monitoring wells, field duplicates, and quality control samples will be obtained after well development. All samples will be analyzed for volatile organic compounds (VOCs) and monitored natural attenuation (MNA) parameters. All pertinent field data will be recorded in a field logbook and on the appropriate sample log sheet.

Groundwater sampling will be conducted in accordance with the low-flow sampling procedure based on USEPA Region III amended Groundwater Sampling Procedure Low-Flow Purge and Sampling Guidance. Monitoring wells will be purged and sampled using a low-flow submersible pump and disposable polyethylene tubing. Groundwater will be directed into a flow-through cell with a multi-probe water quality meter. Each well will be purged until the monitored parameters (pH, temperature, conductivity, turbidity, and dissolved oxygen) of three consecutive readings were within 10 percent.

Field Decontamination

All drilling equipment and sampling equipment will be decontaminated before use, between individual samples, and after drilling and sampling activities.

The down-hole drilling equipment and sampling tools will be cleaned using a high pressure steam generator (steam jenny) before beginning work, between boring and well locations, and at the end of the drilling/well installation program. A temporary decontamination pad will be constructed at the study area in to complete this work. NASJRB will provide potable water for decontamination and cleaning.

The sampling equipment used for collecting samples will be decontaminated before field sampling and between samples (a full discussion of sampling requirements are provided in the Phase II RI Work Plan (Brown & Root Environmental, May 1997). The following decontamination steps will be followed:

- Alconox or liquinox detergent solution wash.
- Potable water rinse.
- Deionized water rinse.
- Air dry.

Field analytical equipment such as pH, conductivity, temperature, and turbidity instrument probes will be first rinsed with Deionized water and then with a portion of the sample liquid.

Investigative Derived Waste

Investigative derived wastes including drill cuttings, development water, purge water, and decontamination fluids will be handled and disposed in accordance with procedures described in the Phase 2 RI Work Plan.

Drill Cuttings

Drill cuttings generated during the rock coring and well installation program will be field screened with a PID. If no elevated organic vapor readings are generated at the rock coring location, the drilling cuttings will be backfilled and the coring hole will be filled with grout. If the drill cuttings from the new well boring locations do not indicate any significant PID readings, the cuttings will be spread around the immediate area of the well.

Development Water

Development water from the newly installed monitoring wells will be directed away from the wellhead and discharged to the ground surface and allowed to infiltrate the soil. If PID readings elevated (above background) are noted at any monitoring well, development water from that well will be containerized, sampled and stored on site pending test results for disposal.

Purge Water

Purge water from the newly installed monitoring wells will be directed away from the wellhead and discharged to the ground surface and allowed to infiltrate the soil. The purge water from newly installed wells will be containerized if the development water from those wells was containerized. Purge water from wells with a known history of VOC compounds will be containerized because VOC compounds are not found in Site 5 soils.

APPENDIX A

Field Verification of TCE Matrix Diffusion in a Fractured Sandstone and Implications for Natural Attenuation and Remediation

Beth L. Parker and Sean N. Sterling
Department of Earth Sciences, University of Waterloo
200 University Avenue West, Waterloo, ON, Canada, N2L 3G1
blparker@sciborg.uwaterloo.ca.

Sedimentary rocks such as sandstones, siltstones, mudstones and shales are referred to as fractured porous media because of their appreciable primary porosity (intergranular porosity) in the matrix between fractures. The primary porosity of lithified sediments generally ranges from a few per cent up to 25%, several orders of magnitude greater than the secondary porosity due to the presence of fractures. Although the matrix has appreciable porosity, the permeability is governed by pore size, and these lithified sediments are referred to as dual permeability media given that the matrix generally has very low permeabilities compared to the fractures, which provide the main avenues for water and DNAPL flow, especially below the water table where the matrix pores are completely filled with water. This large difference between fracture and matrix porosities is an important feature of fractured sedimentary rocks and greatly influences the distribution of chlorinated solvent mass in these deposits in terms of DNAPL persistence as well as solute movement.

Groundwater samples collected from conventional monitoring wells represent a mixture of waters from various fractures, which can be biased in several ways. In some cases, one fracture with exceptionally high concentrations can cause an appearance of relatively high concentrations throughout the open interval in the borehole if this fracture has high hydraulic conductivity; or fractures with high hydraulic conductivity but low concentration levels can mask the presence of high concentration zones. There is no way to determine from monitoring well data alone whether the water samples from the well provide a representative average or a severely biased result. In addition, these groundwater samples are rarely in equilibrium with the pore water concentrations in the matrix and therefore, tell us nothing about the distribution of chemical mass between the relatively immobile pore water of the matrix as compared to the free-flowing water in the fractures. The contaminants such as trichloroethene (TCE) migrate into these low permeability yet porous matrix blocks between fractures by molecular diffusion, which is driven by the chemical's concentration gradient in the aqueous (groundwater) phase. The matrix blocks between the fractures serve as large reservoirs for contaminant mass allowing matrix diffusion alone to cause complete dissolution of immiscible-phase solvents initially present in fractures. Therefore, matrix diffusion diminishes concentrations within plumes, which is a form of natural attenuation.

To investigate this form of natural attenuation, the distribution of TCE in a sandstone matrix was determined by chemical analysis of rock core subsamples taken from two boreholes at an industrial site in southern California. Use of TCE over several decades has resulted in contamination in the underlying Cretaceous Age arkosic sandstone, which contains occasional

beds of siltstone and claystone. Estimated hydraulic conductivities of this formation range from 1.5×10^{-5} to 8.5×10^{-11} cm/s and matrix porosities range from 5 to 16% based on measurements on 11 core samples. The two corehole locations were selected where existing monitoring wells installed within the upper 100-ft of the formation yielded groundwater concentrations of TCE in excess of 10 mg/L. Continuous cores were collected from top of rock (at or near groundsurface) to a depth of 360 ft into rock. Using a field protocol developed specifically for this project, small subsamples (15-180 grams wet-weight) were taken from the core for immediate preservation in 120 ml glass VOA bottles containing a pre-weighted amount of high purity methanol. Three hundred and fifty-nine subsamples were collected and preserved in methanol in the field, of which 271 samples were analyzed. The vertical spacing between discrete-depth subsamples generally ranged between 5 and 10-ft, with 0.5 to 1-ft spacing near many apparent fractures identified during core inspection. The methanol-extract analysis provides total concentrations for TCE per unit-weight of water-saturated rock. These data for the two locations are presented in Figures 1 and 2. Calculations using parameter values for matrix porosity and sorption convert these concentrations to equivalent groundwater concentrations in the matrix pore water.

The rock core concentrations with depth shown in Figures 1 and 2 exhibit large contrasts in TCE distribution. At the location in Figure 1, which is closest to a historical TCE release location, the highest TCE concentrations occur in the vadose zone between 30 and 70-ft depths. At this location, the water typically fluctuates between 70 and 80ft below ground surface (bgs). Almost no TCE was found greater than 130-ft bgs. However, at the second location (Figure 2), no detectable concentrations were obtained in the vadose zone, but high concentrations are observed to a maximum depth of 250-ft bgs. The detection limit for rock core analyses, expressed as equivalent groundwater concentration, varies from sample to sample and ranges from 100-500 ug/L. The highest concentration measured in the matrix pore water was 40 mg/L using a representative retardation factor of 3.75 and matrix porosity of 12%. There is considerable variability in measured concentrations over short distance intervals, indicating the location of contaminant pathways. The profiles of TCE concentration vs. depth show thick zones of TCE at relatively high concentration. Therefore, because the matrix porosity is very large relative to the fracture porosity and because sorption occurs primarily in the matrix, it is apparent that nearly all of the TCE mass at the two locations exists in the rock matrix where groundwater flow has minimal influence. This TCE mass in the matrix serves as a reservoir causing long-term groundwater contamination.

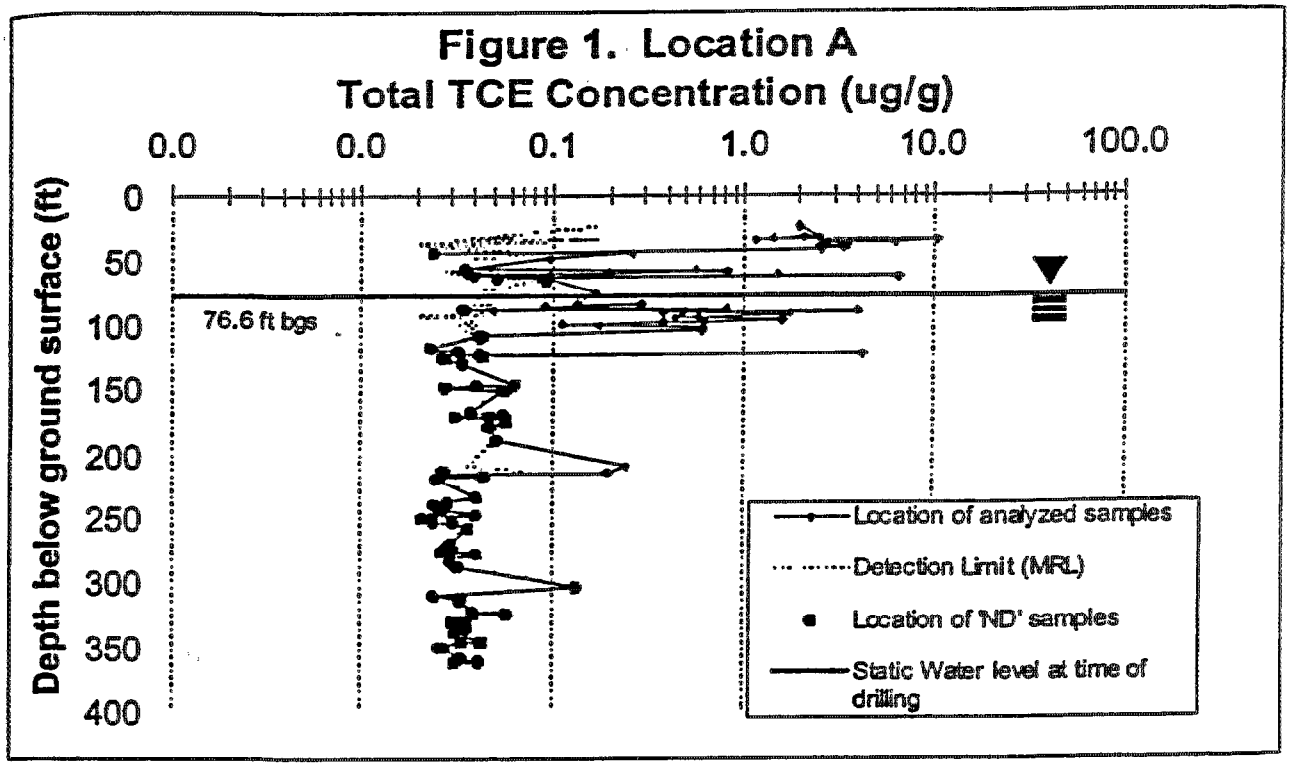


Figure 1. Location A
Total TCE Concentration (ug/g)
0.0
0.0
0.1
1.0
10.0
100.0
Depth below ground surface (ft)
0
50
100
150
200
250
300
350
400
76.6 ft bgs
Location of analyzed samples
Detection Limit (MRL)
Location of 'ND' samples
Static Water level at time of drilling

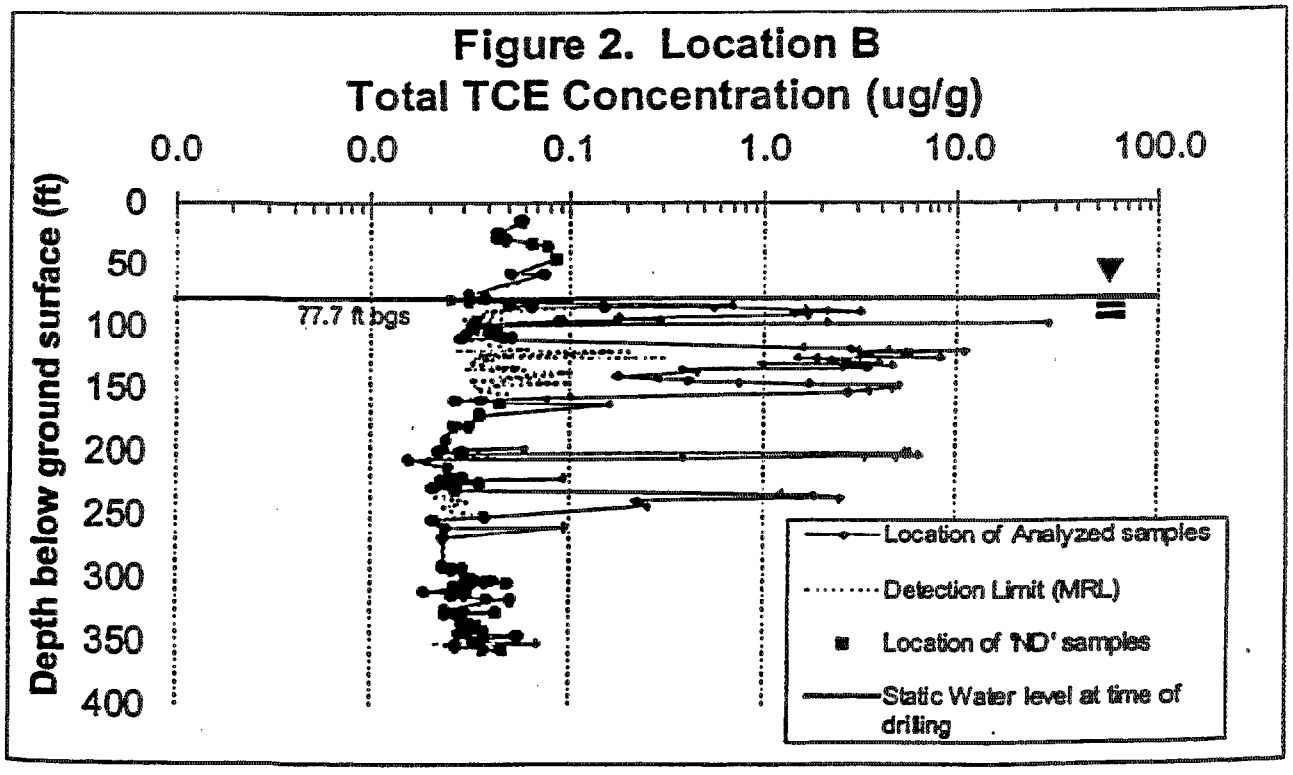


Figure 2. Location B
Total TCE Concentration (ug/g)
0.0
0.0
0.1
1.0
10.0
100.0
Depth below ground surface (ft)
0
50
100
150
200
250
300
350
400
77.7 ft bgs
Location of Analyzed samples
Detection Limit (MRL)
Location of 'ND' samples
Static Water level at time of drilling

LBNL-42718

Proceedings of the International Symposium on DYNAMICS OF FLUIDS IN FRACTURED ROCKS Concepts and Recent Advances

In Honor of Paul A. Witherspoon's 80th Birthday

February 10–12, 1999

Edited by

Boris Faybishenko

Earth Sciences Division
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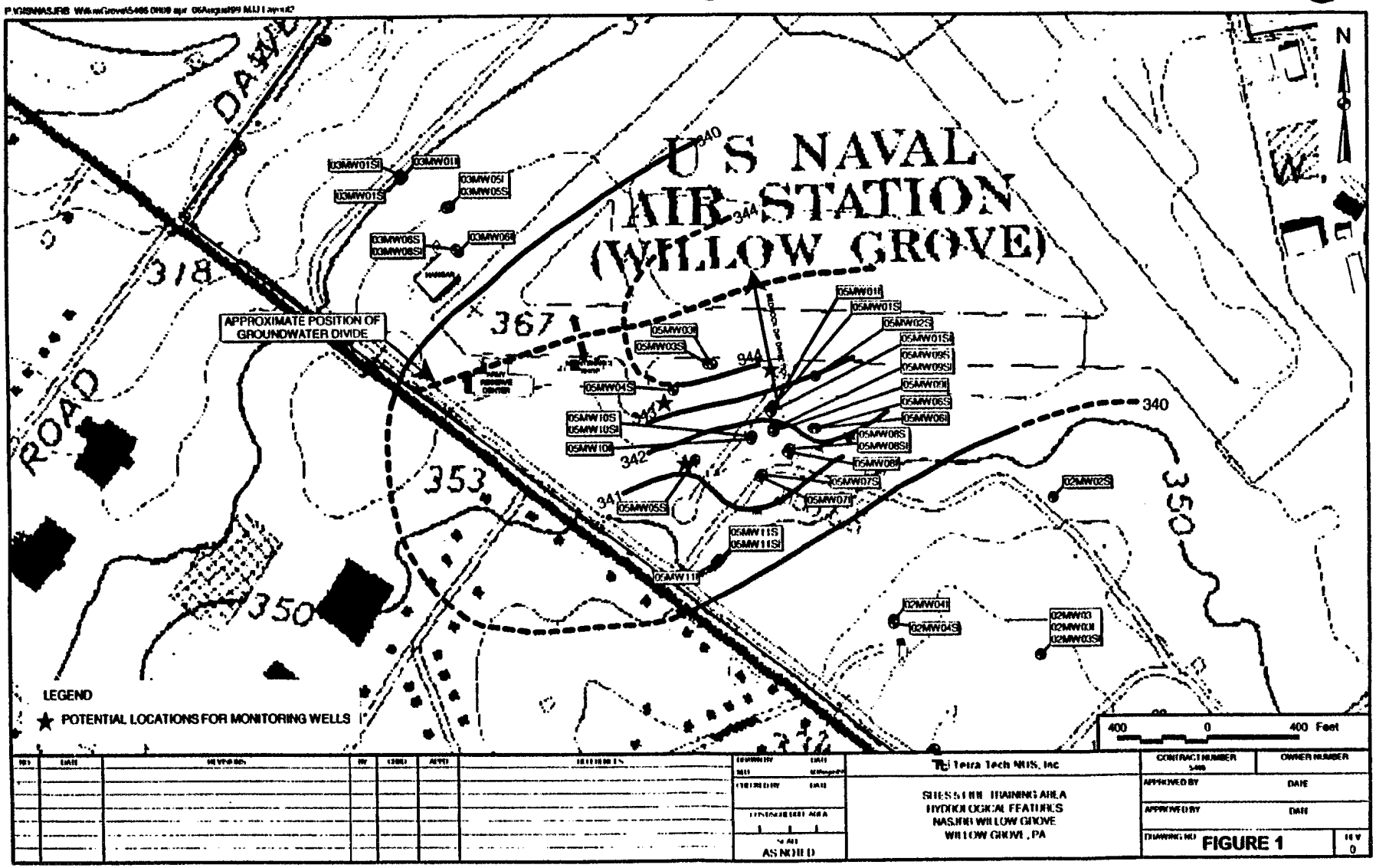
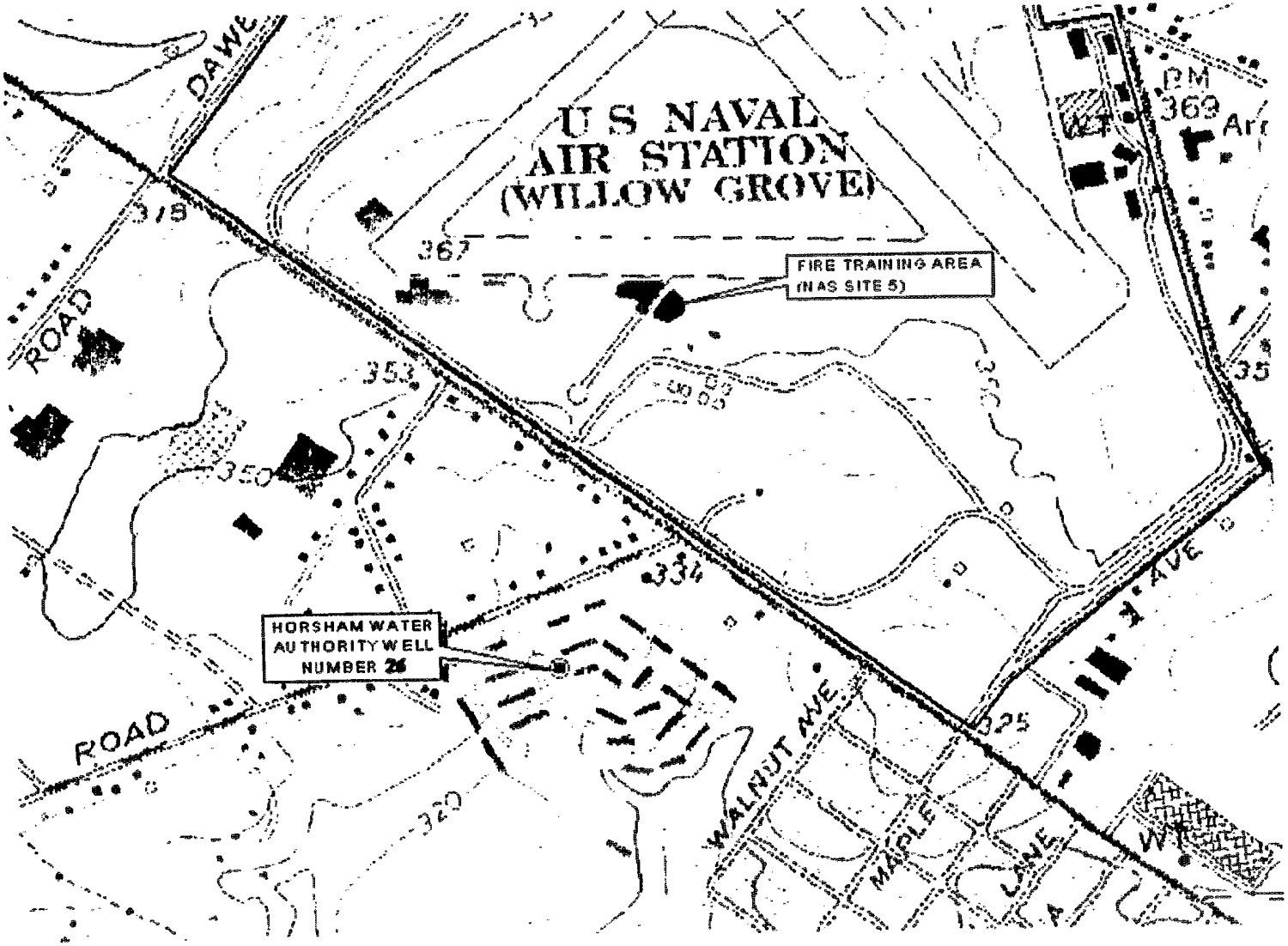
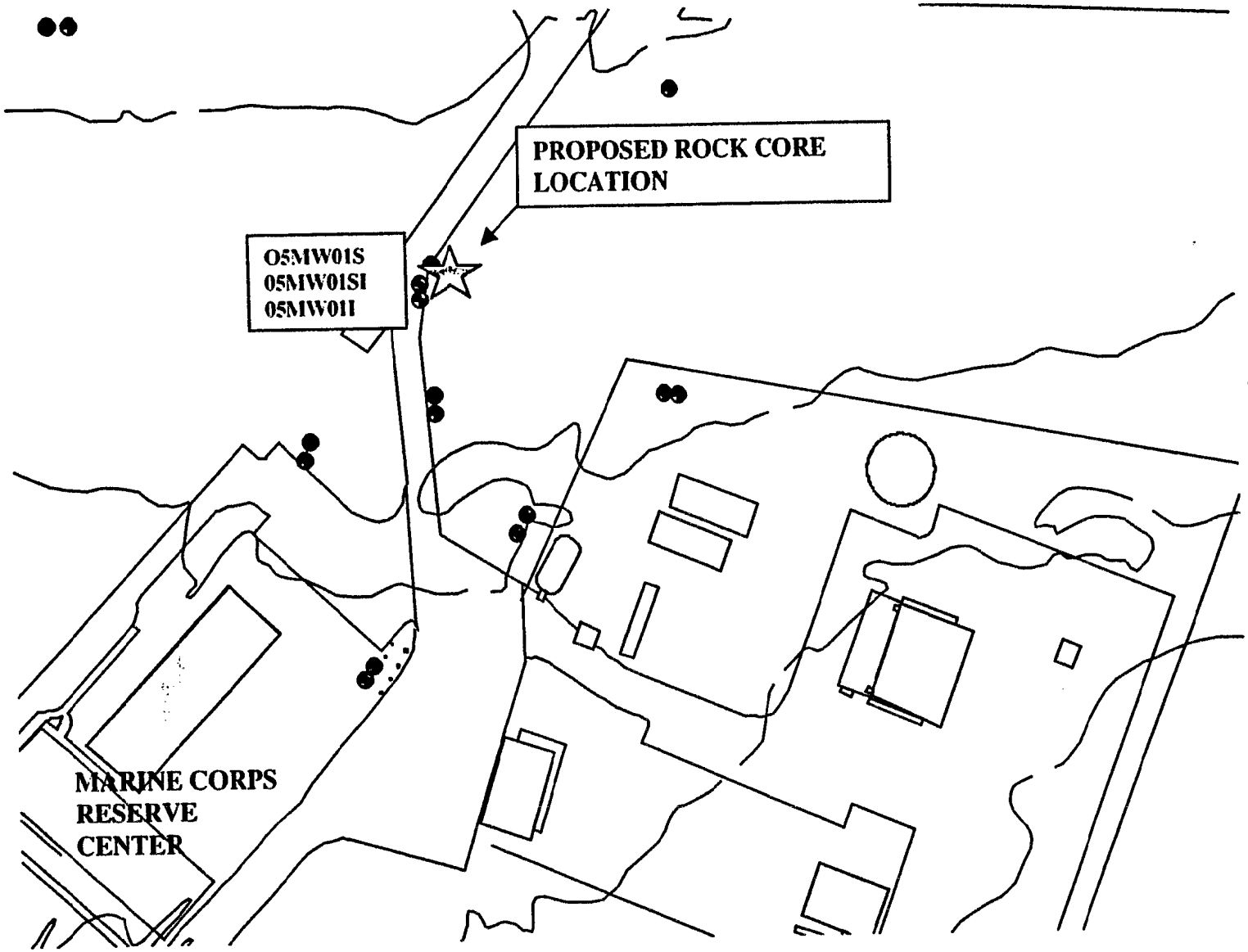
FIGURES


U.S. NAVAL AIR STATION (WILLOW GROVE)
N
APPROXIMATE POSITION OF GROUNDWATER DIVIDE
03MW01SI
03MW01I
03MW01S
03MW05I
03MW05SI
03MW06S
03MW06SI
03MW06I
05MW01I
05MW01S
05MW02S
05MW01SI
05MW09S
05MW09SI
05MW03I
05MW03S
05MW04S
05MW10S
05MW10SI
05MW10I
05MW06S
05MW06I
05MW08S
05MW08SI
05MW08I
05MW07S
05MW07I
05MW05S
05MW11S
05MW11SI
05MW11I
02MW02S
02MW04I
02MW04S
02MW03
02MW03I
02MW03SI
318
367
353
350
340
344
342
341
ROAD
LEGEND
POTENTIAL LOCATIONS FOR MONITORING WELLS
400 0 400 Feet
Tetra Tech NUS, Inc
SITE 5 FIRE TRAINING AREA
HYDROLOGICAL FEATURES
NAS JRB WILLOW GROVE
WILLOW GROVE, PA
AS NOTED
CONTRACT NUMBER
OWNER NUMBER
APPROVED BY
DATE
FIGURE 1
REV 0



NASJRB WILLOW GROVE SITE 5 - FIRE TRAINING AREA
HORSHAM WELL 26 LOCATION

FIGURE 2



NASJRB WILLOW GROVE

SITE 5 - FIRE TRAINING AREA

PROPOSED ROCK CORE LOCATION

FIGURE 3

Recent USGS Work

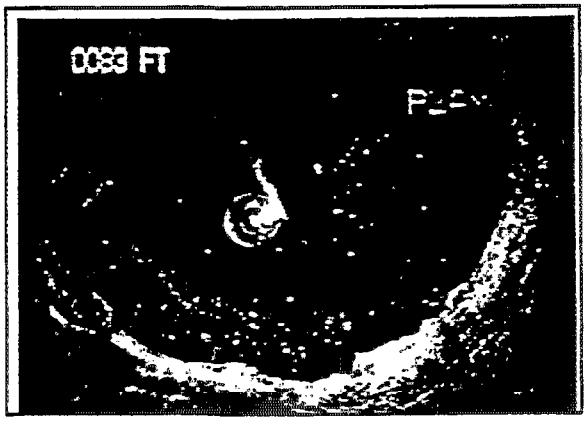
- Production Wells
  - Monitoring during Aquifer Tests
  - Geophysical Logging
  - Packer Testing
- Regional 'Water Table' Mapping
- Horsham Well #26 Shutdown

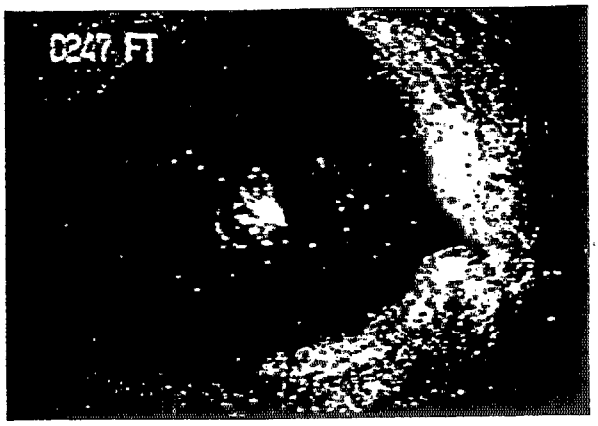
USGS

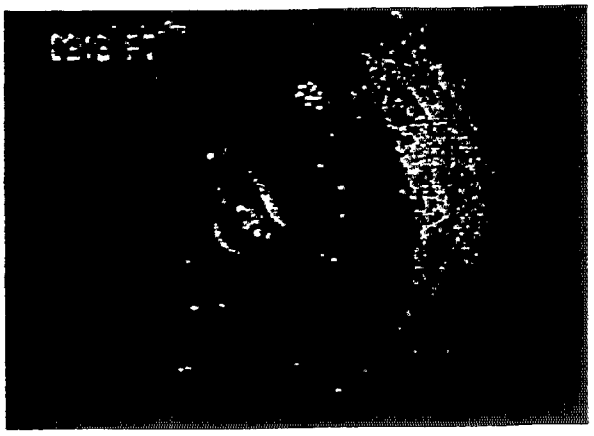
Navy Production Wells

- Geophysical Logging
- Monitoring during Aquifer Tests
  - Testing by TetraTechNUS
  - Continuous water levels
- Packer Testing

USGS







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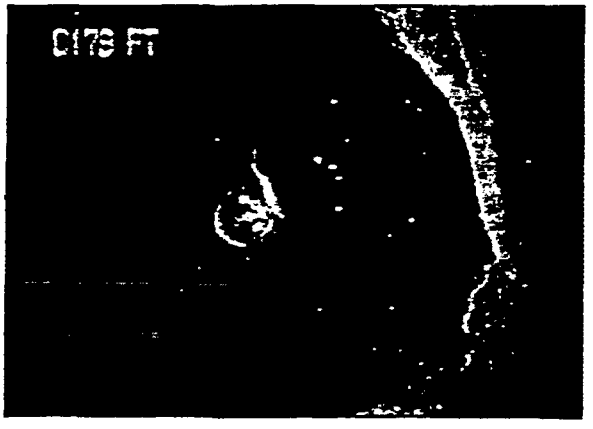
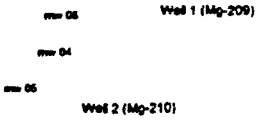
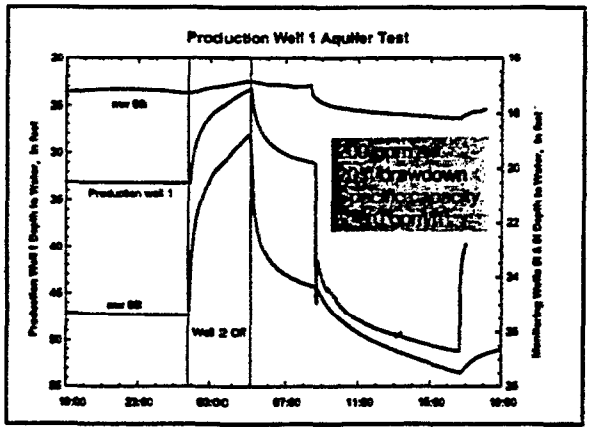


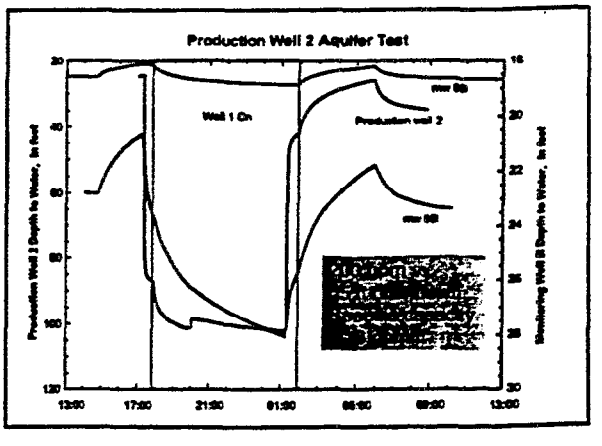
Navy Production Wells

- Geophysical Logging
- Monitoring during Aquifer Tests
  - Testing by TetraTechNUS
  - Continuous water levels
- Packer Testing

USGS



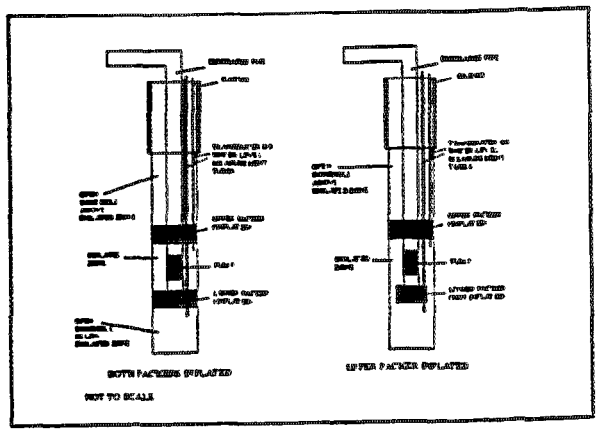


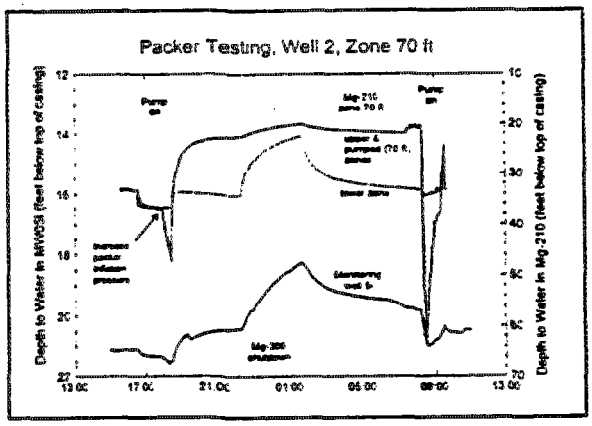


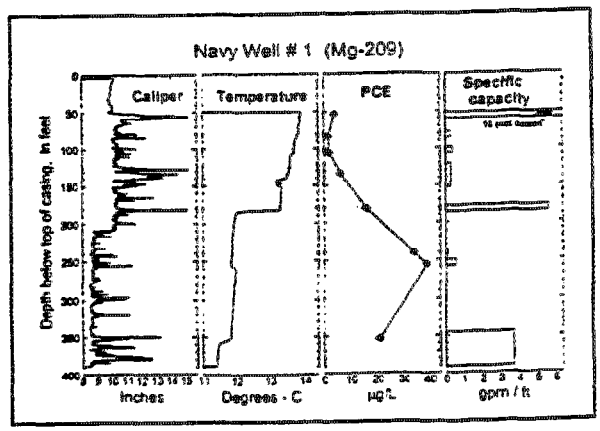
Navy Production Wells

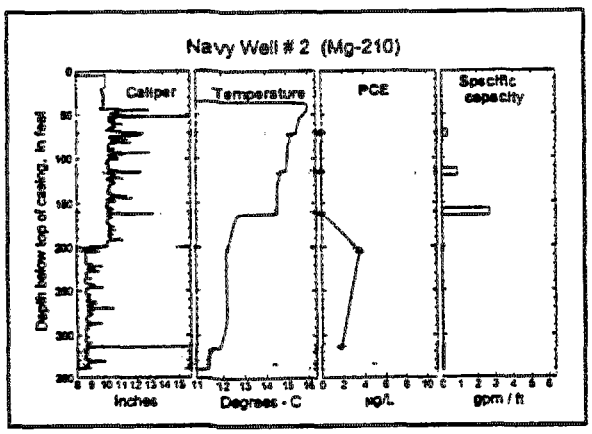
- Geophysical Logging
- Monitoring during Aquifer Tests
  - Testing by TetraTechNUS
  - Continuous water levels
- Packer Testing

USGS





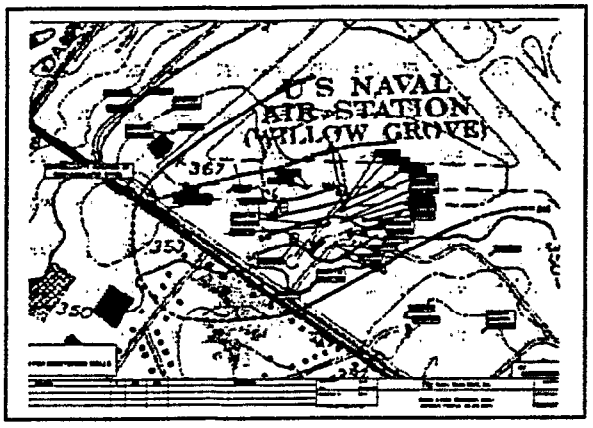


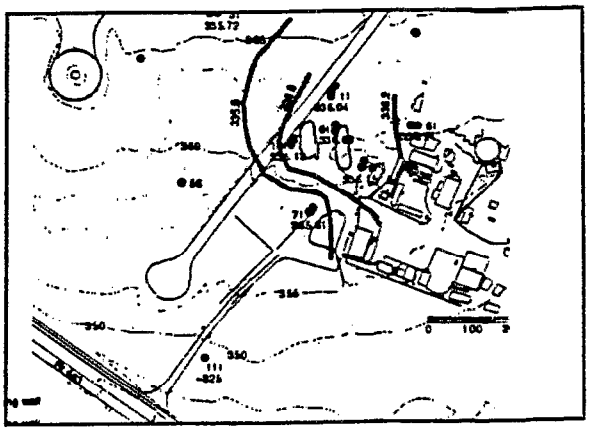


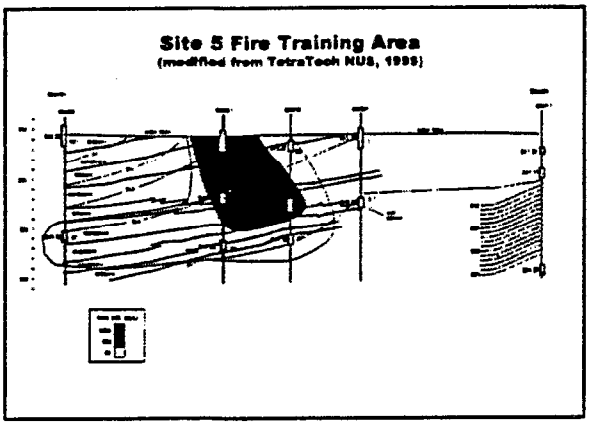
Water Table Mapping

- Monitoring indicator levels
- Regional levels and flow directions

USGS



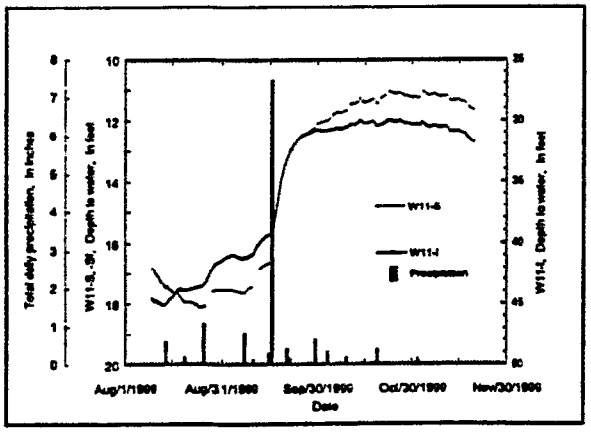


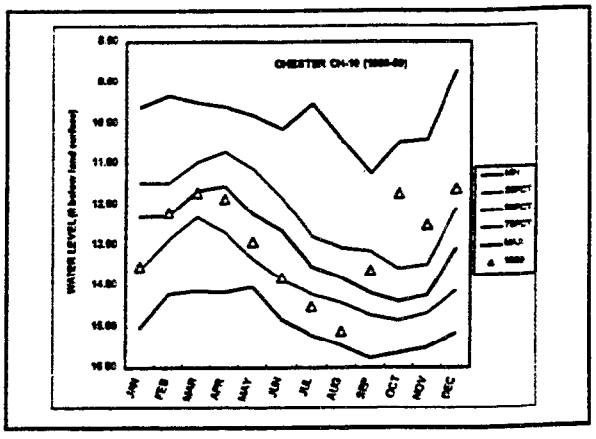


Water Table Mapping

- Monitoring indicator wells
- Regional levels and flow directions

USGS

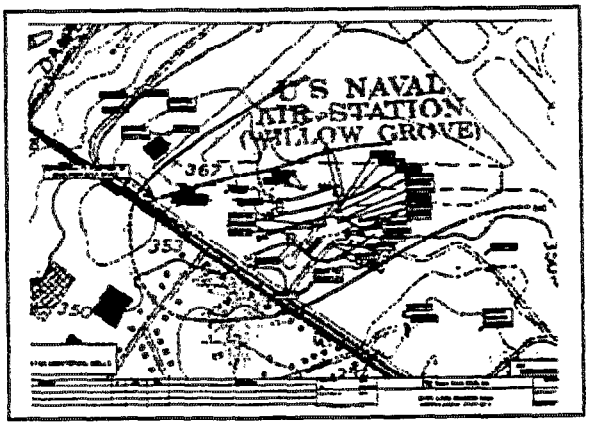




Water Table Mapping

- Monitoring indicator wells
- Regional levels and flow directions

USGS



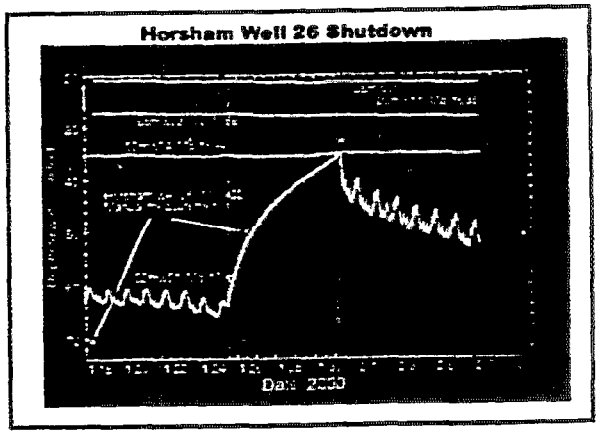
Shutdown Test of Horsham Well 26

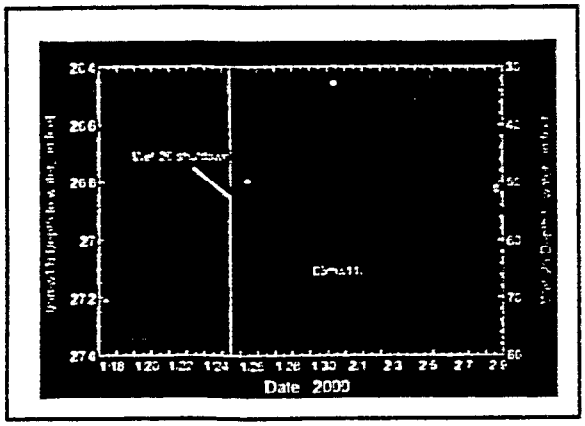
- Public-supply well on tank level switch
- Remove well from service for 6 days
- Monitor water levels
  - TetraTech NUS onsite wells
  - USGS well 26 & homeowner well
- Identify response to shutdown

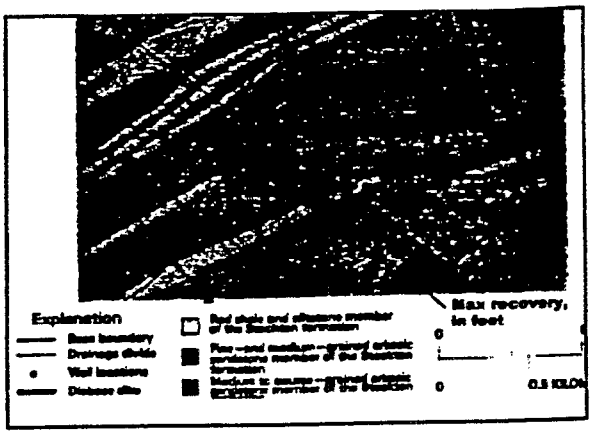
USGS

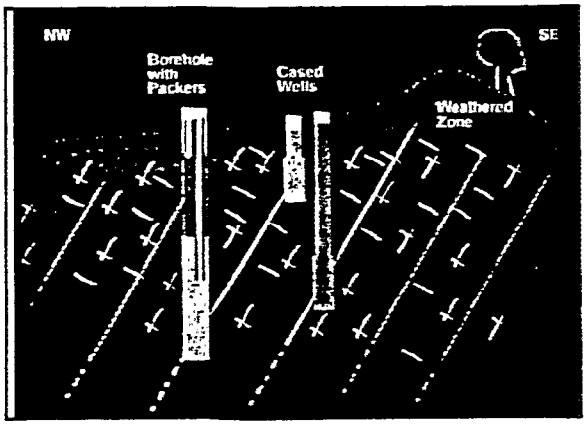
Maximum Recovery after 6 days

- Horsham # 26 37-40 ft
- 02 mw 01i 28 ft
- 05 mw 11i 0.5 ft
- 02 mw 01s 0.3 ft
- 02 mw 04i 0.3 ft
- All other wells had negative recovery, i.e., the water level dropped





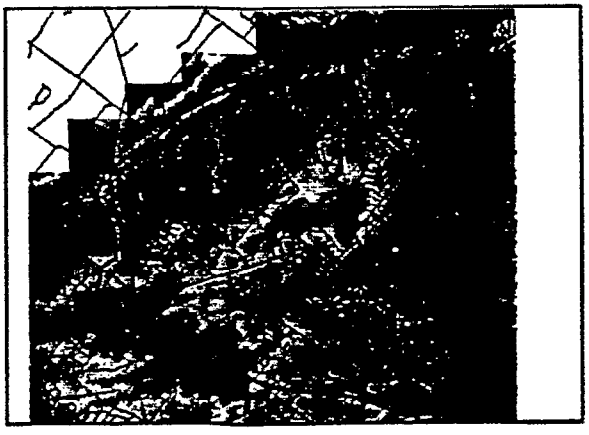


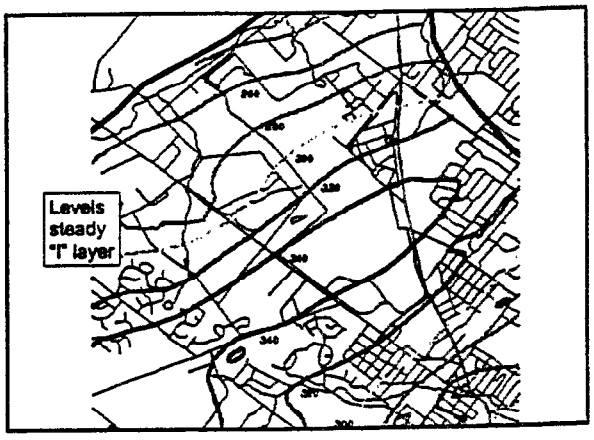


Quantitative Interpretation Ground-Water Flow Model

- Match simulated and measured water levels
- Steady state, pre-shutdown
- Transient response to shutdown
- Simulate contributing areas to streams and wells, average steady-state.

USGS





The End

- Hydrologic Atlas (1 sheet) for w.t. map
- Production well testing report
- Shutdown test report
- Near-term plans
  - Log new monitoring boreholes, Site 5
  - Measure VOC's in shallow core, Site 5

USGS

NAVY REVIEW OF EPIC PHOTOS
FORWARDED BY USEPA REGION III

IR SITE 5 – FIRE TRAINING AREA

INTRODUCTION

In April 1999, the USEPA Region III forwarded a Microsoft Powerpoint file showing a series of anomalies for each of the Navy's Installation Restoration (IR) Sites. These anomalies were identified as a result of the EPA's review of a series of aerial photos known as an EPIC Study. The Navy was requested to review the anomalies at each of the IR Sites and show that soil sampling was conducted in the area of an anomaly or provide rationale for why they are not an environmental concern. Although anomalies were identified for each of the Navy's four main IR sites, the information below will only focus on those anomalies associated with IR Site 5 – Fire Training Area. As each Remedial Investigation (RI) is finalized for each of the IR Sites, a separate rationale, similar to what is provided below, will be provided for each separate IR site and included into the Final RI for that particular site.

ANALYSIS OF EPIC PHOTOS

The first step in the Navy's review of the EPA's EPIC Photos was to independently review each EPIC feature to determine when the feature was first identified. This enabled the Navy to collect background information regarding the potential cause of the feature. A site visit was then conducted and environmental personnel interviewed to try and determine what the anomaly actually might have been. The site visit for IR Site 5 was conducted on October 24, 2000.

The features identified by the USEPA as being of potential concern at IR Site 5 were divided into three categories; (1) those features that are actually within the site boundaries of IR Site 5, (2) those features that are to the south of IR Site 5 and fall within the boundaries of IR Site 6, and (3) those features that are within the boundary of the former Marine Corps Reserve Training Compound.

FEATURES WITHIN IR SITE 5

These features are limited to those on the northern half of the powerpoint slide for Site 5. By overlaying the locations of soil sampling that was conducted as part of the Navy's Phase I and II RI's, it has been determined that each of these anomalies has been subjected to soil sampling and for those areas where the sample result is above a soil cleanup standard, it will be dealt with accordingly. Please note that soil cleanup standards have not yet been established for this site.

26GS appears present in August 17, 1971 as areas of high reflectivity. They appear similar in nature to the sand traps at the golf course, and may represent sand piles. One alternate explanation is the three light colored objects could be aircraft fuselages that were staged in this area and used as part of the fire fighting training effort.

TR6A may exist in the May 5, 1964 photo, but appears to be a part of a longer linear feature, most likely a road. No other evidence of this feature was found during the site visit.

TR6 (there are two, this is the eastern one) is most visible in May 5, 1964. It appears to be a linear trench or drainage ditch filled with water. There are other similar features (water filled ditches) evident on the photo. The photo was likely taken during a wetter period. The feature is visible in the June 1978 photo but appears as an area of different color. The most likely explanation for this could be a lack of vegetation. It is not discernable in the August 1971 photo. According to Jim Edmond, NASJRB Willow Grove Environmental department, this feature was a drainage ditch that was necessary to divert surface runoff during the time that re-grading was underway to raise the runway. This ditch bends south and directed flow towards the fence at the Marine Training Area. A lighter colored feature can be seen in the 1977 photo that looks like an drainage outlet from this surface water runoff system.

Attachment (6)

The other TR6 feature (the west one) and 19DG are co-located. The area is evident as early as August 17, 1971 and may represent storage piles for sand or airplanes. The area appeared to be sparsely covered with trees in May 5, 1964. By 1977, the area is more cleared of vegetation. The ground areas of TR6 and 19DG, and 26GS and 38DG are evident. Part of 19DG is dark in color and parallel to the roadway in the false color July 13, 1984 photo. By 1992, the roadway seems out of service and is now accessed from the south.

GS40 appears to be the burn area located at IR Site 5. This area was sampled during the Navy's Phase I RI effort.

DB6 is visible in many of the photos. It is the primary staging area for the FFTA, and has been extensively investigated during the Navy's Phase I and II RI efforts.

ST2 could not positively be identified, however it's location is very close to the approximate location of a trailer that is shown in figure 4.5.1 of the SI. This anomaly was found in the May 5, 1964 photo and again in July 13, 1984 photo. This anomaly was not located during the October 2000 site visit.

FEATURES WITHIN IR SITE 6

The southern half of the area are less evident features, usually of shorter duration. This second area includes IRP Site 6 – Former Rifle Range #1. This entire area has been re-worked between 1992 and is the present location of a newly constructed Marine Corps Reserve Training Building with an associated paved parking area surrounding the building.

10OS may be a feature visible on the August 17, 1971 photo Frame 5. It seems to be casting a shadow to the Northeast. This could be a parked vehicle, whatever the feature is, it is on a paved area.

7DG is difficult to discern on the photos. It could be part of the larger 38DG in the June 1, 1978 photos, frame 2 in particular. That may be the only set of photos of scale large enough to identify a feature of this size.

1DG is not evident in the photos, but may represent regrading for the parking area described in TR6. This would have occurred between 1984 and 1992.

DG 29 is visible in the August 17, 1971 photos, frame 5 but does not appear to be of a significant environmental concern.

38DG is most evident in the 1942 photos and appears to be the location of the raised rifle range berm for the Former Rifle Range #1 (IR Site 6). In the 1958 photos, the area is being regraded. In the 1978 photos, these two areas just appear to be bare ground. By 1984, the eastern feature is paved or gravel. It was reported that this area was cleared of bullet fragments prior to re-grading in 1965. This location, along with those to the south such as 7DG, 1DG, and DG 29 were re-graded to construct a parking area for recreational vehicles, and later in the 1990's to construct Buildings 176, 177, and 178. Lead sampling was conducted during construction of these new buildings and the results indicated that concentration of lead were detected but were below established background levels for the installation (memo from Jim Colter dated 05 May 1994).

DB6 appears in the June 1, 1978 photos. It also appears to be a feature in August 17, 1971 photo.
It is observed that the 1978 photo set is of the largest scale, enabling identification of numerous small ground scars in the vicinity of site 5. This photo set also clearly identifies a large construction project that appears to be the expansion of the TARMAC. The pond at the NW edge of the Air force's aircraft parking area also appears to be undergoing maintenance of some sort. Due to this construction, a number of larger ground scars and evidence of dirt staging can be found throughout the facility. The June 1978 photos appear to be from a drier period, as many dry areas appear as scars also.

FEATURES WITHING FORMER MARINE CORPS RESERVE TRAINING CENTER

The third area is the former Marine Corps Reserve Training Compound, a fenced area where no disposal activities were reported to have taken place. In general, the features are discussed in a north to south direction.

ST6 appears in June 1, 1978 as three large objects stored south of the fire fighter area. This area was describes as containing a number of small storage buildings of different sizes and construction methods built over a period of time and nicknamed the Marine Shanty-town. The construction of Buildings 638 and 639 eliminated the need for the shanty-town and the structures were removed. No disposal is reported to have taken place within the Marine compound.

OS3/OS5, 10OS appear to be within the Marine reserve area within the fence, where no disposal has been reported.

CONCLUSION

It has been concluded that all of the anomalies identified at IR Site 5 during the EPA's EPIC Study have had some level of soil sampling associated with it. It is further concluded that the other anomalies that are not directly associated with IR Site 5 are features that are not associated with disposal activities and are, therefore, not of any environmental concern.

EVALUATION OF GROUNDWATER SAMPLE DATA QUALITY
NASJRB WILLOW GROVE
PHASE II REMEDIAL INVESTIGATION

Problem Definition

Based on spot review of some of the groundwater sampling data from the phase II remedial investigation (RI), EPA expressed concerns that the proper low-flow protocol may not have been followed for groundwater sample collection. EPA requested that the Navy investigate the method used for each groundwater sample taken. EPA requested that a comparison to historical analytical result values from the same monitoring well, and an evaluation of data usability evaluation be performed for any sample obtained outside of conformance with the low-flow protocol. The objective was to identify potential impacts on the site conceptual model (and the associated human health risk evaluation) at any study site.

Summary of Investigation

Evaluation of data quality for groundwater samples obtained and analyzed in the RI has been completed. Several samples were not obtained in strict conformance with the "low-flow" procedure in the approved work plan. Analytical results from each sample obtained outside of strict procedural conformance were evaluated using a procedure discussed and agreed to between the Navy and EPA. The data quality evaluation procedure was designed to identify the highest reasonable conservative analyte concentration that could be expected for that sample point. There were cases where the imputed ("new") concentration at a particular groundwater sampling point (either the highest historical value or two times the phase II RI result) exceeded the concentration used to evaluate human health or ecological risk. However, there was no substantial change to the site conceptual model in any case. No changes are being recommended for the RI risk evaluations or overall conclusions as a result of the data quality evaluation. However, recommendations for additional investigative/confirmatory activities at individual sites are presented below. A summary of the sample result review procedures and conclusions follow.

ATTACHMENT (8)

Results

Site 1 – Privet Road Compound Area

VOCs – The highest historical value for PCE in monitoring well 01MW02S (110 ug/l in 1989) exceeds the 1997 RI result (ND) and the risk-based concentration (RBC [1.6 ug/l]). However, the 1991 RI result (non detect [ND]) and the 1998 Air Force result (ND) agree well with the 1997 RI result.

Although in this case the site conceptual model would be changed by imputing the highest historical value, the 1997 RI result agrees well with other samples obtained in this decade, so no changes to the RI conclusions or human health risk assessment are recommended.

Metals – No metals analyses were performed on groundwater samples in the 1997 RI.

Site 2 – Antenna Field Landfill

VOCs - The highest historical value for TCE in monitoring well 02MW02S (3J ug/l in 1989) exceeds the 1997 RI result (ND) and the RBC (1.6 ug/l). However, four consecutive samples (including the 1997 RI result), obtained after the 3J value, are all ND.

Although in this case the site conceptual model would be changed by imputing the highest historical value, the 1997 RI result agrees well with three other samples obtained after the 1989 3J value, so no changes to the RI conclusions or human health risk assessment are recommended.

Metals – No metals results from the 1997 RI were significantly lower than available historical results. Metals were generally in the range of available historical results for each location.

Site 3 – Ninth Street Landfill

VOCs – The 1997 RI tetrachloroethene (PCE) analytical results obtained from 03MW03S (5J ug/l), 03MW03SI (18 ug/l), 03MW04S (21 ug/l), 03MW06S (29 ug/l), and 03MW06I (39 ug/l) all exceed the RBC (1.1 ug/l) and four of five exceed the MCL (5 ug/l). The corresponding historical high concentration found in existing monitoring wells 03MW03S (13 ug/l), 03MW03SI (37 ug/l), and 03MW04S (84 ug/l) is higher than the corresponding 1997 RI concentration and also exceeds reference criteria. Two times the concentration found in new monitoring wells would be

03MW06S (58 ug/l), and 03MW06I (74 ug/l), which also exceed the corresponding RBC and MCL.

If these imputed higher concentrations were used, the representative concentration used for calculating estimated human health risk would be higher. However, the site conceptual model (approximate extent of the plume) would not change, and the RI conclusions, to perform a feasibility study to investigate ways to mitigate potential health effects and to perform additional groundwater investigations in the vicinity of the Army Reserve Complex, would not change.

RECOMMENDATION: Some or all of these monitoring wells should be sampled again as ongoing surveillance of plume movement or as part of pre-remedial action activities during or after the feasibility study phase.

Metals – The highest historical value for arsenic in monitoring wells 03MW03S and 03MW04S (3J ug/l in 1989) exceeds the 1997 RI result (ND) and the RBC (0.45 ug/l) but is lower than the MCL (50 ug/l). The highest historical value for nickel in monitoring well 03MW03S (1140J ug/l in 1989) exceeds the 1997 RI result (ND) the tap water RBC (73 ug/l) and the MCL (100 ug/l).

Two times the concentration of chromium found in new monitoring well 03MW06I (90.9 ug/l [RBC 18 ug/l; MCL 100 ug/l]), iron (8170 ug/l [RBC 1100 ug/l]), manganese (457 ug/l [RBC 84 ug/l]) and nickel (84 ug/l [RBC 73 ug/l; MCL 100 ug/l]) would exceed the reference criteria noted.

If these imputed higher metals concentrations were used, the representative concentration used for calculating estimated human health risk from groundwater would become higher and the site conceptual model (extent of the plume) would change. However, the two additional "hits" of arsenic from the historical investigations would have limited impact on the calculation of the estimated human health risk because they are near the value of the representative concentration for arsenic used in the risk assessment (1.98 ug/l). Also, using the imputed 2 times the concentrations of chromium, iron, and manganese found in 03MW06I may be considered overly conservative because these metals were not encountered at levels of concern in historical sampling events, and the sample endpoint turbidity value (~400 NTU) encountered in this newly-installed monitoring well indicates the type of sampling difficulty that could result in metals results biased high (due to non-dissolved metals). The RI conclusions to perform a feasibility study to investigate ways to mitigate potential health effects and to perform additional groundwater investigations in the vicinity of the Army Reserve Complex would not change.

RECOMMENDATION: Monitoring well 03MW06I should be sampled using low-flow techniques and analyzed for metals during the next sampling activity in the vicinity of the Army Reserve Complex.

Site 5 – Fire Training Area

VOCs – The 1989 1,1,1-trichloroethane (1,1,1-TCA) analytical result obtained from 05MW01I (260 ug/l), exceeds the 1997 RI result (54 ug/l) as well as the lowest drinking water advisory reference criterion (200 ug/l) and the MCL (200 ug/l). However, three other historical samples from 05MW01I were all ND. In this case the highest historical concentration does not exceed the RBC (790 ug/l).

In the (new) monitoring well samples where no historical results are available, application of the imputed 2 times the 1997 RI concentrations would result in some "hits" being higher for the human health risk assessment estimation, but no new "hits" would result.

In this case, the site conceptual model would change by imputing the highest historical value for 1,1,1-TCA. However, the 1997 RI result agrees well with three other historical samples obtained from 05MW01I. The conceptual model change would only be the addition of another exceedence in 05MW01I, where a more significant exceedence of PCE has already been noted. Therefore, no changes to the RI conclusions, which recommend an FS to evaluate options for Site 5 groundwater, or to the human health risk assessment are recommended.

Metals – No change to the site conceptual model would result from applying the highest historical concentration or two times the 1997 RI value (in the case where no historical value is available).

From: Kevin C. Kilmartin
To: Russ Turner

Date: July 7, 1999

Re: NASJRB WILLOW GROVE: Analysis of Screened Intervals and Fracture Zones for Monitoring Wells Installed During the Phase II RI

TtNUS was tasked to determine whether any of the screened monitoring wells installed during the Phase II RI were completed in such a manner that the vertical position of the well pump could affect the analytical results when sampling the well under low-flow sampling procedures. In order for the vertical position of the pump to influence the sampling results, the groundwater for that well must be migrating or flowing from multiple, hydraulically isolated fractures that are spaced widely enough that the groundwater from one fracture could be preferentially sampled over the groundwater from the other fracture(s).

A top priority of the borehole retrofitting program was to construct the monitoring wells to obtain groundwater from only one groundwater zone and to not interconnect different groundwater zones. To reach this goal, all boreholes were geophysically logged (including borehole flowmeters), and the potential construction plans were reviewed and discussed with the USGS. The resultant individual well plans were then presented to EPA prior to the construction of the wells. I have reviewed the borehole geophysical logs and the well construction details to reconfirm that the monitoring wells were properly constructed as originally scoped and are obtaining groundwater from only one zone. Therefore, the exact vertical position of the pump within the well screen should not matter, because water can only enter the well through the screen, and all the water entering the screen is from the same zone. Some of my observations that led to this conclusion include:

- The vast majority of wells are screened across only one fracture. Therefore, the groundwater can only be entering the screen through that fracture.

- Some wells are screened across a fracture zone, or a series of smaller fractures rather than one distinct larger fracture. These fractures (typically two or three fractures within a five-foot interval) are very closely spaced vertically (generally on the order of one or two feet), and there was no lithologic indications of confining layers between these fractures. Fractures that are spaced so closely vertically are almost certainly hydraulically interconnected; it would be very unusual for these fractures to be hydraulically isolated from each other. In fact, due to the presence of high-angle vertical fractures (from the television survey), some of these "fracture zones" may be the same fracture intercepted on opposite sides of the borehole walls.

- The flowmeter was carefully considered for each well construction. Screens were extended across multiple fractures only if there was no evidence of intraborehole flow between the respective fractures. In fact, some screens were constructed specifically to monitor one fracture(s) but not the other(s) because of evidence of intraborehole flow.

ATTACHMENT (9)

July 2, 1999

NASJRB WILLOW GROVE
REPLY TO EPA TOXICOLOGICAL COMMENTS
DRAFT PHASE II REMEDIAL INVESTIGATION REPORT

GENERAL COMMENTS

1. The decision criteria employed for determination whether a compound is above background and PCOC and CPOC selection should be further explained. As written, the most useful information concerning the selection of a compound as a CPOC, PCOC or significance above background is shown on individual tables which summarize the results of statistical testing. The footnotes should be expanded upon in Section 2.3 of the report and a logic flowchart presented to identify the yes/no result of each test.

Reply: Concur. Selection criteria for chemicals of potential concern will be presented in more detail in Section 2.3. A logic flowchart and/or table will accompany the updated text to further clarify the selection process.

2. Section 3.1.1.4 indicates that representative concentrations were calculated based on both 1997 and 1991 RI data. Data from these two sampling events were pooled, but there is no indication whether sampling populations from each event were comparable. The text should be revised and an analysis presented to ensure that pooling of data for each contaminant was appropriate.

Reply: Concur. The text in Section 3.1 1.4 will be revised to better reflect what was done. Generally (for all media except groundwater) the data sets from 1991 and 1997 were combined because the Work Plan was formulated to obtain samples to further define extent of contamination (i.e., fill data gaps). At each site, the contamination of concern resulted from past practices ending 20 or more years ago, no new contamination has been deposited in the period of the investigation, and the sampling plan was predicated on filling data gaps in contiguous media within the area of concern.

In the case of groundwater, all existing monitoring wells were sampled and risk assessment was calculated based on the most recent (1997) data only. However, at Site 1, there was no metals data from the 1997 sampling round. Therefore, for Site 1, the two data sets were combined (inorganics and organics) to permit human health risk calculations to proceed. In the case of Site 1, the two groundwater data sets will be compared as suggested.

3. Tables are included in the document that present the results of a comparison of surface water analytical data to applicable or relevant and appropriate requirements (ARARs) and to be considered (TBC) values. There are no freshwater chronic ambient water quality criteria (AWQC) provided for aluminum, beryllium or iron (see, for example, Table 4-12). This is incorrect. The aluminum criterion is pH dependent and may be calculated based on site-

specific or proxy pH values. The iron criterion is 1,000 micrograms per liter (µg/L). The beryllium value is 5.3 µg/L (lowest observed effect level). All tables should be updated using applicable freshwater chronic AWQC.

Reply: Concur. All appropriate tables will be updated using chemical-specific freshwater chronic AWQC values.

4. References for citations in the human health risk assessment portions of the RI report are not provided. References for all citations located throughout the RI report should be provided.

Reply: Concur. References will be added or updated in the human health risk assessment portions of the report.

5. Section 3 presents a discussion of five potential receptors for the NASJRB Willow Grove sites. In addition, extensive risk calculations were prepared for each receptor for each site. However, the human health risk assessment conclusions for each site do not present the results for all five receptors and typically only discuss the results for one or two receptors (i.e., occupational workers and recreational child). It is unclear why the results for each receptor at each site are not discussed in the conclusions, especially when several receptors at each site usually meet EPA's acceptable risk criteria. The results of risk calculations performed for all receptors and all media at each site should be discussed in the conclusion sections for each site so that human health risks for all scenarios are clearly defined. If the results for all five receptor scenarios are not discussed because the scenarios are not applicable for each site (e.g., building residential homes on Site 2, Antenna Road Landfill, or Site 3, Ninth Street Landfill), then these receptors and scenarios should have been screened out in the exposure assessment (Section 3.1.3).

Reply: Concur. The conclusions for each of the site-specific human health risk assessments will be updated to include text concerning all of the carcinogenic and noncarcinogenic risks for all potential receptors that are exposed to media at that site.

6. The evaluation of the sites includes data collected from various media in 1991 during the Phase I Remedial Investigation in addition to the Phase II data. The use of different temporal data sets should be discussed and the figures should be revised to clearly distinguish between samples collected during the two events.

Reply: Data appearing on maps could pertain to the 1991 or 1997 remedial investigations. In the case of groundwater sample results reported on figures, the year the groundwater sample was obtained is noted with the result. For other media, such as sediments and soils, the text and tables provide the requested information.

July 2, 1999

7. In order to avoid potentially unnecessary institutional controls to limit excavation, subsurface soil risk evaluations to potential receptors, including future residents should be performed. Similarly, residential rather than industrial RBCs should be used to screen for COPCs. Otherwise, an institutional control may be necessary to ensure that the property remains industrial/commercial and is not used for residential development at any time in the future.

Reply: Future land use at the base is known. The land use will remain as industrial/light industrial and NASJRB Willow will remain as an active military base. Residential and recreational land uses presented in each site-specific human health risk assessment are hypothetical in nature. No change is required to the risk assessment RBCs. Appropriate caveats will be inserted in the text to indicate that if the land use designation were to change in the future, the human health risk assessment selection criteria may need to be revised. — Residential RBCs must be used unless restrictions are already inplace (EPA, 2/7/01)

SPECIFIC COMMENTS

1. **Executive Summary, Site 1 - The Privet Road Compound, Page ES-1, Paragraph 2.** This paragraph states that "Consistent with United States Environmental Protection Agency (EPA) guidelines, the 'reasonable anticipated future land use' exposure scenario is Occupational Worker." It is unclear what these guidelines are and how this land use was determined. The human health risk assessment analyses for Site 1, as detailed in Tables 4-24, 4-25, 4-26, and 4-27, indicate that the following scenarios have acceptable carcinogenic and noncarcinogenic risks associated with them: adult/child trespasser, recreational child, and excavation worker. Risks to the occupational worker just slightly exceed EPA's acceptable carcinogenic risk criteria. Cancer and noncancer risks to residents exceed EPA's risk criteria. The paragraph should be revised to accurately reflect the results of all human health and ecological risk assessment analyses. This comment also applies to Section 4.9.

Reply: The subject EPA guidelines referred to, OSWER Directive No. 93555.7-4 (Land Use in the CERCLA Remedy Selection Process), and OSWER 9355.0-69 (Rules of Thumb for Superfund Remedy Selection) will be referenced in the text.

The current and future land use of this property is controlled by the United States Navy. The anticipated land use is described in the Master Plan for NASJRB Willow Grove. The anticipated future land use could change from the current military-type use if there were an Air Station property transfer. There are generally only two methods of transferring this type of Navy property, through BRAC (which would take an act of Congress) or through the GSA, (in the event that parcels were to be declared excess). Under BRAC, action would be taken in accordance with the legislation. Excess property transfers handled by GSA could be conveyed with deed restrictions as determined at the time of property transfer. In

any event, CERCLA 120(h) requirements would apply.

The objective of the Executive Summary and the Evaluation Summary sections is to summarize the pertinent information for a reviewer who may not be interested in studying the entire voluminous RI document. Therefore some information, available elsewhere in the RI/FS record, is not repeated in the summary sections.

This paragraph states that "human health risk assessment ... found that the site does not pose a threat to current or reasonably anticipated future human ... receptors." However, the human health risk assessment analyses indicated that the EPA's acceptable carcinogenic and noncarcinogenic risk criteria are exceeded for adult/child residents. In addition, the occupational worker just slightly exceeds EPA's acceptable carcinogenic risk value. This paragraph should be revised to clearly state the conclusions from the human health risk assessment. This comment also applies to Section 4.9.

Reply: The text will be corrected to reflect that the occupational worker scenario just slightly exceeds EPA's acceptable carcinogenic risk value.

2. **Executive Summary, Site 2 - The Antenna Field Landfill, Page ES-2, Paragraph 6.** This paragraph states that "Consistent with EPA guidelines, the 'reasonable anticipated future land use' exposure scenario is Occupational Worker." It is unclear what these guidelines are and how this land use was determined. The human health risk assessment analyses for Site 2, as presented in Tables 5-25, 5-26, 5-27, and 5-28, indicate that the following scenarios have acceptable carcinogenic and noncarcinogenic risks associated with them: occupational worker, adult/child trespasser, recreational child, and excavation worker. Cancer and noncancer risks to residents exceed EPA's risk criteria. The paragraph should be revised to accurately reflect the results of all human health and ecological risk assessment analyses. This comment also applies to Section 5.9.

Reply: The subject EPA guidelines referred to, OSWER Directive No. 93555.7-4 (Land Use in the CERCLA Remedy Selection Process), and OSWER 9355.0-69 (Rules of Thumb for Superfund Remedy Selection) will be referenced in the text.

The current and future land use of this property is controlled by the United States Navy. The anticipated land use is described in the Master Plan for NASJRB Willow Grove. The anticipated future land use could change from the current military-type use if there were an Air Station property transfer. There are generally only two methods of transferring this type of Navy property, through BRAC (which would take an act of Congress) or through the GSA, (in the event that parcels were to be declared excess). Under BRAC, action would be taken in accordance with the legislation. Excess property transfers handled by GSA could be conveyed with deed restrictions as determined at the time of property transfer. In any event, CERCLA 120(h) requirements would apply.

July 2, 1999

The objective of the Executive Summary and the Evaluation Summary sections is to summarize the pertinent information for a reviewer who may not be interested in studying the entire voluminous RI document. Therefore some information, available elsewhere in the RI/FS record, is not repeated in the summary sections.

3. **Executive Summary, Site 2 - The Antenna Field Landfill, Page ES-3, Paragraph 1.** This paragraph states that "human health risk assessment found that the site does not pose a threat to current or reasonably anticipated future human receptors." However, the human health risk assessment analyses indicate that EPA's acceptable carcinogenic and noncarcinogenic risk criteria are exceeded for adult/child residents. This paragraph should be revised to clearly state the conclusions from the human health risk assessment. This comment also applies to Section 5.9.

Reply: This paragraph appears correct as it is written.

4. **Executive Summary, Site 3 - Ninth Street Landfill, Page ES-3, Paragraph 2.** This paragraph states that "Consistent with EPA guidelines, the 'reasonable anticipated future land use' exposure scenario is Occupational Worker and Recreational Child." It is unclear what these guidelines are and how these land uses were determined. The human health risk assessment analyses for Site 3, as detailed in Tables 6-23, 6-24, 6-25, and 6-26, indicate that the following scenarios have acceptable carcinogenic and noncarcinogenic risks associated with them: occupational worker, adult/child trespasser, recreational child, and excavation worker. However, the human health risk assessment analysis indicates that EPA's acceptable noncancer criteria is exceeded for adult/child residents. The paragraph should be revised to accurately reflect the results of all human health and ecological risk assessment analyses. This comment also applies to Section 6.9.

Reply: The subject EPA guidelines referred to, OSWER Directive No. 93555.7-4 (Land Use in the CERCLA Remedy Selection Process), and OSWER 9355.0-69 (Rules of Thumb for Superfund Remedy Selection) will be referenced in the text.

The current and future land use of this property is controlled by the United States Navy. The anticipated land use is described in the Master Plan for NASJRB Willow Grove. The anticipated future land use could change from the current military-type use if there were an Air Station property transfer. There are generally only two methods of transferring this type of Navy property, through BRAC (which would take an act of Congress) or through the GSA, (in the event that parcels were to be declared excess). Under BRAC, action would be taken in accordance with the legislation. Excess property transfers handled by GSA could be conveyed with deed restrictions as determined at the time of property transfer. In any event, CERCLA 120(h) requirements would apply.

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The objective of the Executive Summary and the Evaluation Summary sections is to summarize the pertinent information for a reviewer who may not be interested in studying the entire voluminous RI document. Therefore some information, available elsewhere in the RI/FS record, is not repeated in the summary sections.

5. **Executive Summary, Site 3 - Ninth Street Landfill, Page ES-3, Paragraph 2.** This paragraph states that the "human health risk assessment found that the site does not pose a threat to current or reasonably anticipated future human receptors." However, the human health risk assessment analyses indicated that EPA's acceptable noncarcinogenic risk criteria is exceeded for adult/child residents. This paragraph should be revised to clearly state the conclusions from the human health risk assessment. This comment also applies to Section 6.9.

Reply: This Paragraph appears correct as written. In an attempt to keep this summary concise, only pertinent information is presented. Other information is readily available elsewhere in the RI/FS documents.

6. **Executive Summary, Site 5 - The Fire Training Area, Page ES-4, Paragraph 7.** This paragraph states that "Consistent with United States Environmental Protection Agency (EPA) guidelines, the 'reasonable anticipated future land use' exposure scenario is Occupational Worker". It is unclear what these guidelines are and how this land use was determined. The human health risk assessment analyses for Site 3, as detailed in Tables 7-23, 7-24, 7-25, and 7-26, indicate that the following scenarios have acceptable carcinogenic and noncarcinogenic risks associated with them: occupational worker, adult/child trespasser, and recreational child. However, the human health risk assessment analysis indicates that EPA's acceptable cancer and noncancer risk criteria are exceeded for adult/child residents. In addition, the EPA's noncancer criteria are exceeded for a future excavation worker. The paragraph should be revised to accurately reflect the results of all human health and ecological risk assessment analyses. This comment also applies to Section 7.9.

Reply: The subject EPA guidelines referred to, OSWER Directive No. 93555.7-4 (Land Use in the CERCLA Remedy Selection Process), and OSWER 9355.0-69 (Rules of Thumb for Superfund Remedy Selection) will be referenced in the text.

The current and future land use of this property is controlled by the United States Navy. The anticipated land use plan is described in the Master Plan for NASJRB Willow Grove. The anticipated future land use could change from the current military-type use if there were an Air Station property transfer. There are generally only two methods of transferring this type of Navy property, through BRAC (which would take an act of Congress) or through the GSA, (in the event that parcels were to be declared excess). Under BRAC, action would be taken in accordance with the legislation. Excess property transfers handled by GSA could be conveyed with deed restrictions as determined at the

time of property transfer. In any event, CERCLA 120(h) requirements would apply.

The objective of the Executive Summary and the Evaluation Summary sections is to summarize the pertinent information for a reviewer who may not be interested in studying the entire voluminous RI document. Therefore some information, available elsewhere in the RI/FS record, is not repeated in the summary sections.

7. **Executive Summary, Site 5 - The Fire Training Area, Page ES-5, Paragraph 1.**
This paragraph states that "human health risk assessment found that the site does not pose a threat to current or reasonably anticipated future human. receptors." However, the human health risk assessment analyses indicated that EPA's acceptable carcinogenic and noncarcinogenic risk criteria are exceeded for adult/child residents. This paragraph should be revised to clearly state the conclusions from the human health risk assessment. This comment also applies to Section 7.9.

Reply: This paragraph appears to be correct as written.

8. **Executive Summary, Human Health Risk Assessment, Site 1 - The Privet Road Compound, Page ES-19, Paragraph 5.**
This paragraph states that "the total cumulative carcinogenic risk for the current occupational worker is equal to EPA's target carcinogenic risk range at Site 1 for the RME scenario." However, Table 4-24 indicates that the calculated total risk is 1.20E-4 which marginally exceeds the EPA target carcinogenic risk range of 1.0E-4 to 1.0E-6. Consideration of site-specific conditions, as well as risk management factors, should dictate the need for action (or not) in this instance. In addition, the results for human health risk assessment analyses for all receptors should be included in this paragraph.

Reply: The text will be corrected to reflect that the occupational worker scenario just slightly exceeds EPA's acceptable carcinogenic risk value.

9. **Executive Summary, Human Health Risk Assessment, Site 2 - The Antenna Field Landfill, Page ES-21, Paragraph 5.**
This paragraph states that "noncarcinogenic HIs for the potential receptors at Site 2 are less than 1.0". However, Tables 5-27 and 5-28 indicate that the total cumulative RME and CTE noncarcinogenic risk for adult/child residents exceed the EPA's noncarcinogenic HI value. The text should be revised so that it is consistent with the summary data tables. In addition, the results for human health risk assessment analyses for all receptors should be included in this paragraph.

Reply: This section appears to be correct as written. The objective of the Executive Summary and the Evaluation Summary sections is to summarize the pertinent information for a reviewer who may not be interested in studying the entire voluminous RI document. Therefore some information, available elsewhere in the RI/FS record, is not repeated in the

summary sections.

10. Executive Summary, Human Health Risk Assessment, Site 3 - Ninth Street Landfill, Page ES-24, Paragraph 5.

This paragraph states that "the total cumulative carcinogenic risk for the future residential receptor is 9E-05 under the RME" risk scenario. However, Table 6-23 indicates that the total cumulative carcinogenic risk for the future residential receptor is 4.54E-05 under the RME risk scenario. This paragraph also states that "the RME risk for groundwater consumption ... for a future residential receptor is 7E-05". However, Table 6-23 indicates that the carcinogenic risk for groundwater consumption for a future residential receptor is 1.51E-05. The text should be revised to correct these inconsistencies. In addition, the results for human health risk assessment analyses for all receptors should be included in this paragraph.

Reply: Concur. The text will be revised for numeric inconsistencies.

The objective of the Executive Summary and the Evaluation Summary sections is to summarize the pertinent information for a reviewer who may not be interested in studying the entire voluminous RI document. Therefore some information, available elsewhere in the RI/FS record, is not repeated in the summary sections.

This paragraph states that iron and barium in groundwater are main contributors to the RME and CTE noncarcinogenic risk at Site 3 for a future residential child and adult receptor. However, the results shown in Appendix J, Tables J-35 and J-36, appear to indicate that chromium and manganese are stronger contributors to risk in groundwater. In addition, this section also states that iron and dieldrin in surface soil are the main contributors to noncarcinogenic risk at Site 3. However, the individual contaminant results shown in Appendix J, Table J-5 and J-6 indicate that for a future residential child, the main contributor is iron followed by aluminum, manganese, and dieldrin. For a future residential adult, the main contributor is iron, followed by aluminum, dieldrin, and manganese. The text should be revised so that it is consistent with the data tables or an explanation as to how dieldrin was chosen as a main contributor should be included.

Reply: Concur. The text will be revised for risk driver inconsistencies.

11. Section 2.0, Field Investigation, Page 2-1.

Field activities and collection of samples which were conducted during the Phase I Remedial Investigation, 1991, should be discussed in this section.

Reply: The Phase I RI Report contains a complete discussion of these activities. Where appropriate, Phase I RI samples are discussed in the site-specific Nature and Extent of Contamination sections for each of the four IR sites in the Phase II RI.

July 2, 1999

12. **Section 2.3, Establishment of Background Concentrations, Page 2-31.**
The limitations of using surface soil as a surrogate for subsurface background conditions should be discussed.

Reply: Concur. The limitations of using background surface soil as a surrogate data set for background subsurface soil will be discussed in the human health risk assessment uncertainty section.

13. **Section 2.3, Establishment of Background Concentrations, Page 2-31, Paragraph 2.**
This paragraph states that background sample analytical statistics for groundwater were not attempted. However, background sample analytical statistics for groundwater are presented for each site. The text and tables should be revised to correct this inconsistency. Also, note that in the specific comments for each site, as discussed below, that the groundwater background sample analytical statistic tables appear to be incorrect.

Reply: Concur. Text and tables concerning background analytical statistics related to groundwater data sets will be removed from each site-specific human health risk assessment.

14. **Table 2-13**
Many of the calculated means are the same as 95th percent UTLs. Please explain. Also, when the 95th percent UTL for background exceeds the maximum detection for a given compound, was the maximum detect used as the default comparison value?

Reply: Disagree. In Table 2-13, 95% UTLs were not calculated. Only the background means were listed. The text "95 % Upper Tolerance Limit (UTL)" is present as a divider section with only the very last column of the table actually showing the UTL value.

15. **Section 3.1.1.3, Page 3-4**
Contrary to the text on this page, it seems that background concentrations were considered for the screening of organics.

Reply: Disagree. Background concentrations were not considered for the screening of organic compounds. Information regarding background concentrations and organics were presented in the report for informational purposes only. Text and tables will be revised as appropriate to clarify that background comparison analysis was not used to eliminate organic chemicals as COPCs.

16. **Section 3.1.1.3, Identification of Chemicals of Potential Concern (COPC), Page 3-6, Paragraph 5.**
This paragraph explains the exceptions to the COPC selection for each medium described on Pages 3-4 to 3-6. However, due to the formatting of the text, it appears that these exceptions are only relevant to groundwater COPC selection. These exceptions should be

moved to the beginning of Section 3.1.1.3, so that it is clear that they are relevant to COPC selection for all media.

Reply: Concur. The text will be revised as appropriate to clearly explain COPC selection.

In addition, the tables in Section 4, 5, 6, and 7 which illustrate the COPC selection for each site appear to indicate that chemicals that do not have an RBC will not be selected as a COPC. However, this approach is not discussed in the text. All criteria that were used to include or exclude a chemical as a COPC should be discussed in the text. Chemicals lacking RBCs should be retained as COPCs or evaluated using structurally similar surrogates.

Reply: Chemicals without a quantitative RBC will be retained as COPCs and will only be discussed qualitatively in the uncertainty section of the human health risk assessment [surrogates will not be assigned to COPCs without quantitative toxicity values because of the high uncertainty associated with this procedure]. Text and tables will be revised as appropriate.

Also, on pages 3-5 and 3-6, screening benchmarks for sediment and surface water are based on professional judgement. This should be clearly stated in the text.

Reply: Concur. Selection of sediment and surface water exposure scenarios will be clarified in text.

17. **Table 3-1, Page 3-12.**
A number of discrepancies were found in a comparison between values presented in Table 3-1 and IRIS (on-line), HEAST (1997), Region III RBCs (April 1998), and Region III Oral ABS Values for Oral-to-Dermal Extrapolation (December 1996). Since no dates were provided in this Table 3-1 and no references were provided with the human health risk assessment, it was not possible to identify the source of the discrepancies. The following values obtained from the references listed above are different from those in Table 3-1.

A. Fraction of COPC Absorbed in the Gastrointestinal Tract N/A for carcinogenic PAHs.
0.89 for RfD; CSF see IRIS for PCBs.
0.02 for Vanadium.
0.025 for Zinc.

B. Oral RfD
2.0E-02 for 1,1,1-trichloroethane.
3E-02 for 1,2-dichloroethane.
3E-03 for benzene.

2E-03 for beryllium.

C. Dermal RfD and SFs
See following comment on Section 3.1.2.4., Page 3-14

D. Inhalation RfD
1.4E-03 for 1,2-dichloroethane
1.4E-01 for tetrachloroethene
5.7E-06 for beryllium

E. Inhalation SFs
1.4E-02 for Bis(2-ethylhexyl)phthalate
2.0E+00 for PCBs

Reply: The values for Oral RfD (Comment B), Inhalation RfD (Comment D), and Inhalation SF (Comment E) were all taken from Region 3 RBC Tables dated 3-14-97, which was the latest update at the time the risks were estimated. For Fraction of COPC Absorbed in GI Tract (Comment A), Table 3-1 lists the values as provided from ATSDR, which at the time the risks were estimated were considered to be representative of fraction of COPC absorbed in the GI Tract.

18. Section 3.1.2 Toxicity Assessment, Adjustment of Dose-Response Parameters, Paragraph 5, Page 3-14 and Table 3-1, Page 3-12.
The equations for deriving dermal RfDs and SFs from oral RfDs and SFs are correct in the text. However, the dermal RfDs and SFs are calculated incorrectly as shown in Table 3-1. It appears that in the table, the oral RfDs were incorrectly divided by the $ABSEFF_{oral}$ to derive the dermal RfDs, and the oral SFs were incorrectly multiplied by the $ABSEFF_{oral}$ to derive the dermal SFs. However, a spot check of the calculations in Appendix J indicates that the correct dermal RfDs and SFs were used.

Reply: Concur. Table 3-1 will be revised as appropriate for numeric inconsistencies.

19. Table 3-3, Page 3-17.
The absorption factors presented in Table 3-3 represent chemical-specific values to adjust site doses, not toxicity values. These factors apply only to soil and sediment and represent the "ABS" parameter for dermal pathway (e.g., in Table 3-12).

Reply: Concur. Table 3-3 will be revised as appropriate for numeric inconsistencies.

20. Section 3.1.3.2, Potential Receptors, Page 3-20, Paragraph 4.
This paragraph indicates that cancer and noncancer risks will be estimated separately for adolescent and adult trespassers. However, the summary tables for each individual site present the cancer risk results for adult/child trespassers combined. The text and tables

should be revised to correct this inconsistency. Adult and adolescent trespassers should be evaluated separately.

Reply: Concur. Adolescent and adult trespassers will be evaluated separately for non-carcinogenic effects and carcinogenic effects. Text and tables will be revised as appropriate

21. Section 3.1.3,5.1, Exposure Estimates, Page 3-23, Paragraph 2.
The text states that the "CTE is only to be run at a particular site when the total cancer risk exceeds 1E-04 (considered the upper bound of EPA's acceptable risk range) or when the noncarcinogenic HI is greater than 1.0." This approach evaluates the results of the RME scenario first, then determines which site, medium, and receptors require CTE calculations. However in the RI report, the CTE was run for all sites, receptors, and media, although in many cases the RME risks and HI were below EPA acceptable risk criteria. The text should be revised to correspond to the procedures followed in the BRA.

Reply: Concur. The text will be revised to state that "all RME and CTE risks were presented in this risk assessment, however, CTE should only be considered when RME cancer risks exceed 1E-04 or when RME noncarcinogenic HI's exceed 1.0.

22. Section 3.1.3.5.1, Surface and Subsurface Soil Exposure, Page 3-23, Paragraph 4.
This section cites EPA, 1989a as the source of the soil ingestion, dermal contact, and inhalation of fugitive dust equations. Since references are not provided, it has been assumed, based on other information presented in the RI report with the same citation, that the source is Risk Assessment Guidance on Superfund (RAGS). However, RAGS does not present the same equations as shown here. For example, the dermal contact equations in the RI report include a factor for EV (event frequency), which is not included in the equations found in RAGS. The correct references for each equation should be provided and if modifications to the referenced, standard equations are made, the modifications should be described. This comment also applies to the surface water, sediment, and groundwater exposure equations.

Reply: Concur. The correct references will be cited as appropriate for the equations and any modifications to the standardized equations will be noted and described.

23. Table 3-10, Page 3-32
According to this table, the RME exposure frequency for a recreational child is seven days per year. This is not very conservative. Please justify.

Reply: The 7 day/year exposure frequency value is taken from RAGs Part A, as the national average for swimming days per year. Swimming is not evaluated in this BRA, however, 7 days/year was thought to be representative of a typical recreational activities event and as such was applied to the recreational child.

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24. **Table 3-14, Page 3-36**
According to this table, the RME exposure frequency for an excavation worker is 30 days per year. The default value for this receptor is generally 250 days per year. Either the exposure frequency for this receptor should be replaced by a more realistic estimate, or strong justification should be provided.

Reply: Excavation workers are generally not going to be subjected to the same exposure frequency as the standard industrial worker (i.e. 250 day/year exposure). Excavation activities were assumed to last for approximately 1 month per year. Major excavation activities at Willow Grove (i.e., those lasting more than 1 month) are not anticipated.

25. **Section 3.1.3.6, Page 3-61, Paragraph 2**
According to this paragraph, an exposure frequency of 219 days per year was assumed in the adult lead model. Why wasn't the default of 250 days per year used?

Reply: Average exposure values should be input into the adult lead model. An exposure frequency of 219 days per year represents and average value for an industrial worker.

26. **Section 4-5, Nature and Extent of Contamination, Page 4-10.**
Revise the text to correctly refer to Figures 4-21A through C.

Reply: Concur. Text will be corrected.

27. **Table 4-5, Page T-4-4.**
A footnote should be included for the qualifier B. This comment pertains to similar tables in the report.

Reply: Concur. The qualifier B and its meaning (compound also found in blank sample) will be added to each table as appropriate.

28. **Section 4.6.1, Transport and Transformation of Detected Contaminants, Page 4-20.**
Revise text from "reference center" to "reference criteria".

Reply: Concur. Text will be corrected.

29. **Section 4.6.2, Conclusions, Page 4-22.** A discussion should be presented on the compound arsenic in this section. Arsenic was identified as COPC in soils, subsurface soils, sediments, and groundwater. It's presence in these media and elevated concentrations indicate that it is site related and future migration could occur.

Reply: Conclusions based on the discussion of arsenic in Section 4.6.1 will be added.

30. Section 4.7.6, Conclusions, Page 4-31, Paragraph 4

The section states that other than a future residential child receptor, the noncarcinogenic HIs for the other potential receptors at Site 1 are less than 1.0. However, Tables 4-26 and 4-27 indicate that the RME and CTE noncarcinogenic HIs for a future adult receptor are 1.95 and 1.38 respectively, which exceed the EPA's target HI. The text should be revised to reflect the results presented in Tables 4-26 and 4-27.

Reply: Concur. The risks presented in the text and risks presented in tables will be checked for accuracy and consistency. Appropriate text and/or table changes will be made.

31. Table 4-17, Page T-4-87.

This table presents background comparison test results for groundwater data for Site 1. The footnotes indicate that the overall decision for each groundwater pollutant is NA, if all individual background tests are NA. While the table indicates that all individual background tests are NA for each groundwater pollutant, the overall conclusion for each pollutant is not NA but evaluated as yes or no. This table should be revised so that either the correct overall conclusion for each pollutant is shown or the correct result for each individual background test is shown.

Reply: Concur. Table 4-17 will be changed as appropriate.

32. Tables 4-19 to 4-23, page T-4-105 to T-4-114.

These tables present the COPC selection for each contaminant in each medium at Site 1. However, the footnotes which explain the criteria for COPC selection are not complete. Since the criteria for COPC selection are already described in Section 3, the footnotes should be deleted and a reference to Section 3 should be added. In addition, a final column should be added to the table which describes the reason the contaminant was included as a COPC (i.e., exceeded RBC and background, exceeded RBC, chemical is break-down product of a COPC, etc.) so that it is clear why the chemical was selected as a COPC.

Reply: Concur. The footnotes regarding selection criteria will be taken off Tables 4-19 through 4-23 and a reference to Section 3 selection criteria text will be added. A column will be added to each table stating the reason for inclusion or exclusion of each chemical.

Tables 4-19 to 4-22 include the background results. However, Table 4-23 does not include background results. The format of Tables 4-19 to 4-23 should be consistent and background results should be added to Table 4-23.

Reply: Concur. Tables 4-19 through 4-22 will be checked for consistency and changes will be made as appropriate.

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33. **Table 4-23, page T-4-112.**
This table presents the selection of sediment COPCs for Site 1. However, Table 4-21 on page T-4-109 presents the same information. In addition, there is a second Table 4-23 on page T-4-113 that presents groundwater COPCs for Site 1. Table 4-23 on page T-4-112 should be removed from the report.

Reply: Tables 4-23 and 4-21 will be checked for content and accuracy and changes to the tables and or text that presents them will be made as appropriate.

34. **Table 4-23, page T-4-113.**
This table presents the selection of COPCs in groundwater at Site 1. However, some the data listed for the organic contaminants appear to be incorrect. The representative concentration listed for 1,2-dichloroethene (total) is 5. However, Table 4-16 lists the representative concentration as 4.35. The representative concentration listed for tetrachloroethene is 7.49. However, Table 4-16 lists the representative concentration as 9.2. The representative concentration listed for trichloroethene is 11. However, Table 4-16 lists the representative concentration as 12. In addition, Table 4-16 includes 1,1,1-trichloroethane, 1,1-dichloroethane, carbon tetrachloroethene, and toluene. However, these pollutants are not included in Table 4-23. The tables should be revised so that they are consistent.

Reply: Concur. The numbers will be checked concerning risks shown in Tables 4-16 and 4-23 and the numbers referred to in the text. Changes will be made as appropriate.

35. **Section 5.6.2 Conclusions, Page 5-12.**
A discussion should be presented on the potential for arsenic and dieldrin to migrate from the site. Arsenic and dieldrin were selected as a COPC in soils, subsurface soils, surface water, sediment, and groundwater and detected in seep samples. Erosion of soils was identified as a significant process at the site.

Reply: These issues will be further discussed, as requested.

36. **Section 5.7.6, Conclusions, Page 5-22, Paragraph 1.**
The section states that other than a future residential child receptor, the noncarcinogenic HIs for the other potential receptors at Site 2 are less than 1.0 However, Tables 5-27 and 5-28 indicate that the RME and CTE noncarcinogenic HIs for a future residential adult receptor are 1.56 and 1.27, which exceed the EPA's target HI. The text should be revised to reflect the results presented in Table 5-27 and 5-28. In addition an HI of 1.56 would round to a value of 2. This discrepancy should be corrected.

Reply: Text will be modified to discuss values found in the tables.

Risks will be presented in the text that are consistent in terms of significant digits.

37. Table 5-18, Page T-5-66.
This table presents background comparison test results for groundwater data for Site 2. The footnotes indicate that the overall decision for each groundwater pollutant is NA if all individual background tests are NA. While the table indicates that all individual background tests are NA for each groundwater pollutant, the overall conclusion for each pollutant is not NA but evaluated as yes or no. This table should be revised so that either the correct overall conclusion for each pollutant is shown or the correct result for each individual background test is shown.

Reply: Concur. Table 5-18 will be changed as appropriate.

38. Tables 5-20 to 5-24, page T-5-72 to T-5-83.
These tables present the COPC selection for each contaminant in each medium at Site 2. A final column should be added to the table which describes the reason the contaminant was included as a COPC (i.e., exceeded RBC and background, exceeded RBC, chemical is break-down product of a COPC, etc.), so that it is clear why the chemical was selected as a COPC.

Reply: Concur. A column will be added to each table stating the reason for inclusion or exclusion of each chemical.

Tables 5-20 to 5-23 include the background results. However, Table 5-24 does not include background results. The format of Tables 5-20 to 5-24 should be consistent and Table 5-24 should include background results.

Reply: Tables 5-20 through 5-23 will be checked for consistency and changes will be made as appropriate.

39. Table 5-25, page T-5-84.
The sum of the inhalation RME cancer risks for each medium for a future resident is incorrectly stated at 3.10E-07. The correct value is 4.85E-07. The table should be revised so that the correct sum is shown.

Reply: Concur. Table 5-25 will be changed as appropriate.

40. Section 5.5.1.2, Page 5-5.
The document states that TCDD-TEQs exceeded reference criteria in the two surface soil samples that were analyzed for dioxins. However, Table 5-5, which presents a comparison of detected compounds to ARARs and TBCs, does not present the results of the dioxin analyses. Further, it appears that the nature and extent of dioxin contamination may remain undefined. It is not clear that dioxin in surface water, seeps or sediments would have been identified in this evaluation. Therefore, the uncertainty associated with

potential dioxin contamination should, at a minimum, be evaluated as part of the site-specific uncertainty analysis.

Reply: Concur. The dioxin analysis and explanation will be updated in the human health risk assessment.

41. **Section 6.5, Nature and Extent of Contamination.**
Revise the text to correctly reference Figure 6-11 A through E.

Reply: Concur. These figures should be called Figures 6-12 A through E.

42. **Section 6.5, Nature and Extent of Contamination.**
According to the text, detections in surface and sediment at this site were determined to be statistically unrelated to the site. The methodology and tests employed to reach this conclusion should be discussed.

Reply: Concur. This issue will be further clarified.

43. **Table 6-16, Page T-6-68.**
This table presents background comparison test results for groundwater data for Site 3. The footnotes indicate that the overall decision for each groundwater pollutant is NA, if all individual background tests are NA. While the table indicates that individual background tests are NA for each groundwater pollutant, the overall conclusion for each pollutant is not NA. This table should be revised so that either the correct overall conclusion for each pollutant is shown or the correct result for each individual background test is shown.

Reply: Concur. Table 6-16 will be changed as appropriate.

44. **Tables 6-18 to 6-22, page T-6-81 to T-6-92.**
These tables present the COPC selection for each contaminant in each medium at Site 3. A final column should be added to the table which describes the reason the contaminant was included as a COPC (i.e., exceeded RBC and background, exceeded RBC, chemical is break-down product of a COPC, etc.), so that it is clear why the chemical was selected as a COPC.

Reply: Concur. A column will be added to each table stating the reason for inclusion or exclusion of each chemical.

Tables 6-18 to 6-21 include the background results. However, Table 6-22 does not include background results. The format of Tables 6-18 to 6-22 should be consistent and background results should be added to Table 6-22.

Reply: Tables 6-18 through 6-21 will be checked for consistency and changes will be made as appropriate.

45. Section 6.7.6, Conclusions, Page 6-24, Paragraph 4.

This section indicates that the total cumulative RME carcinogenic risk for a future residential receptor is 9E-05 and the RME carcinogenic risk for groundwater consumption for a future residential receptor is 7E-05. However, Table 6-23 indicates the results are 4.54E-05 and 2.35E-05, respectively. The text and table should be revised so that they are consistent.

Concur. The text and tables will be checked for accuracy and consistency and revised as appropriate.

This section states that iron and barium in groundwater are main contributors to the RME and CTE noncarcinogenic risk at Site 3 for a future residential child and adult receptor. However, the results shown in Appendix J, Tables J-35 and J-36, appear to indicate that chromium and manganese are stronger contributors in groundwater. In addition, this section also states that iron and dieldrin in surface soil are the main contributors to noncarcinogenic risk at Site 3. However, the individual contaminant results shown in Appendix J, Tables J-5 and J-6 indicate that for a future residential child, the main contributor is iron followed by aluminum, manganese, and dieldrin and for a future residential adult, the main contributor is iron, followed by aluminum, dieldrin, and manganese. The text should be revised so that it is consistent with the data tables or an explanation as to how dieldrin was chosen as a main contributor should be included.

Reply: The text will be revised to be consistent with the data tables.

46. Section 7.5, Nature and Extent of Contamination, Page 7-4.

Revise the text to correctly reference Figure 7-9 A through D.

Reply: Concur. Text will be corrected

47. Section 7.6.2, Conclusions

Examination of figures 7-9A and 7-9B shows soils contaminated with SVOCs and groundwater contaminated primarily with VOCs. The conclusion that "residual soil contamination is a continuing source of VOCs to groundwater" appears unfounded. The text should be revised.

Reply: Concur. This conclusion will be restated to reflect the dearth of VOCs found in soils.

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48. **Section 7.7.1, Data Evaluation, Surface Soils, Page 7-11, Paragraph 3.**
This section lists the organic and inorganic COPCs as presented in Table 7-18. However, dibenzofuran is listed as a COPC in Table 7-18, but is not included on the list. The text should be revised so that it is consistent with the results in Table 7-18.

Reply: Concur. The text will be revised to be consistent with the data tables.

49. **Section 7.7.6, Conclusions, Page 7-21, Paragraph 1.**
The section states that other than a future residential child receptor, the noncarcinogenic HIs for the other potential receptors at Site 5 are less than 1.0. However, Table 7-25 indicates that the RME noncarcinogenic HI for a future adult receptor is 2.24 and Table 7-26 indicates that the CTE noncarcinogenic HI for a future adult receptor is 1.76 and for a future excavation worker is 62.1. The text should be revised to reflect the results presented in Tables 7-25 and 7-26.

Reply: Text will be modified to discuss values found in the tables.

50. **Table 7-16, Page T-7-62.**
This table presents background comparison test results for groundwater data for Site 5. The footnotes indicate that the overall decision for each groundwater pollutant is NA if all individual background tests are NA but evaluated as yes or no. While the table indicates that individual background tests are NA for each groundwater pollutant, the overall conclusion for each pollutant is not NA. This table should be revised so that either the correct overall conclusion for each pollutant is shown or the correct results for each individual background test is shown.

Reply: Concur. Table 7-16 will be changed as appropriate.

51. **Tables 7-18 to 7-22, page T-7-73 to T-7-83.**
These tables present the COPC selection for each contaminant in each medium at Site 5. A final column should be added to the table which describes the reason the contaminant was included as a COPC (i.e., exceeded RBC and background, exceeded RBC, chemical is break-down product of a COPC, etc.) so that it is clear why the chemical was selected as a COPC.

Reply: Concur. A column will be added to each table stating the reason for inclusion or exclusion of each chemical.

Tables 7-18 to 7-21 include the background results. However, Table 7-22 does not include background results. The format of Tables 7-18 to 7-22 should be consistent and background results should be added to Table 7-22.

Reply: Tables 7-18 through 7-21 will be checked for consistency and changes will be made as appropriate.

52. **Table 7-24, page T-7-85.**
This table lists values for the estimated CTE total cancer risk for ingestion, dermal contact, and inhalation of subsurface soil for a future excavation worker at Site 5. However, Table J-16, which contains the backup calculations of estimated CTE cancer risks and noncarcinogenic hazard indices for a future excavation worker from subsurface soil exposure at Site 5, lists all the values as NA. The tables should be revised so that they are consistent.

Reply: Table 7-24 and the text presenting it will be checked for accuracy and revised as appropriate.

53. **Appendix J, Human Health Risk Assessment Documentation.**
Appendix J does not contain page numbers. Page numbers should be included throughout the report, including in Appendix J.

Reply: Concur. Page numbers will be added.

The equation for Surface Soil Exposure, Dermal Contact defines "ABS" as fraction from contaminated source for arsenic. "ABS" should be defined as the chemical-specific absorption factor for dermal contact.

Reply: Concur. The "ABS" term will be defined as appropriate.

The inhalation equation in Appendix J states R_{10} is equal to E_{10}/A. However, Section 3.1.3.5.1 presents R_{10} as equal to $E_{10} * A$. The inhalation equations should be revised to show the correct relationship between the variables and should be consistent throughout the RI report.

Reply: The inhalation equations will be revised as appropriate.

The equations presented in Section 3.1.3.5 and in Appendix J are not consistent. For example, the ingestion equation on Page 3-25 uses different units and includes a 365 days/yr conversion factor. The surface/subsurface soil lung inhalation equation on page 3-25 uses the variable X and IF_R; however these variables are not included in the inhalation equation in Appendix J. Instead, the inhalation equation in Appendix J uses the variables CA and FR-I. CA was previously defined as carcinogenic risk; however in this equation, it represents contaminant concentration. The sediment dermal intake equation on page 3-40 uses the variables BW, SA, ED, and EV; however, these variables are not used in the sediment dermal intake equations in Appendix J. Instead, the sediment dermal intake equation in Appendix J uses the variable AGE. Equations with

consistent nomenclature should be used throughout the RI report and should be consistent with those equations found in EPA reference documents.

Reply: Concur. Consistency regarding terminology will be provided throughout the revised HHRA.

3.2 ECOLOGICAL RISK ASSESSMENT APPROACH

Ecological receptors at NASJRB Willow Grove may be at risk from contaminants associated with Sites 1, 2, 3, and 5. Therefore, an ecological risk assessment (ERA) was performed to characterize the potential risks from site-related contaminants to ecological receptors that inhabit the installation. The ERA was based on laboratory analyses of surface soil, surface water, and sediment samples collected from each site. This section provides an outline of the approach that was taken to assess the impacts of site contamination on ecological receptors and the habitats that support these organisms. This assessment followed a two-step process:

Step 1: Preliminary Problem Formulation and Ecological Effects Evaluation (Section 3.2.1)

- Preliminary Problem Formulation - This is the first phase of an ERA, which discusses the goals, breadth, and focus of the assessment. It includes general descriptions of NASJRB Willow Grove sites with emphasis on the habitats and ecological receptors present. This phase also involves characterization of contaminant sources and migration pathways, evaluation of routes of contaminant exposure, and selection of analytes to be assessed. Assessment and measurement endpoints are also selected in this phase. In addition, a conceptual model is developed that describes how contaminants associated with the RI sites may come into contact with ecological receptors.

- Preliminary Ecological Effects Evaluation - In this phase, medium-specific ecological screening levels for each analyte (i.e., concentrations of each contaminant above which adverse effects to ecological receptors may occur) are identified. This step is undertaken concurrently with the exposure assessment described below.

Step 2: Preliminary Exposure Assessment and Risk Calculation (Section 3.2.2)

- Preliminary Exposure Estimate - This portion of the ERA includes the identification of contaminant concentration data used to represent ecological exposure in various media and the selection of exposure point contaminant concentrations from those data.

- Preliminary Risk Calculation - In this step, exposure point concentrations are compared to screening levels in order to characterize potential risks to ecological receptors of concern. Analytes found to pose potential risk after these comparisons are selected as ecological chemicals of potential concern (COPCs).

When these two steps are completed, the results are interpreted and the uncertainties associated with the ERA are addressed. The above process, described in further detail below, represents the general approach recommended in the most recent U.S. EPA guidance for performing ecological risk assessments (U.S. EPA, 1997), which served as the basis for the ERA methodology. Additional guidance consulted for this ERA includes Department of the Navy ERA policy (DON, 1999), EPA Region III BTAG ERA guidelines (USEPA, 1994), and other ERA guidance documents and publications (Calabrese and Baldwin, 1993; Suter, 1993; Wentsel et al., 1996).

Due to the potential complexity of ERAs, they are usually conducted using a tiered approach and punctuated with Scientific/Management Decision Points (SMDPs). SMDPs are meetings involving the risk managers and risk assessment team and are conducted to evaluate the work up to that point and to ensure that the ecological risk assessment is proceeding in an efficient manner. Information analyzed in one tier is evaluated to determine whether the objectives of the study have been met. The results are then used to identify the data required for the next tier, if necessary. The Tier 1 ERA is also known as a Screening Risk Assessment. The Screening Risk Assessment uses conservative (i.e. stringent) assumptions to evaluate site data and determine whether additional ecological risk assessment or accelerated site cleanup may be warranted, or that the site poses negligible ecological risks.

The second tier is a baseline ERA (BERA), which is conducted if the results of the screening-level ERA indicate that additional study is warranted. The BERA comprises Steps 3 through 7 of the 8-step ERA process, and is a more focused study of the initial COPCs. The beginning of the BERA also presents a more balanced evaluation of the conservativeness inherent in the first two steps of the ERA process (DON, 1999).

3.2.1 Preliminary Problem Formulation and Ecological Effects Evaluation

Section 3.2.1.1 discusses the components of problem formulation and Section 3.2.2.2 discusses the components of ecological effects evaluation.

3.2.1.1 Preliminary Problem Formulation

Ecological Setting

The preliminary problem formulation contains a description of the background of the site and a general description of the ecological setting at NASJRB Willow Grove. These topics are presented in Section 1.4. The main areas of interest at NASJRB Willow Grove for this ERA are Sites 1, 2, 3, and 5. These sites are described in detail in site-specific sections.

Habitat Types and Ecological Receptors

Descriptions of habitat types and ecological receptors were composed for Sites 1, 2, 3, and 5, and are presented in site-specific sections of this report. Data regarding habitats and ecological receptors were obtained from previous reports and from biological characterizations conducted at the installation during this investigation. Information on the occurrence of threatened and endangered species on and near the four sites was obtained from the U.S. Fish and Wildlife Service, the Pennsylvania Game Commission, the Pennsylvania Fish and Boat Commission, the Pennsylvania Department of Environmental Protection, and the Natural Resources Manager at NASJRB Willow Grove.

Contaminant Sources, Release Mechanisms, and Migration Pathways

Site-specific contaminant sources, release mechanisms, and migration pathways are discussed in site-specific sections of this report. The general transport mechanisms that were investigated include combustion, volatilization, wind erosion, overland runoff, and infiltration of contaminants. Constituents in soil could volatilize from surficial material or become airborne through wind erosion. Contaminated fugitive dust could be generated during ground-disturbing activities such as construction or excavation. Contaminants could then be dispersed in the surrounding environment and transported to downwind locations, where they could become deposited in surface soil, surface water, or sediment. Combustion was probably a major transport mechanism during the period when the landfills and fire training area were in use. However, combustion is assumed to currently represent a negligible transport mechanism at NASJRB Willow Grove since open burning activities have ceased.

Precipitation runoff could carry constituents to nearby surface water and sediment. Infiltrating precipitation could cause the contamination of subsurface soil and groundwater. Upon infiltrating the soil column and reaching the water table, a contaminant may be carried with the flow of groundwater to downgradient locations. Groundwater from the site may eventually discharge to surface water; contaminants could be subsequently deposited in sediment or accumulate in the tissues of aquatic organisms.

Exposure Routes

Terrestrial animals could be exposed to soil contaminants through the ingestion of contaminated food items. Animals can also incidentally ingest soil while grooming fur, preening feathers, digging, grazing close to the soil, or feeding on items to which soil has adhered (such as roots and tubers). Terrestrial vegetation could be exposed to contaminants via direct aerial deposition and root translocation. However, aerial deposition was not investigated, primarily because the contaminant sources at the sites under investigation are largely covered by vegetation. Terrestrial animal receptors may also come into contact with contaminants in surface water through drinking, although this exposure route represents a negligible portion of total exposure for most receptors. Exposure to contaminants in the soil via dermal contact may occur but is unlikely to represent a major exposure pathway because fur, feathers, and chitinous exoskeletons minimize transfer of contaminants across dermal tissue.

Inhalation does not represent a significant exposure pathway because air contaminant concentrations are assumed to be quite low, even for burrowing wildlife. In addition, inhalation ecotoxicity data for chronic exposure are lacking. Therefore, the air pathway was not considered for ecological receptors.

Aquatic and semi-aquatic organisms at NASJRB Willow Grove could be exposed to contaminants via direct contact with surface water and sediments, incidental ingestion of surface water and sediments, and consumption of contaminated food items. Aquatic and semi-aquatic organisms could also be exposed to constituents from contaminated groundwater that potentially discharges into nearby surface water.

Selection of Analytes to be Investigated

All analytes detected in surface water, sediment, and surface soil samples collected during 1991 Phase I and 1997 Phase II sampling activities were assessed in this investigation. However, calcium, magnesium, potassium, and sodium were excluded in the screening process since they are essential nutrients that are toxic only in extremely high concentrations. Due to the scarcity of data for these essential nutrients, it was not possible to develop ranges of toxicity even at high concentrations. The limited toxicity data available indicate that high dietary intake of these nutrients is well tolerated.

Assessment and Measurement Endpoints

One of the major tasks in problem formulation is the selection of assessment and measurement endpoints. An assessment endpoint is "an explicit expression of actual environmental values that are to be protected" and measurement endpoints are "measurable ecological characteristics that are related to the valued characteristic chosen as the assessment endpoint" (USEPA, 1997). For this ERA, the assessment endpoint was the maintenance of aquatic and terrestrial receptor populations. Therefore, the specific objectives of this assessment were to determine if exposure to contaminants present in the surface water, sediment, and soil on and near the sites are likely to result in declines in ecological receptor populations. Declines in populations could result in a shift in community structure and possible elimination of resident species from aquatic, semi-aquatic, and terrestrial environments.

Measurement endpoints serve as surrogates for assessment endpoints, since they are more easily quantified or observed than assessment endpoints. Measurement endpoints consisted of contaminant concentrations associated with adverse effects on growth, survival, and reproduction of aquatic organisms (surface water screening levels), benthic organisms (sediment screening levels), and terrestrial vegetation and soil invertebrates (surface soil screening levels).

Conceptual Site Model

The conceptual model is designed to diagrammatically identify potentially exposed receptor populations and applicable exposure pathways, based on the physical nature of the site and the potential contaminant source areas. Actual or potential exposures of ecological receptors associated with the sites were determined by identifying the most likely pathways of contaminant release and transport. A complete exposure pathway has

three components: a source of contaminants that can be released to the environment; a route of contaminant transport through an environmental medium; and an exposure or contact point for an ecological receptor. The conceptual model for each site is presented in site-specific sections of this report.

3.2.1.2 Preliminary Ecological Effects Evaluation

For this ERA, exposure-point concentrations of detected analytes in surface water, sediment, and surface soil were compared to ecologically based guidelines to determine if the analytes should be selected as COPCs. Although groundwater-to-surface-water migration of groundwater contaminants is possible at NASJRB Willow Grove, ecological receptors are not directly exposed to groundwater. Additionally, no groundwater thresholds have been developed based on ecological concerns. Potential ecological risks associated with groundwater contaminants are reflected in the evaluation of the potential risks associated with surface water and sediment, since the sources of contamination at the sites under investigation have been in place long enough for groundwater plumes to discharge into nearby surface water and sediment. Thus, groundwater contaminants were not screened against surface water contaminants in the ecological risk assessment. It is noted that an artesian flowing well formerly existed downstream from the pond near Site 3. However, this well has been capped so that flow from this monitoring well is nonexistent. There are no other flowing artesian wells near any other site investigated in this report. The Navy corrected the problem of flowing artesian monitoring wells during RI field investigations in the spring of 1997 by repairing the leaking sample assemblies. Long-term annual inspection and maintenance of these artesian monitoring wells will ensure no flow of groundwater to surface water.

Methods used for the selection of medium-specific benchmarks used in this ERA are provided below.

Surface Water Screening Levels

Actual exposures of aquatic receptors to surface water contaminants at NASJRB Willow Grove were assumed to be primarily chronic (long-term) exposures, usually at sublethal concentrations. Initial screening levels for this ERA were chronic screening values obtained from USEPA Region III BTAG (EPA, 1995), EPA chronic ambient water quality criteria (AWQC), EPA final chronic values (FCVs), and Tier II values (EPA, 1996b).

Sediment Screening Levels

Initial contaminant screening levels for benthic organisms were preferentially EPA Region III BTAG screening levels (EPA, 1995). These values are primarily Effects Range-Low (ER-L) values from Long and Morgan (1990) and Long et al. (1995), and Apparent Effects Thresholds (AETs).

Surface Soil Screening Levels

Initial screening levels for soil organisms consisted primarily of USEPA Region III BTAG screening levels (EPA, 1995), Oak Ridge National Laboratory (ORNL) surface soil screening levels, and Dutch "B" levels that represent ecological toxicity endpoints (Netherlands, 1994).

3.2.2 Preliminary Exposure Estimate and Risk Calculation

Section 3.2.2.1 describes the components of preliminary exposure estimate and Section 3.2.2.2 describes the components of preliminary risk calculation.

3.2.2.1 Preliminary Exposure Estimate

The maximum detected concentrations of analytes in surface water, sediment, and surface soil were used as exposure point contaminant concentrations for comparison to ecological screening levels in the risk calculation step. Detailed descriptions of sampling locations, data validation, data treatment, and data selection were presented in previous sections.

3.2.2.2 Preliminary Risk Calculation

The preliminary risk calculation step in the ERA process compares exposure-point contaminant concentrations with screening levels protective of ecological receptors (EPA, 1997). The ratio of the exposure-point contaminant concentration to the screening level is called the hazard quotient (HQ) and is defined as follows:

$$HQ_i = EPC/ESL_i$$

where: HQ_i = Hazard Quotient for analyte "i" (unitless)

EPC_i = Exposure Point Concentration for analyte "i" (µg/L or mg/kg)

ESL_i = Ecological Screening Level for analyte "i" (µg/L or mg/kg)

When the ratio of the exposure point concentration to its respective screening level equaled or exceeded 1.0, adverse impacts were considered possible, and the contaminant was retained as a COPC. The HQ value should not be construed as being probabilistic; rather, it is a numerical indicator of the extent to which an exposure point concentration exceeds or is less than a screening level. HQ values equal or greater than 1.0 indicate that ecological receptors are potentially at risk; additional evaluation or data may be necessary to confirm with greater certainty whether ecological receptors are actually at risk.

The use of HQs is probably the most common method used for risk characterization in ERAs. Advantages of this method, according to Barnthouse et al. (1986), include the following:

- The HQ method is relatively easy to use, is generally accepted, and can be applied to any data.
- The method is useful when a large number of contaminants must be screened.

This method of risk characterization has some inherent limitations. One primary limitation is that it is a "no/maybe" method for relating toxicity to exposure. That is, it uses single values for exposure concentrations and screening levels. The HQ method does not account for the variability in both these parameters or for incremental or cumulative toxicity.

The comparisons of maximum contaminant concentrations in each medium to screening levels are presented in screening tables. The screening tables include the frequency of detection for each analyte, the range of detected values, and contaminant-specific screening levels.

3.2.3 Step 3a: Refinement of Contaminants of Potential Concern

The ERA methods described above constitute the first two steps of the 8-step ERA process. Thus, the ERA, up to this point, can be considered to be a "screening-level" assessment, or "Tier 1" assessment, since it is based primarily on a conservative initial screening of contaminant concentrations against contaminant-specific screening levels. As will be seen in site-specific ERAs, maximum concentrations of several analytes exceed ecological screening levels. Because of this, and since the locations and number of samples appears to be adequate to determine the nature and extent of site related contamination, a more thorough assessment is warranted. Therefore, in accordance with EPA (1997) and Navy policy (DON, 1999), and as

per discussions with Region III BTAG, a portion of Step 3 of the 8-step ERA process was included in this assessment.

Step 3 of the 8-step ERA process is BERA problem formulation (EPA, 1997). This step consists of several sub-steps designed to develop the goals, breadth, and focus of the BERA. The initial sub-step within Step 3 is refinement of contaminants of potential concern, and is referred to as "Step 3a - Refinement of Conservative Exposure Assumptions" in the Navy's ERA guidance (DON, 1999).

The use of conservative guidelines and maximum detected concentrations in the screening-level assessment is necessary to ensure that potential risks are not underestimated. However, if the hazard quotients derived from comparisons of maximum concentrations to conservative screening levels are used as the single factor for including a COPC in a baseline ERA without consideration of other relevant information, additional ecological studies such as toxicity testing or tissue analyses could be undertaken for COPCs that do not actually pose significant risks. For this reason, refinement of COPCs, the first sub-step within Step 3, was incorporated into the ERA. Step 3a involves the consideration of factors such as background data (mainly for inorganics), toxicological evaluation of COPCs, frequency of detection, and comparisons of COPCs to alternate guidelines (EPA, 1997; DON, 1999).

3.2.3.1 Alternate Guidelines

Less conservative guidelines are presented in Step 3a of this ERA to provide balance to the conservative screening-level assessment. For example, some sediment screening values in Steps 1 and 2 consisted of ER-L values obtained from Long et al. (1995) However, an ER-L is defined as the concentration below which adverse ecological effects "would rarely be observed", and the effects range-medium (ER-M) is the concentration below which adverse effects "would occasionally occur" (Long et al., 1995). Therefore, ascribing risk to a sediment contaminant detected in a concentration that exceeds the ER-L but is below the ER-M can be misleading. Recent studies have indicated that ER-Ms are much better indicators of potential adverse effects than ER-Ls (Long et al., 1998), and thus, ER-Ms are included in Step 3a.

Less conservative sediment guidelines also include Probable Effects Levels (PELs) developed by the Florida Department of Environmental Protection (FDEP, 1994). The PELs are loosely analogous to ER-Ms. The data set used by Long et al. (1995) to develop ER-Ls and ER-Ms was used also by FDEP. However, unlike the ER-Ls and ER-Ms, PELs also incorporate chemical concentrations observed or predicted to be associated with no adverse biological effects (no effects data). The PEL is the geometric mean of the 50th percentile in the effects data set and 85th percentile in the no effects data set. The PEL represents the lower limit of the range of contaminant concentrations that are usually, or always, associated with adverse biological effects (FDEP, 1994).

Other less conservative sediment guidelines such as Severe Effects Levels (SELs) developed by the Ontario Ministry of the Environment (MOE) are also presented in Step 3a. MOE guidelines are based exclusively on observed effects in the field (absence of certain species). The SEL represents the contaminant level that could potentially eliminate most of the benthic organisms. Unlike National Oceanic and Atmospheric Administration (NOAA) and FDEP guidelines, MOE guidelines are based on freshwater sediments. Probable Effects Concentrations (PECs) developed as part of EPA's Assessment and Remediation of Contaminated Sediments Program (EPA, 1996c), and other guidelines are also presented in Step 3a.

Alternate guidelines for surface water are not as plentiful as for sediments. Therefore, a broad range of alternate guidelines for surface water could not be developed. However, alternate guidelines are presented, when available, for surface water COPCs in Step 3a for each site investigated herein.

Alternate surface soil guidelines for some COPCs were available from ORNL (Efroymson et al., 1997a; 1997b) and are presented in Step 3a. These data were derived to be used as screening values for investigating the potential effects of contaminants on soil litter invertebrates (i.e. earthworms), soil microbes,

and plants. Other alternate ecological soil guidelines include Dutch "B" soil valves indicative of "moderate soil contamination that requires further study" (Beyer, 1990), and Canadian Council of Ministers of the Environment Soil Quality Guidelines (CCME, 1997).

3.2.3.2 Toxicological Evaluation of COPCs

Toxicity data and information from various sources in the literature are discussed as they relate to the interpretation of potential risks from each COPC. These sources include the USFWS Chemical Hazard Reviews, commonly referred to as the "Eisler" publications, ATSDR Toxicity Profiles on CD-ROM, and ecotoxicological journals.

3.2.3.3 Other Considerations

The establishment of background concentrations was discussed in Section 2.3. Background data were obtained from the sampling and analysis of surface water, sediment, and surface soil during Phase II activities. As a result, background data are available for use in assessing the extent to which chemical concentrations at Sites 1, 2, 3, and 5 are due to site-related activities, since concentrations of inorganic contaminants can be naturally elevated and exceed screening values.

The frequency of detection and spatial analysis of elevated contaminant concentrations were evaluated to determine whether potential risks are widespread or limited to a small area. The magnitude of the HQs was also considered. As described earlier, the relationship between the magnitude of an HQ and toxicity is not necessarily linear. However, the magnitude of an HQ can be used as a rough approximation of the extent of potential risks, especially if there is sufficient confidence in the guideline used.

3.2.4 Ecological Risk Assessment Approach Summary

Due to past contaminant releases at Sites 1, 2, 3, and 5, a screening-level ERA was conducted for each of these sites. Maximum contaminant concentrations in surface water, sediment, and surface soil were compared to screening level toxicity values that are protective of ecological receptors. Potential risks to ecological receptors were investigated in the form of HQ values, which is the ratio of the representative contaminant concentration to the screening level toxicity value. Risks were considered possible when an HQ value was equal to or greater than 1.0. Subsequently, other quantitative and qualitative factors were investigated in Step 3a to more fully assess potential risks. A "weight-of-evidence" approach (EPA, 1997) was used as part of Step 3a to determine the extent of potential risks when HQ values exceeded 1.0. Information in Step 3a was used to determine final ecological contaminants of concern (COCs).

3.2.5 Screening Level and Step 3a Uncertainty Analysis

Uncertainty is associated with all aspects of the ERA process. This section provides a summary of the general uncertainties involved in this ERA, and discusses how the uncertainties may affect the final risk values and conclusions. Discussions of site-specific uncertainties are contained in site-specific sections of this report.

Once an ERA is complete, the results must be reviewed and evaluated to identify the types and magnitudes of uncertainties involved. Relying on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. If numerous conservative assumptions are combined in the ERA process, the resulting calculations will propagate the uncertainties associated with each of those assumptions. The resulting bias is toward over-predicting risks. Thus, both the results of the risk assessment and the uncertainties associated with those results must be considered when making risk management decisions.

Generally, risk assessments carry two types of uncertainty: measurement and informational. Measurement uncertainty refers to the variability inherent in measured data. Informational uncertainty stems from the limited availability of necessary information. There is often a significant gap between what is needed and what is available. Information regarding the effects of certain contaminants on ecological receptors, the biological mechanism of a contaminant, the impact of physiological differences on exposure pathways, or the behavior of a contaminant in various environmental media is often absent.

Uncertainty is associated with each of the steps of the risk assessment process:

- Uncertainty in problem formulation can result from limited information regarding contaminant sources, release mechanisms, and exposure routes.
- Uncertainty in the ecological effects evaluation arises from the quality of the existing screening values and toxicity data to support a determination of potential adverse impacts to ecological receptors.
- Uncertainty associated with the exposure estimate includes the methods used and the assumptions made to determine exposure point concentrations.
- Uncertainty in risk calculation includes that associated with the potential effects of exposure to multiple contaminants and the cumulative uncertainty from combining conservative assumptions made in earlier activities.

3.2.5.1 Uncertainty in the Preliminary Problem Formulation

The sites investigated in this ERA receive contaminant inputs from more than one source, although initially, contaminants are conservatively assumed to stem directly from site-related activities. Since contaminant concentrations may reflect inputs from many sources, uncertainties exist regarding whether risk characterized at a discrete site stems from site-related contaminants.

3.2.5.2 Uncertainty in the Ecological Effects Evaluation

Uncertainty in this risk assessment results from the nature and quality of the available toxicity data used to derive toxicity screening values. This uncertainty is reduced when similar effects are observed across species, strain, sex, and exposure route; when the magnitude of the response is clearly dose related; and when postulated mechanisms of toxicity are similar for laboratory and wildlife species. Most screening values are based on the most conservative assumptions possible. Thus, although an inherent level of conservatism is needed in an ecological risk assessment to ensure that the most sensitive receptors are protected, conservative screening values may heavily overestimate potential risks and the resulting HQ values may be misleading. AWQC and some sediment screening values used in this assessment are based on laboratory studies that do not take into account mitigating or ameliorating physical and chemical conditions in the environment. For example, the most bioavailable (i.e., toxic) form of the contaminant is usually applied to the exposure medium. In reality, bioavailability is rarely, if ever, 100 percent. Several of these uncertainties were addressed as part of Step 3A, but uncertainties still remain.

In addition, ERAs, unlike human health risk assessments, must consider risks to many different species. However, calculation of risk values for each potential receptor species is not possible. For this ERA, conservative screening values protective of a wide range of ecological receptors were sought. The underlying assumption associated with the use of these screening values is that contaminant concentrations in excess of these values are indicative of potential impacts to actual receptors inhabiting the area. However, species-specific physiological differences that may influence an organism's response to a contaminant or subtle behavioral differences that may increase/decrease a receptor's contact with a contaminant are seldom known. Also, contaminants were present in some media for which no suitable benchmarks were available,

and as a result, they could not be quantitatively assessed. Risks may be biased low in these instances. For these reasons, the use of toxicity screening values will introduce error into the results of an assessment.

Potential risks may be under- or over-estimated due to the interactive effects of contaminants. Contaminants with similar modes of action may have additive effects (e.g., organochlorine pesticides) or synergistic effects. In this case, potential risks could be underestimated. Contaminants can also have ameliorating effects on certain receptors. In this case, potential risks could be overestimated.

3.2.5.3 Uncertainty in the Exposure Estimate

Uncertainty in the exposure estimate arises mainly in the methods used to obtain exposure point concentrations. The maximum detected contaminant concentrations were used to represent the highest contaminant concentrations to which ecological receptors might be exposed. If the samples evaluated in this ERA are representative of contaminant concentrations associated with each site, then this approach is conservative and should overestimate potential risks to ecological receptors. The maximum concentration of a contaminant in a given medium may have been collected in a "hot spot" of contamination, and may be much higher than the remaining values in the data set. In such a case, the use of maximum values may overestimate potential risks. Additionally, contaminants that appear to pose significant potential risk may be mitigated by several factors, including a low frequency of detection or elevated concentrations in areas with no significant habitat. These factors would reduce actual exposure.

Dermal and inhalation exposures were not evaluated in this ERA. Dermal exposure is usually limited by the outer coverings of most receptors. Nevertheless, certain portions of some receptors, such as footpads, eyes, and nose do not contain fur or feathers, and may have a higher chance of exposure. However, these areas generally constitute a small portion of the total surface area of most receptors. Inhalation of contaminants is assumed to be miniscule. Airborne aerosols, particulates, and vapors are assumed to be inapplicable for aquatic media, and there is little bare soil at the sites under investigation. As a result, airborne particles would be expected to be minimal. Burrowing wildlife such as woodchucks could be exposed to some contaminants via inhalation. However, data regarding inhalation exposure and toxicity for wildlife were not available. In summary, the dermal and inhalation exposure routes are considered to be minor, but since they cannot be quantitatively assessed, the associated potential risks are inherently underestimated.

3.2.5.4 Uncertainty in the Risk Calculation

Uncertainty in the risk calculation is affected by all aspects of the ERA process described in the above sections. Uncertainty in risk calculation also results from the combination of different components of the ERA in this step. Each of those components already contains different types of uncertainty, as discussed above. Thus, uncertainties may be propagated when these components are combined. To try to reduce the overall uncertainty in the risk assessment, the weight-of-evidence approach is used to make risk decisions. This approach considers all aspects of the assessment, including the uncertainties, to make determinations of potential risks.

7.8 ECOLOGICAL RISK ASSESSMENT

This section presents the results of the ecological risk assessment performed at Site 5, the Fire Training Area.

7.8.1 Preliminary Problem Formulation

This section includes a discussion of available habitats, ecological receptors, contaminant sources, release mechanisms, migration pathways, exposure routes, selection of analytes to be investigated, assessment and measurement endpoints, and the conceptual site model.

7.8.1.1 Habitat Types and Ecological Receptors

Site 5 consists of disturbed areas of grass, weeds, and shrubs (Figure 7-10). The northern portion of the site is a regularly mowed grassy area adjacent to aircraft taxiway Juliet. A shrub thicket is located west of the paved access road into the site. An area of weeds and shrubs exists east of the access road in the vicinity of the former burn area. Sumac (*Rhus* spp.) and box-elder (*Acer negundo*) are abundant in that area. A shallow drainage ditch east of the access road separates the weedy area from the grassy area near the taxiway. The area surrounding the ditch is thickly vegetated with common reed (*Phragmites australis*) and cattail (*Typha* spp.). Two small, shallow excavated ponds (approximately 80 ft by 20 ft) are located approximately 100 feet south of the site. These ponds are not shown on the National Wetlands Inventory Map of the area (U.S. Department of the Interior, undated), but marsh vegetation has become established in the area surrounding the two ponds. The western pond was completely covered with a dense layer of cattail during a site visit in March 1999.

The site is adjacent to an open taxiway to the north, the Marine Corps Compound to the south and southeast, and a paved access road to the west. Thus, to a large extent, wildlife species at the site consist of those that have become accustomed to human disturbance. These include rabbits, raccoons, smaller mammals such as mice, reptiles and amphibians, and various birds. A woodchuck burrow was observed near the former burn area during the March 1999 site visit. During periods of relative human inactivity, deer and red foxes are known to occasionally utilize the site. Avian raptors are expected to forage in the grassy area adjacent to the taxiway. The two small ponds are inhabited by minnows, aquatic invertebrates, reptiles and amphibians, and are occasionally utilized by various receptors that forage on aquatic organisms (e.g., wading birds, waterfowl, raccoons, etc.). There are no known animals or plants state- or federally-listed as threatened, endangered, or candidates for listing, at the site.

7.8.1.2 Contaminant Sources, Release Mechanisms, and Migration Pathways

The contaminant source at Site 5 consists of the former Fire Training Area. Petroleum and related wastes were burned at the site for fire training exercises. Potential contaminant release pathways at the site include volatilization, wind erosion, overland runoff, and infiltration of contaminants. Combustion was probably a major transport mechanism during the period when the fire training area was in use. However, combustion is not a current transport mechanism at Site 5 since open burning activities have ceased.

Constituents in soil could volatilize from surficial material or become airborne via wind erosion. Contaminated fugitive dust can be generated during ground-disturbing activities, such as construction or excavation. The contaminants could then be dispersed in the surrounding environment and transported to downwind locations where they could repartition to surface soil, surface water, or sediment through gravitational settling, precipitation, and deposition. However, most of the site is heavily vegetated,

minimizing the airborne contaminant transport pathway. The absence of vegetation in the immediate area of the burn ring could contribute to fugitive emissions of fine-grained soil particles, but since this area is small, fugitive emissions are probably insignificant.

The flat topography in the vicinity of the site decreases the degree of precipitation runoff. However, two small ponds are approximately 100 feet from the site in a slight downslope direction. In addition, some runoff could eventually drain into ditches that exit the base approximately 2,000 ft south of the site. This drainage eventually flows into Pennypack Creek approximately 3,000 south of the air station.

Infiltrating precipitation can cause the contamination of subsurface soil and groundwater. After reaching the water table, contaminants can be carried with the flow of groundwater to downgradient locations. Contaminants transported in groundwater to surface water can be deposited subsequently in sediment or surface water, and can potentially accumulate in the tissues of aquatic organisms downstream. Groundwater beneath Site 5 flows southeast or southwest, depending on location and depth. The nearest surface water (other than the two nearby ponds) into which site groundwater could discharge is Pennypack Creek, approximately 4,500 feet south of the site. There is no evidence from the RI indicating that groundwater discharges into Pennypack Creek.

7.8.1.3 Exposure Routes

Terrestrial animals at Site 5 can be exposed to soil contaminants through the ingestion of contaminated food items. In addition, animals can incidentally ingest soil while grooming fur, preening feathers, digging, grazing close to the soil, or feeding on items that are covered with soil (such as roots and tubers). Terrestrial vegetation can be exposed to contaminants through direct aerial deposition and root translocation. Aerial deposition could have been a significant exposure route during historical landfill activities. However, aerial deposition is presently minimal since most of the site is vegetated. Terrestrial receptors can also come into contact with contaminants in surface water by using it for drinking, although this exposure route generally represents a negligible portion of total exposure for most receptors.

Aquatic and semi-aquatic organisms in the ponds near Site 5 can be exposed to contaminants through direct contact with surface water and sediments, incidental ingestion of surface water and sediments, and consumption of contaminated food items. Exposure to contaminants in the soil via dermal contact can occur but is unlikely to represent a major exposure pathway because fur, feathers, and chitinous exoskeletons minimize the transfer of contaminants across dermal tissue.

Volatile constituents could be present in some site soils and soil-bound contaminant airborne suspension could occur at Site 5. However, inhalation does not represent a significant exposure pathway because this investigation assumes that air contaminant concentrations are quite low, even for burrowing wildlife. Since inhalation ecotoxicity data for chronic exposure are lacking, the air pathway was not considered for ecological receptors.

7.8.1.4 Selection of Analytes to be Investigated

As discussed in Section 3.2.1.1, calcium, magnesium, potassium, and sodium were excluded as COPCs in all media because they are essential nutrients that are toxic only in extremely high concentrations. Otherwise, analytes selected for evaluation consisted of all analytes detected during current and previous sampling of surface water, sediment, and surface soil at Site 5.

7.8.1.5 Assessment and Measurement Endpoints

A description of assessment and measurement endpoints for this investigation is presented in Section 3.2.1.1.

7.8.1.6 Conceptual Site Model

Figure 7-11 shows the conceptual model for Site 5. The figure shows a complete exposure route for the wind erosion pathway. However, since most of the site is heavily vegetated, the wind erosion pathway is assumed to be minimal. In addition, the dermal (direct contact) exposure route is included in the conceptual model since it is theoretically possible, but as mentioned earlier, it represents a minor exposure route and was not investigated.

7.8.2 Preliminary Ecological Effects Evaluation

Ecologically-based screening values (ESVs), concentrations of contaminants in various media considered protective of ecological receptors, were compared to exposure point concentrations of detected analytes in surface water, sediment, and surface soil to determine if the analytes qualify as ecological COPCs at Site 5. The selection of ESVs was discussed in section 3.2.1.2.

7.8.3 Preliminary Exposure Estimate

The maximum detected contaminant concentrations in surface water, sediment, and surface soil were used as exposure point concentrations for comparison to ecological screening levels. Mean contaminant concentrations and 95% UCL of the mean contaminant concentrations (when available) were also compared to alternate guidelines in Step 3a of the assessment.

7.8.4 Preliminary Risk Calculation

The maximum detected concentrations of aluminum, barium, iron, lead, and dieldrin in surface water exceeded screening levels and thus, they were retained as COPCs (Table 7-27).

No inorganic sediment analytes exceeded screening levels (Table 7-28). Aluminum, barium, beryllium, cobalt, iron, manganese, and vanadium were retained as sediment COPCs since no screening levels were available. Several organics in sediments were retained as COPCs since their maximum concentrations exceeded screening levels; these consisted of anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, phenanthrene, and pyrene. Aldrin, dieldrin, benzo(k)fluoranthene, 2-butanone, and toluene were retained as sediment COPCs since no screening levels were available.

Aluminum, antimony, arsenic, cadmium, chromium, iron, lead, manganese, thallium, vanadium, and zinc were retained as inorganic COPCs in surface soil since their maximum concentrations exceeded screening levels (Table 7-29). Several SVOCs (primarily PAHs) were retained as organic COPCs in surface soils because their maximum concentrations exceeded screening levels. Acetone and a few SVOCs were retained as COPCs because no screening levels were available.

7.8.5 Step 3a: Discussion

Step 3a considerations are discussed below on a COPC-specific basis.

7.8.5.1 Metals

Aluminum

Aluminum was a COPC in sediment because no initial screening level was available, and was a COPC in surface water and soil because its HQ exceeded 1.0. Its concentration in surface water was twice the ORNL lowest chronic value (Table 7-30). Aluminum concentrations in sediment were well below the only available alternate guideline (Table 7-31), which was a probable effects concentration (PEC) from the USEPA Assessment and Remediation of Contaminated Sediments Program (ARCS). The maximum concentration of aluminum in sediments was less than twice the average background concentration. Concentrations of aluminum in all surface soil samples were within the range of background concentrations.

Aluminum is not readily absorbed through the skin and gastrointestinal absorption of ingested aluminum is poor due to the transformation of aluminum salts into insoluble aluminum phosphate (Venugopal and Luckey, 1978). Another factor in the lack of accumulation of aluminum in animals with age or the absence of any increase in tissue levels of aluminum following fairly high dietary intake may be that certain organisms possess a homeostatic mechanism for this element. Aluminum compounds are generally not harmful to most terrestrial organisms and are considered to be toxicologically inert, except in cases of high experimental doses or prolonged inhalation (Venugopal and Luckey, 1978). Data on the toxicity of aluminum to aquatic organisms is somewhat limited. Freshwater organisms usually are not adversely affected when pH is between 6.5 and 9.0 (EPA, 1988). The pH in the surface water sample collected from the western small pond south of the site was within this range (pH=6.77, Appendix C). The pH in the surface water sample collected from the eastern small pond south of the site was slightly lower, at pH=6.35. Overall, however, the aluminum concentrations in Site 5 media are similar to background values. For these reasons, aluminum should be dropped from further consideration at Site 5.

Antimony

Antimony was a COPC in surface soil, but was not detected in surface water and was not a COPC in sediment. Antimony was not detected in background surface soil samples but its HQ was relatively low (HQ=1.8). Few alternate ESVs are available for antimony in surface soil (Table 7-32). Because of its absence in surface water and low concentrations in sediment, and its and relatively low concentrations in surface soil, antimony should be dropped from further consideration at Site 5.

Arsenic

Arsenic was not a COPC in surface water or sediment. Arsenic concentrations in surface soil exceeded the initial screening level in only one sample, and its HQ was low (HQ=1.1). The concentration in this sample was less than the BTAG screening level, less than all alternate ESVs, and was within the range of background values (Table 7-32). For these reasons, arsenic should be dropped from further consideration at Site 5.

Barium

Barium was a COPC in surface water and sediment, but an initial sediment ESV was not available. The maximum surface water concentration was much less than the BTAG ESV (Table 7-30). Barium was detected in both surface water and sediment samples from each of the two ponds, but all values were less than the average background concentrations (Tables 7-30 and 7-31). Barium is a common element in sediments and it is not generally associated with significant toxicity (ATSDR, 1997). For these reasons, barium should be dropped from further consideration at Site 5.

Beryllium

Beryllium was a COPC in sediment since an ESV was not available. Beryllium was not detected in surface water and was not a COPC in surface soil. Although no sediment ESVs were available for beryllium, its concentrations in sediment samples from both ponds were less than the average background concentration (Table 7-31). Therefore, beryllium should be dropped from further consideration at Site 5.

Cadmium

Cadmium was a COPC in surface soil, but was not detected in surface water or sediment. It was detected in 3 of 15 surface soil samples, and it exceeded the initial ESV in only one sample (Appendix A, Table A-18), with an HQ of 1.6. Its concentration in this single sample (4.7 mg/kg) was less than, or only slightly greater than the alternate ESVs shown in Table 7-32. Because of its absence in surface water and sediment, and its relatively low concentrations in surface soil, cadmium should be dropped from further consideration at Site 5.

Chromium

Chromium was a COPC in surface soil, but was not detected in surface water and was not a COPC in sediment. Chromium concentrations in surface soil exceeded the maximum background concentration in three samples (Appendix A, Table A-18), but were greater than twice the average background concentration in only one sample (05SS27), with a value of 56.5 mg/kg.

There is a wide range among available surface soil ESVs for chromium (Table 7-32). The ORNL values in table 7-32 are for hexavalent chromium, the most toxic form of this metal (Efroymson et al, 1997a; 1997b). All chromium concentrations at Site 5 are total chromium. The CCME value of 64 mg/kg is for total chromium (CCME, 1997). The Dutch B value of 250 mg/kg is also for total chromium (Beyer, 1990). Although not shown in Table 7-32, the Dutch "A" value representative of background values (Beyer, 1990), as well as the Dutch "Target Value" that represents the "soil quality required for the full restoration of the soil's functionality for human, animal and plant life" is 100 mg/kg (NMHSP&E, 1994). Since chromium concentrations exceeded twice the average background concentration in only one of 15 samples, and the concentration in this sample was less than most ESVs for total chromium, potential ecological risks (if any) appear to be limited to a small area. Therefore, chromium should be dropped from further consideration at Site 5.

Cobalt

Cobalt was a COPC in sediment because no initial ESV was available. It was not detected in surface water and was not a COPC in surface soil. Cobalt was detected at the same concentration (7.1 mg/kg) in both sediment samples. This value was less than the average concentration in background sediments, and was considerably less than the only available ESV of 50 mg/kg (Table 7-31). Cobalt is present in all natural media, and is a component of certain B vitamins, which are essential for birds and mammals. (ATSDR, 1997). For these reasons, cobalt should be dropped from further consideration at Site 5.

Iron

Iron was a COPC in surface water and surface soil because it exceeded the initial ESVs for these media, and was a COPC in sediment since an initial ESV was not available. The maximum concentration of iron in surface water only slightly exceeded the ESV (HQ = 1.2). The maximum sediment concentration was less than the average background sediment concentration, and was considerably less than the lowest available ESV, which is a "lowest effect level" established by the Ontario Ministry of the Environment (Table 7-31). Surface soil concentrations of iron exceeded the maximum background concentration in only three samples (Appendix A, Table A18), but concentrations in all samples were considerably less than twice the average background concentration (Table 7-32). Because its concentration in surface

water only slightly exceeded the ESV, and since its presence in surface soil and sediment was similar to background concentrations, iron should be dropped from further consideration at Site 5.

Lead

Lead was a COPC in surface water and surface soil but not in sediment. The surface water HQ was low (HQ=1.2), and the maximum concentration in surface water (3.0 µg/L) was less than the BTAG ESV and the ORNL lowest chronic value (Table 7-30). In addition, the concentrations in each of the two surface water samples were flagged with a "K" qualifier (Appendix A, Table A-20), indicating that the values are "biased high due to exceedance of technical quality control criteria". Lead concentrations in five of 15 surface soil samples exceeded twice the average background concentration and the maximum background value of 64.7 mg/kg (Figure 7-9C). Lead concentrations in all five of these samples exceeded the CCME guideline, and the Dutch "B" value was exceeded in two samples (Table 7-32). All soil lead concentrations were less than the ORNL ESV of 500 mg/kg. The maximum concentration of 412 mg/kg was in sample 05SS22 at the southern portion of the former burn area. Lead in this sample might pose potential risks to ecological receptors.

Manganese

Manganese was a COPC in sediment because an initial ESV was not available, and was a COPC in surface soil with an HQ of 2.65. Its maximum concentration in sediment was less than one half of the average background sediment concentration, and was considerably less than all available screening levels (Table 7-31). Most surface soil concentrations exceeded the few available ESVs (Table 7-32), but the HQ was relatively low. All surface soil concentrations were less than the maximum background soil concentration, and most were less than the average background value. Manganese is a common element in the earth's crust and an essential nutrient. Because of its relatively low HQ and its presence at concentrations within the range of background concentrations, manganese should be dropped from further consideration at Site 5.

Thallium

Thallium was a COPC in surface soil but was not detected in surface water or sediment. Thallium was detected in 7 of 15 surface soil samples and its concentration slightly exceeded the maximum background value in only two samples (Appendix A, Table A-18). All surface soil concentrations were less than twice the average background value (Table 7-32). Only two ESVs were available for thallium in surface soil, and these differed by a factor of 1,000 (Table 7-32), so its potential toxicity is difficult to assess. However, all soil concentrations were less than the ORNL screening level of 1.0 mg/kg, a value established for soil phytotoxicity (Efroymson et al , 1997b). Because of this, and since thallium in surface soil was similar to background soil concentrations, thallium should be dropped from further consideration at Site 5.

Vanadium

Vanadium was a COPC in sediment because an initial ESV was not available, and was a COPC in surface soil with an HQ of 1.8. Vanadium was not detected in surface water. No sediment ESVs were available for vanadium, but all sediment concentrations at Site 5 were less than the average background sediment concentration (Table 7-31). Surface soil concentrations were generally within the range of background soil values, and all surface soil concentrations were less than twice the average background soil concentration (Table 7-32). Available ESVs cover a wide range of values (Table 7-32), so the potential toxicity is difficult to assess, but vanadium is not generally considered to be toxic in the environment (Mailman, 1980). Because of this, and since concentrations at Site 5 were similar to background concentrations, vanadium should be dropped from further consideration at Site 5.

Zinc

Zinc was a COPC in surface soil with an HQ of 2.7, and was not a COPC in surface water or sediment. Surface soil concentrations were generally less than the average background soil concentration, and the maximum soil concentration was less than one-fourth of the maximum background soil concentration (Table 7-32). Soil concentrations were greater than the lowest available ESV of 10 mg/kg, but less than the Dutch "B" value. Because zinc was not a COPC in surface water or sediment, and its concentrations in Site 5 soil samples were well within the range of background soil concentrations, zinc should be dropped from further consideration at Site 5.

7.8.5.2 Pesticides

Aldrin

Aldrin was a sediment COPC since an initial ESV was not available. It was not detected in surface water or surface soil. The single detected value of aldrin in sediment was considerably less than the Ontario severe effects level (SEL) for aldrin (Table 7-31). The SEL values are based on actual observed field effects. Although aldrin was not detected in background sediments, it was probably used base-wide in the past for pest control and is unrelated to Site 5. For these reasons, aldrin should be dropped from further consideration at Site 5.

Dieldrin

Dieldrin was a sediment COPC since an initial ESV was not available, and was a COPC in surface water (HQ=31.6). It was not detected in surface soil. The single detected value of dieldrin in surface water was less than the alternate guideline for dieldrin. Sediment concentrations were considerably less than the SEL value (Table 7-31). As with aldrin, it is probable that dieldrin was used base-wide in the past for pest control and is unrelated to Site 5. For these reasons, dieldrin should be dropped from further consideration at Site 5.

7.8.5.3 Semivolatile Organic Compounds

Several SVOCs were retained as COPCs in sediment and surface soil; none were detected in surface water. Carbazole and dibenzofuran were detected in most surface soil samples but in no sediment samples. There were no soil ESVs for carbazole or dibenzofuran, but their concentrations were elevated only in a single sample (05SS30, Appendix A, Table A-18). Because ESVs were not available for these two compounds, and since they were elevated in only one sample, carbazole and dibenzofuran should be dropped from further consideration at Site 5.

PAH Compounds

All other SVOCs at Site 5 consisted of PAH compounds. Eight PAHs, as well as total PAHs, were retained as sediment COPCs sediment since their maximum concentrations exceeded ESVs. The HQ values for these compounds were relatively low, and none of the maximum concentrations of those compounds exceeded ER-M values or SEL values (Table 7-31). In addition, although not naturally-occurring, the concentrations of most of those compounds in Site 5 sediments were not markedly greater than the concentrations in background sediments. PAHs are common in media from industrialized areas, especially areas that experience vehicular traffic. One PAH compound (benzo(k)fluoranthene) was retained as a sediment COPC since no ESV was available, but its maximum concentration was comparable to the maximum concentrations of similar PAHs which did not exceed their alternate guidelines. Concentrations of total PAHs in all sediment samples were less than the ER-M, PEL, PEC,

and SEL values shown in table 7-31. For the reasons discussed above, no PAH compounds were retained as final sediment COCs, and PAH compounds in sediments should be dropped from further consideration at Site 5.

Several PAHs were retained as surface soil COPCs since their maximum concentrations exceeded ESVs or because ESVs were not available. Concentrations of most PAHs in surface soil samples located west of the access road and furthest from the burn area (samples 05SS26, 05SS27, and 05SS28; Figure 7-9C) were not significantly elevated. These samples were located in close proximity to the aircraft taxiway, and PAH concentrations in these samples may be the result of runoff.

Concentrations of several PAHs in samples collected closer to the burn pit were significantly elevated over initial ESVs and alternate guidelines. Specifically, concentrations of several PAHs in samples collected along the western edge of the burn area (05SS17, 05SS18, 05SS21, and 05SS22), the southern edge of the burn area (05SS23, 05SS24, and 05SS25), and the eastern edge of the burn area (05SS29 and 05SS30) were considerably elevated. Concentrations of all PAHs were highest in sample 05SS30, reaching a maximum of 200,000 µg/kg (for phenanthrene). Several individual PAHs and total PAHs east of the access road near the burn area appear to pose potential risks to terrestrial receptors at Site 5, and therefore, are selected as surface soil COCs (Table 7-32).

7.8.5.4 Volatile Organic Compounds

Acetone

Acetone was a COPC in surface soil since an ESV was not available. Acetone was not detected in surface water or sediment. Because acetone is a common laboratory contaminant, and since it was detected in only one soil sample and in no surface water or sediment samples, it should be dropped from further consideration at Site 5.

2-Butanone

2-butanone was detected in one sediment sample and was a COPC since an ESV was not available. Acetone was not detected in surface water or surface soil. Because of its relatively low concentration in one sediment sample (22 µg/kg), and the absence of detections in other media at Site 5, 2-butanone should be dropped from further consideration at Site 5.

Toluene

Toluene was detected in one sediment sample and was a COPC since an ESV was not available. It was not a COPC in surface soil and was not detected in surface water. The only detection of toluene in sediment (4 µg/kg) was much less than its alternate guideline (670 µg/kg), an EPA sediment quality benchmark (Table 7-31). Because of its relatively low concentration in one sediment sample and its absence as a COPC in other media at Site 5, toluene should be dropped from further consideration at Site 5.

7.8.6 Screening Level and Step 3a Uncertainty Analysis

Uncertainty is associated with all aspects of the ERA process. A detailed discussion of the general uncertainties involved in this ERA, and how the uncertainties may affect the final risk values and

conclusions, was presented in Section 3.2.5. This section discusses how site-specific uncertainties may affect the results and conclusions of the ERA for Site 5.

Site 5 has probably received contaminant inputs from sources other than former activities at the Fire Training Area. For example, at least some portions of Site 5 probably receive contaminant inputs from the adjacent aircraft taxiway north of the site. The extent that other sources are responsible for the presence of COCs at Site 5 is uncertain. However, the high concentrations of PAHs in the vicinity of the former burn area suggest that the former fire-fighting activities are responsible for the PAH "hot spot" in this area.

Few data are available for investigating risks to reptiles and amphibians. As a result, direct conclusions about the potential risks to reptiles and amphibians cannot be made. However, contaminants do not appear to have migrated to the two nearby ponds from the Fire Training Area. Thus, potential risks to amphibians and aquatic reptiles in the vicinity of the ponds appear to be low.

The maximum detected chemical concentrations were initially used to represent the chemical concentrations to which ecological receptors might be exposed. If the maximum concentration of a chemical in a given medium was collected in a "hot spot" of contamination and was much higher than the remaining values in the data set, potential risks may be grossly over-estimated. However, the uncertainties related to the location of samples were reduced in this ERA by the large number of surface soil samples collected. Fifteen soil samples were collected at a relatively small site. Thus, the soil concentrations probably present a relatively accurate estimate of soil contamination at the site.

7.8.7 Ecological Risk Summary

Several inorganic and organic contaminants were present in Site 5 surface water, sediment, and surface soil samples in concentrations in exceedance of ecological screening levels and were, therefore, retained as COPCs. Several other contaminants in all media assessed in this ERA were retained as COPCs since screening levels were not available. Most of these contaminants were eliminated as COCs in Step 3a of the risk assessment process for one or more reasons, such as low frequency of detection, concentrations comparable to background values (primarily inorganics) or alternative screening levels, and spatial analysis of detections.

Contaminants do not appear to have migrated to the two nearby ponds from the Fire Training Area. Potential risks to aquatic receptors that inhabit the ponds appear to be low. Therefore, no COCs were selected for surface water and sediment.

The number and location of surface soil samples appear to be sufficient to delineate the nature and extent of surface soil contamination at Site 5. Organic compounds that could pose potential risks to terrestrial receptors on and near Site 5 are limited to PAH compounds. Concentrations of PAHs in surface soil samples collected west of the access road that borders the burn area were only slightly elevated, and that area may receive PAH inputs from the taxiway to the north. Conversely, concentrations of several PAHs in samples collected around the burn pit greatly exceeded screening levels for individual and total PAHs. Therefore, these PAHs are selected as COCs in Site 5 surface soils around the burn area. The high concentrations of PAHs in the vicinity of the former burn area suggest that the former fire-fighting activities are responsible for the PAH "hot spot" in this area. Lead was the only inorganic COC in Site 5 surface soil, and appears to pose potential ecological risks only in the area that is also the hot spot for PAH compounds. Although terrestrial habitat in this area is marginal, it is utilized by ecological receptors such as mammals and birds. Since the area of highest lead and PAH contamination is relatively discrete and does not contain mature trees, wetlands, or other aquatic habitats, remediation of contaminated soils appears to be possible with minimal damage to the existing ecology of the site.

TABLE 7-30
STEP 3A: REFINEMENT OF CONTAMINANTS OF POTENTIAL CONCERN – SURFACE WATER
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE

COPC	Maximum Concentration	Mean Concentration	Initial Screening Level	BTAG Screening Level	Alternate Screening Level	Mean/Max Background	Retained as Final COC?
Metals (ug/L)							
Aluminum	926.0	926	25	25	87[a]/460[b]	561[e]	No
Barium	44.8	34.1	3.9	10,000	4.0[c]	101/112	No
Iron	1170.0	716	1,000	320	158[b]	321/635	No
Lead	3.0	2.2	2.5	3.2	1.32[a]/12.3[b]	0.538/0.8	No
Pesticides (ug/L)							
Dieldrin	0.06	0.055	0.0019	0.0019	0.062[d]	ND	No

a AWQC (USEPA, 1995)
b ORNL Lowest Chronic Value (Suter and Tsao, 1996)
c Secondary Chronic Value (Suter and Tsao, 1996)
d Final Chronic Value (USEPA, 1996b)
e Aluminum was analyzed in only one background surface water sample.
ND = not detected.

TABLE 7-31
STEP 3A: REFINEMENT OF CONTAMINANTS OF POTENTIAL CONCERN – SEDIMENT
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE

COPC	Maximum Concentration	Mean Concentration	Initial Screening Level	BTAG Screening Level	ER-M[a]	PEL[b]	ARCS PEC[c]	Ontario MOE[d]	Other Screening Level	Mean/Max. Background	Retained as Final COC?
Metals (mg/kg)											
Aluminum	12000.00	11600	NA	NA	NA	NA	58030	NA	NA	6620/8950	No
Barium	74.30	72.1	NA	NA	NA	NA	NA	NA	20-60[g]	98.2/160.5	No
Beryllium	0.77	0.675	NA	NA	NA	NA	NA	NA	NA	0.878/1.2	No
Cobalt	7.10	7.1	NA	NA	NA	NA	NA	NA	50[h]	7.21/12.4	No
Iron	11900.00	11500	NA	NA	NA	NA	NA	20,000/40,000	NA	16500/35400	No
Manganese	222.00	165	NA	NA	NA	NA	1081	460/1110	300-500[g]	514/759	No
Vanadium	21.20	18.4	NA	NA	NA	NA	NA	NA	NA	22.6/52.6	No
Pesticides/PCBs (ug/kg)											
Aldrin	11.00	6.05	NA	NA	NA	NA	NA	2/80	NA	ND	No
Dieldrin	220.00	119	NA	NA	NA	4.3	NA	2/910	52[e]	2.26/3.1	No
SVOCS (ug/kg)											
Anthracene	160.00	160	85.3	85.3	1100	245	547.7	220/3700	NA	ND	No
Benz(a)anthracene	850.00	750	261	261	1600	693	4200	320/14800	NA	275/580	No
Benzo(a)pyrene	910.00	715	430	430	1600	763	393.7	370/14400	NA	268/530	No
Benzo(k)fluoranthene	700.00	565	NA	NA	NA	NA	NA	240/13400	NA	240/300	No
Chrysene	1200.00	960	384	384	2800	846	5200	340/4600	NA	238/640	No
Dibenz(a,h)anthracene	120.00	170	63.4	63.4	260	135	28.2	60/1300	NA	ND	No
Fluoranthene	1800.00	1550	600	600	5100	1494	834.27	750/10200	2900[e]	221/510	No
Phenanthrene	880.00	750	240	240	1500	544	NA	560/9500	850[e]	235/260	No
Pyrene	1900.00	1700	660	665	2600	1398	3225	490/8500	NA	315/1300	No
Total PAHs	10,900	8480	4,000	NA	44792	16,770	13660	4000/100,000	NA	834/4790	No
VOCS (ug/kg)											
2-Butanone	22.00	14.3	NA	NA	NA	NA	NA	NA	NA	ND	No
Toluene	4.00	5.25	NA	NA	NA	NA	NA	NA	670[f]	ND	No

a. Effects Range - Median (Long et al., 1995).
b. Probable Effects Levels (FDEP, 1994).
c. Assessment and Remediation of Contaminated Sediments Program; Probable Effects Concentration (USEPA 1996c).
d. Ontario Ministry of the Environment: LEL = lowest effect level / SEL = severe effect level (Jones et al, 1997).
e. EPA Sediment Quality Criteria (USEPA, 1996b)
f. EPA Sediment Quality Benchmark (USEPA, 1996b)
g. EPA Region 5 guideline indicating moderate pollution (Giesy & Hoeke, 1990).
h. Open water disposal guideline, Ontario Ministry of the Environment (Jones et al, 1997)
NA = not available or not applicable.
ND = not detected.

TABLE 7-32
STEP 3A: REFINEMENT OF CONTAMINANTS OF POTENTIAL CONCERN – SURFACE SOIL
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE

Contaminant	Maximum Concentration	95% UCL	Mean Concentration	Initial Screening Level	BTAG Screening Level	ORNL[a,b]	Dutch B[c]	CCME[d]	Mean/Max. Background	Retained as Final COC?
Metals (mg/kg)										
Aluminum	12400.00	10600	9840	1.0	1.0	600[a]	NA	NA	11300/15000	No
Antimony	9.20	9.89	4.82	5	0.48	5[b]	NA	NA	ND	No
Arsenic	10.5	6.04	4.87	10	328	60[a]/10[b]	30	19	6.6/10.6	No
Cadmium	4.70	1.73	1.17	3	2.5	20[a]/4[b]	5.0	3.8	ND	No
Chromium	56.50	23.8	18.6	10	0.0075	0.4[a]/1.0[b]	250	64	15.3/20.8	No
Iron	21600.00	16700	14400	12	12	200[a]	NA	NA	14800/17600	No
Lead	412.00	217	90	50	0.01	500[a]	150	70	30.6/64.7	Yes
Manganese	873.00	582	494	330	330	100[a]/500[b]	NA	NA	642/1190	No
Thallium	0.39	0.26	0.202	0.001	0.001	1.0[b]	NA	NA	0.226/0.34	No
Vanadium	36.3	27.7	24.3	20	0.5	20[a]/2[b]	NA	130	24.9/28.2	No
Zinc	137.00	87.6	59.6	50	10	100[a]/50[b]	200	NA	90.1/597	No
SVOCs (ug/kg)										
2-methylnaphthalene	16000.0	1270	1170	NA	NA	NA	NA	NA	ND	Yes
Acenaphthene	36000.0	4370	2560	100	100	20,000[b]	NA	NA	178/64	Yes
Acenaphthylene	2300.0	643	356	NA	NA	NA	NA	NA	177/62	No
Anthracene	54000.0	11800	4290	2050	100	NA	10,000	NA	154/160	Yes
Benzo(a)anthracene	48000.0	45400	711	2050	100	NA	NA	NA	306/940	Yes
Benzo(a)pyrene	36000.0	26700	5760	2050	100	NA	1,000	750	394/1100	Yes
Benzo(b)fluoranthene	35000.0	39100	7260	2050	100	NA	NA	NA	507/1500	Yes
Benzo(g,h,i)perylene	13000.0	5910	2290	2050	100	NA	NA	NA	225/490	Yes
Benzo(k)fluoranthene	29000.0	22800	4630	2050	100	NA	NA	NA	370/920	Yes
Carbazole	19000.0	3200	1780	NA	NA	NA	NA	NA	213/310	No
Chrysene	45000.0	37500	7290	2050	100	NA	NA	NA	420/1200	Yes
Dibenz(a,h)anthracene	4800.0	1710	843	2050	100	NA	NA	NA	161/160	Yes
Dibenzofuran	34000.0	3120	2380	NA	NA	NA	NA	NA	172/120	No
Fluoranthene	140000.0	151000	17600	2050	100	NA	10,000	NA	902/2600	Yes
Fluorene	56000.0	5560	3890	2050	100	30,000[a]	400,000	NA	184/160	Yes

Contaminant	Maximum Concentration	95% UCL	Mean Concentration	Initial Screening Level	BTAG Screening Level	ORNL[a,b]	Dutch B[c]	CCME[d]	Mean/Max. Background	Retained as Final COC?
Indeno(1,2,3-cd)pyrene	18000.0	9700	3180	2050	100	NA	NA	NA	251/640	Yes
Naphthalene	22000.0	1610	1540	2050	100	NA	5,000	600	ND	Yes
Phenanthrene	200000.0	106000	18100	2050	100	NA	5,000	NA	667/1700	Yes
Pyrene	120000.0	135000	15800	2050	100	NA	10,000	NA	723/2100	Yes
Total PAHs	928,000	5,410,000	107,000	4,000	NA	NA	20,000	NA	4,450/14,100	Yes
VOCs (ug/kg)										
Acetone	17.0	16.8	7.7	NA	NA	NA	NA	NA	ND	No

a. Oak Ridge National Laboratory (ORNL) screening levels; a = lowest valve for earthworms and soil micro-organisms (Efroymson et al, 1997a).
b. ORNL screening levels; b = soil phytotoxicity (Efroymson et al, 1997b).
c. Dutch "B" soil valve: moderate soil contamination that requires further study (Beyer, 1990).
d. Canadian Council of Ministers of the Environment Soil Quality Guidelines (CCME, 1997).
NA = not available or not applicable.
ND = not detected.