BIRD INVENTORY AND HYDROLOGICAL ASSESSMENT FOR WETLANDS 7 AND 8

MILLINGTON SUPPACT TN

2/7/2003

ENSAFE INC

WETLANDS 7 and 8

BIRD INVENTORY AND HYDROLOGICAL ASSESSMENT

Naval Support Activity Mid-South
Millington, Tennessee

Prepared by:

EnSafe Inc.
5724 Summer Trees Drive
Memphis, Tennessee 38134
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1.0 INTRODUCTION

The soil and hydrology at two NSA Mid-South wetlands were assessed to determine which native wetland plant species might be successfully introduced to enhance wetland function and value, specifically nesting or forage habitat for Neotropical songbirds and migratory waterfowl.

The wetlands, designated as Wetland 7 and 8, are a pair of abandoned settlement basins near the installation's southern boundary. The 2001 Integrated Natural Resource Management Plan (INRMP) prepared for NSA Mid-South identified these man-made wetlands as candidates for enhancement, citing reclamation potential for a variety of uses, including recreational fishing. This assessment serves as an initial evaluation to determine if existing conditions would support the addition of natural wetland plant species for habitat enhancements.

2.0 BACKGROUND

Wetlands 7 and 8 are located approximately 450 feet south of the southern boundary of the NSA Mid-South naval facility immediately west of Singleton Parkway and approximately 175 feet south of Big Creek Drainage Canal. The abandoned settlement basins, separated by an earthen berm, were once used as part of the wastewater treatment system for NSA Mid-South from 1969 to 1978. During basewide environmental investigations at NSA Mid-South, soil, sediment, surface water, groundwater, and fish tissue data were collected at the ponds to characterize residual contamination. The investigation concluded that no further action (sampling, monitoring, remediation, etc.) was warranted. Undisturbed since 1978, the rectangular lagoons are being naturally transformed into functioning wetlands.

3.0 SITE DESCRIPTION

Based on historic observations, the two shallow basins are inundated with water for most of the year but, lacking inputs from tributaries or storm water discharges, the water levels in the basins fluctuate with rainfall amount, with a maximum observed depth of approximately 4 feet. In periods of extreme drought, the basins do dry up.

Access to the basins is made by an unmarked entrance off Singleton Parkway south of the Big Creek overpass. A grass drive leads abruptly downhill from a paved road to a small low grass field and then turns and continues westward up a small slope to a second cleared grassy area just north of the berm which separates the two basins. Big Creek Drainage Canal and its associated riparian habitats are less than 50 yards northeast of the lagoons and an expansive bottomland forest to the east and south limits unauthorized access and the majority of anthropogenic influences.

During several visits during the summer and fall of 2002, biologists found the wetland area to be thriving with wildlife. The sloped shorelines were protected by a 10- to 20-foot wide band of lush and healthy riparian vegetation, consisting of mostly herbaceous scrub species, but also numerous mature trees. The fluctuating water level has created distinct zones of emergent vegetation with floating species farthest from the shoreline. A maintained grass trail leads from the second clearing around the entire perimeter of the wetland complex, separating the riparian buffer zone from the surrounding bottomland hardwood forest. It was from this trail that many of the wildlife species were observed.

Avian Wildlife — Biologists surveying the wetlands observed numerous avian species including American robin, ruby-throated hummingbird, indigo bunting, yellow-rumped warbler, yellow-shafted flicker, mourning dove, American crow, mockingbird, red-winged blackbird, black-capped chickadee, Carolina wren, and tufted titmice. Waterfowl confirmed at the site were wood duck (with ducklings), mallard, great blue heron, green-backed heron, belted kingfisher, pied-billed grebe, killdeer, and solitary sandpiper. Bird species observed or reported to occur at NSA Mid-South and likely to be present in and around the Wetlands 7 and 8 are listed in Table 3-1 (INRMP, 2001). Several snakes, turtles, and other herptiles were observed in and around the wetlands and river otter were seen foraging along the nearshore emergent vegetation.

Table 3-1
Birds Observed or Likely to be Present at Wetlands 7 & 8

American crow	European starling	Painted bunting
American robin	Goldfinch	Pied-billed grebe
Barn swallow	Great blue heron	Purple martin
Barred Owl	Great horned owl	Red-bellied woodpecker
Black-and-white warbler	Great-crested flycatcher	Red-tailed hawk
Black-billed cuckoo	Green heron	Red-winged blackbird
Black-crested night heron	Hairy woodpecker	Rock dove
Blue jay	House finch	Rufous-sided towhee
Brown thrasher	House sparrow	Scarlet tanager
Brown-headed cowbird	Indigo bunting	Semipalmated sandpiper
Canada goose	Kestrel	Solitary sandpiper
Chimney swift	Killdeer	Summer tanager
Common grackle	Least flycatcher	Tree swallow
Common screech owl	Mourning dove	Tufted titmouse
Common yellow-throat	Northern oriole	Turkey vulture
Downy woodpecker	Northern cardinal	Yellow-billed cuckoo
Eastern bluebird	Northern flicker	Yellow-rumped warbler
Eastern kingfisher	Northern mockingbird	Yellow-shafted flicker
Eastern phoebe	Northern parula warbler	Tree swallow
Eastern towhee	Northern shrike	

Note:
Less common species that may occur at NSA Mid-South, include Swainson's Warbler (*Limnothlypis swainsonii*), Bell's Vireo (*Vireo bellii*), and Bewick's Wren (*Thryomanes bewickii*).

4.0 SITE GEOLOGY

According to the soil profiles logged during the installation of four borings at Wetlands 7 and 8, the area is geologically and hydrologically heterogeneous and complex. The shallow soil types encountered include surficial alluvium, loéss, and fluvial sediments. Attachment A includes the boring log for each location which profiles the alluvium, loéss, and fluvial sediments.

The dominant surface soil type at Wetland 7 and 8 is *alluvium*, which continues 40 to 50 feet below surface to the top of the Cockfield Formation. Alluvium includes "alluviated" or reworked loéss and is composed primarily of silt with varying clay content. In other borings near the Big Creek Drainage Canal, loéss and fluvial deposits are present from ground surface to the top of the Cockfield Formation.

Surficial Soils at Wetlands 7 and 8

It is likely that the construction of the two ponds in the late 1960s created an unnatural distribution of these soil/sediments types but since there is no record of non-native fill material being used during pond construction, it is assumed that the soil types at Wetlands 7 and 8 are consistent with regional soil types, which are discussed below.

Review of the *Soil Survey* for Shelby County, Tennessee (United States Department of Agriculture, February 1989) indicates that the soil association is present in the area of Wetlands 7 and 8 is the Falaya-Waverly-Collins which is characterized by level, poorly drained to moderately well drained, silty soils. Found in the normal flood plain, soils of the Falaya-Waverly-Collins association are subject to frequent or occasional flooding, which is reasonable since the lagoons were constructed in the historic flood plain of Big Creek.

Surficial soils comprise the Falaya and Waverly silt loam, which is considered hydric and characteristic of soils that form under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in their upper parts. In Shelby County, such hydric soils will support woody vegetation under natural conditions.

Through geotechnical testing and subsequent evaluation, engineering parameters have been derived from individual soil samples collected from the Falaya-Waverly-Collins association and, specifically, Wetlands 7 and 8. Regionally, evaluation of Shelby County soil survey data for both the Falaya and Waverly series estimates that each of these soil types exhibits the following characteristics within the upper 5.0 feet:

- low shrink-swell potential,
- a reaction value, or pH range, of 5.1-5.5,
- a permeability (for uncompacted sample) ranging 0.63-2.0 inches/hour, and
- an available water capacity of 0.2.0 inches/inch of soil.

Based on observed soil characteristics and soil types, the majority of surficial soils at Wetlands 7 and 8 are hydric, but with hydrologic inputs limited to rainfall, year-round inundation of these isolated wetlands is unlikely, as confirmed by the ponds drying up during periods of drought. Enhancement efforts should therefore reflect seasonal inundations, especially for proposed plantings. Wetland areas that may be dry for extended periods should not be vegetated with species requiring year-round wet conditions.

5.0 ECOLOGICAL SUSTAINABILITY

While the habitats at Wetlands 7 and 8 are not the highest quality, the diverse population of Neotropical songbirds and migratory waterfowl observed suggests that it does successfully attract these avian species. Waterfowl use the lagoons to nest and rear young and shoreline vegetation provides the adequate and necessary cover. Mature trees along the wetland perimeter offer perch sites for piscivorous birds like heron and kingfishers to watch for prey. Wading birds also forage in the shallow waters of the lagoons and when exposed, the muddy shorelines provide forage for shorebirds like sandpipers and killdeer.

6.0 ENHANCEMENTS ALTERNATIVES

Enhancements typically provide wildlife with additional food, nest sites, and/or cover. For Wetland 7 & 8, site food sources for songbirds and waterfowl could be increased by adding plants with items they prefer to eat, such as fruits, nuts, seeds, berries, nectar, or foliage. Table 5-1 lists native trees, shrubs, and vines known to attract herbivorous wildlife. A planting scheme which incorporates some of these species would increase the site's appeal to wildlife.

Table 5-1
Native Plants That Attract Avian Wildlife

Scientific Name	Common Name(s)	Plant Type	Wildlife Attracted
Aesculus pavia	Red Buckeye	Shrub/Small Tree	Hummingbirds feed on early nectar
Amelanchier species	Juneberries, sarvisberries	Shrub/Small Tree	Orioles, tanagers, bluebirds and towhees
Aralia spinosa	Devil's walking stick	Shrub/Small Tree	Thrushes, orioles, mockingbirds & vireos
Aronia arbutifolia *Aronia melanocarpa*	Red chokeberry Black chokeberry	Shrub	Meadowlark, catbirds, cedar waxwing, wild turkeys, jays, mockingbirds
Callicarpa americana *Callicarpa americana lactea*	Purple beautyberry White beautyberry	Shrub	Robins, cardinals, mockingbirds, Bobwhites, bluebirds, cedar waxwings & thrushes
Carpinus caroliniana	Ironwood	Small tree	Ruffled grouse, wood duck, Myrtle warblers
Carya illinoensis	Native pecan	Tree	Grouse, wild turkeys, jays & woodpeckers
Carya ovata	Shagbark hickory	Tree	White breasted nuthatch,
Celastrus scandens	American bittersweet	Vine	At least 15 species of birds eat the fruit
Cephalanthus occidentalis	Buttonbush	Aquatic shrub	Hummingbirds catch insects on this shrub
Celtis tenufolia	Dwarf hackberry	Small tree	Bluebirds, fox sparrows, phoebes & more
Cercis canadensis	Eastern redbud	Small tree	Carolina chickadee,
Cornus alternaefolia *Cornus amomum* *Cornus drummondii* *Cornus florida* *Cornus obliqua* *Cornus racemosa*	Pagoda dogwood Pale dogwood Roughleaf dogwood Flowering dogwood Silky dogwood Gray dogwood	Shrub to mid-sized tree	More than 90 species of birds feed on Dogwood fruits incl. vireos, white-throated sparrows, bluebirds, indigo buntings, cardinals, kingbirds, thrushes and many warblers; other birds hunt for insects in their bark.
Fagus grandifolia	American beech	Tree	Grouse, wild turkeys, woodpeckers & jays
Forestiera acuminata	Swamp foresteria	Shrub/Small Tree	Quail, mallards and wood ducks
Ilex opaca	American holly	Evergreen tree	Waxwings, catbirds, bluebirds, robins, hermit thrush & mockingbirds enjoy holly fruit.
Juglans cinerea	Butternut/white walnut	Tree	Carolina wrens, nuthatches & chickadees
Juniperus virginiana	Eastern red cedar	Mid-sized tree	Blue bird, catbird, evening grosbeak, Hermit thrush, Myrtle warbler, crossbill & waxwings
Lindera benzoin	Spicebush	Shrub	Wood thrush, veery & at least 15 species
Liquidambar styraciflua	Sweet gum	Tree	Chickadees, towhee, Carolina wren, juncos
Lirodendron tulipifera	Tulip poplar	Tree	Purple finch, house finch, hummingbird
Lonicera sempervirens	Trumpet honeysuckle	Tree	Hummingbird, bluebird & finches

Table 5-1
Native Plants That Attract Avian Wildlife

Scientific Name	Common Name(s)	Plant Type	Wildlife Attracted
Magnolia acuminata *Magnolia macrophylla* *Magnolia tripetala* *Magnolia virginiana*	Cucumber tree Bigleaf magnolia Umbrella magnolia Sweet bay magnolia	Tree	Red-eyed vireos, American redstart, towhees, robins, ruffled grouse, wild turkeys, Northern flicker, pileated woodpecker, crested flycatcher & blue jays.
Mahonia trifoliata	Algarita / agarita	Shrub	Cedar waxwings, chickadees & robins
Nyssa sylvatica	Sour gum	Tree	Rose-breasted grosbeak & cedar waxwings
Oxydendrum arboreum	Sourwood	Tree	Wild turkeys, bobwhites & grouse
Quercus coccinea *Quercus macrocarpa* *Quercus nigra* *Quercus palustris*	Scarlet oak Bur oak Water oak Pin oak	Tree	Jays, chickadees, quail, turkeys, grosbeaks, cardinals and grouse are some of the birds that eat acorns along with other wildlife. Nesting sites are widely used in oaks.
Rhus copallina *Rhus glabra*	Winged sumac Smooth sumac	Shrub/Small Tree	More than 95 species have been observed eating sumac berries incl. woodpeckers, chickadees & tanagers.
Staphylea trifolia	Bladdernut	Shrub/Small Tree	American goldfinch, pine siskins
Viburnum dentatum *Viburnum nudum* *Viburnum prunifolium*	Arrowwood Possumhaw Smooth blackhaw	Shrub/Small Tree	Robins, grosbeaks, thrushes, waxwings, catbirds, thrashers, towhees, bobwhites, cuckoos, cardinals & bluebirds
Vitis riparia	Riverbank grape	Vine	Tennessee warbler, red bellied woodpecker

Several duck boxes installed in the lagoons could increase usage by nesting waterfowl, as would a few low, vegetated nesting islands constructed in the center of the lagoon. Wildlife would also benefit from the installation of "turtle logs" (exposed tree trunks) or floating platforms in the lagoons, provide ample sites for basking and perching. If the water is deep enough, a string of used tires attached together with cables or chains and submerged would provide habitat for aquatic insects which, in turn, provide food for larval fish.

Birdhouses mounted throughout the surrounding woods would provide additional nesting habitat for the flicker, purple martin, American kestrel, bluebird, and prothonotary warbler and several bat houses would provide daytime shelter for big and little brown bats.

The existing thick weedy vegetation around the lagoons makes an ideal home for small animals such as rabbits, quail and small rodents. Enhancing this riparian zone by introducing a few

native species such as Johnson grass, pokeweed, goldenrod, asters, ragweed, partridge peas, foxtail, smartweed, orchard grass, evening primrose, or curly dock would provide a more diverse vegetative community and improve both forage and shelter habitat. The planting of various types of small trees and shrubs such as black willow, buttonbush, and pondweed in and around the lagoons could provide additional habitat and a small perennial food plot with a mixture of species like bicolor lespedeza, iron clay cowpeas, and Lee soybeans could attract an abundance of wildlife. Brush piles are another type of habitat that is easy to establish and maintain and provide shelter for many species of wildlife.

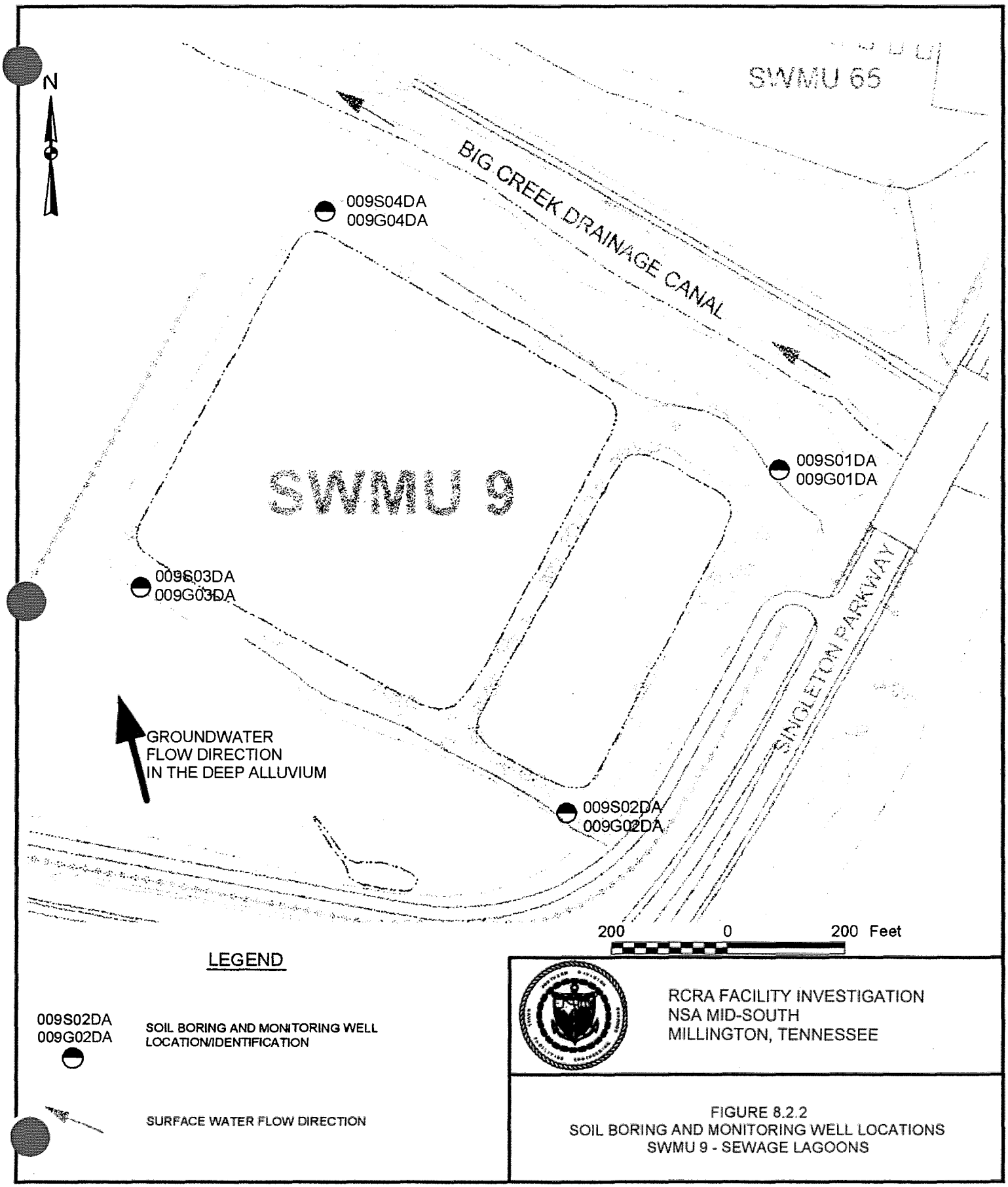
Planned Enhancements

An enhancement currently being proposed at the former lagoon area is the establishment of a Wetland Wildlife Observation Area to allow the public to visit the restored lagoons and enjoy the natural resources year-round. In addition to an access road and small parking area, the Wildlife Observation Area will also include an elevated observation deck constructed between the two lagoons so visitors can have a panoramic view of the entire wetland complex. Informative displays at the observation deck will present color images to identify some of various songbirds and waterfowl likely to be encountered, along with a brief history of the wetlands.

Q:\T.3134\NSA MidSouth\Bird Inventory Wetland Hydrology\hydrology report.doc

Attachment A

Boring Logs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SWMU 65
BIG CREEK DRAINAGE CANAL
009S04DA
009G04DA
SWMU 9
009S01DA
009G01DA
009S03DA
009G03DA
SINGLETON PARKWAY
GROUNDWATER
FLOW DIRECTION
IN THE DEEP ALLUVIUM
009S02DA
009G02DA
200 0 200 Feet
LEGEND
009S02DA
009G02DA
SOIL BORING AND MONITORING WELL
LOCATION/IDENTIFICATION
SURFACE WATER FLOW DIRECTION
RCRA FACILITY INVESTIGATION
NSA MID-SOUTH
MILLINGTON, TENNESSEE
FIGURE 8.2.2
SOIL BORING AND MONITORING WELL LOCATIONS
SWMU 9 - SEWAGE LAGOONS

EnSafe/Allen & Hoshall

Monitoring Well 009G04DA

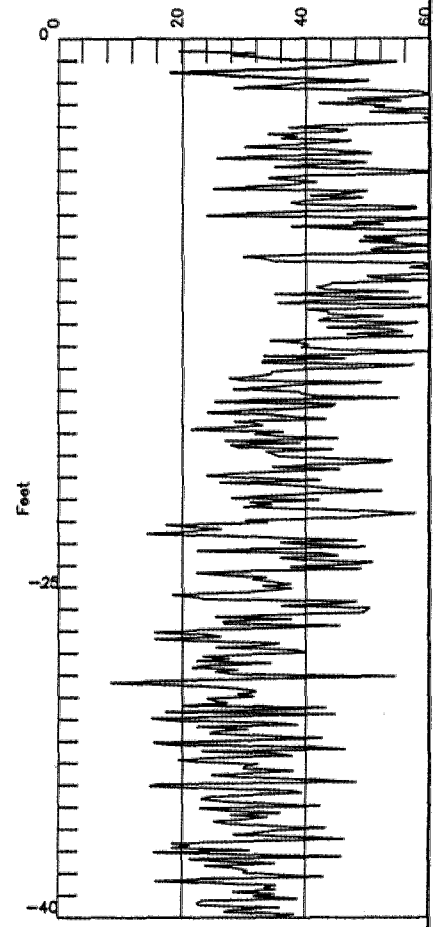
Project: NSA Memphis	Location: Millington, TN. SWMU #9 (Sewage Lagoons)
Project No.: 0106-08420	Surface Elevation: 268.15 feet msl
Started at 0745 on 2-15-96	TOC Elevation: 270.09 feet msl
Completed at 1000 on 2-15-96	Depth to Groundwater: 19.89 feet Measured: 4/8/96
Drilling Method: Rotaconic-4" inner core barrel/6"OD casing	Groundwater Elevation: 250.20 feet msl
Drilling Company: Alliance Environmental, Inc.	Total Depth: 76 feet
Geologist: J.A. Kingsbury	Well Screen: 62 to 72 feet

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)	WELL DIAGRAM
0					BG			(0-41') Upper Alluvium (see descriptions below).		
5					BG		ML	(0-6') Clayey silt, brown in color. Appears to be fill material used during levee construction.		
			1	50	BG				262.1	
10					BG			Slightly silty clay, brownish-gray in color. Very stiff.		
			2	85	BG		CL	Increasing silt fraction. Mottling with olive gray-colored silt. Dark greenish-yellow staining is present with iron/organic specks.		
15					BG				252.1	
					BG			(16-42') Silt (see descriptions below).		
20					BG			(16-22') Yellowish-brown to yellowish-gray in color with dark orangish-yellow staining. Moist to wet.		
			3	100	BG					
25					BG			(22-26') Color change to predominantly gray. Wet.		
					BG			(26-34') Olive gray to greenish-gray in color, with common snail shells. Wet.		
30					BG		ML			
			4	120	BG					
35					BG			Increasing clay fraction from 34' to 36'. Brownish-gray in color.		
					BG			(36-38') Brownish-gray in color, dry.		
40					BG			(38-42') Contains some scattered gravel and a few sand lenses. Contact with Deeper Alluvium deposits (41-72') estimated at 41'.		

2" ID, Sch. 40 PVC casing

GAMMA RAY LOG

COUNTS PER SECOND



CASING TYPE: 2" PVC

TOP OF LOG = GROUND SURFACE

DATE LOGGED: 05/22/96

NOTES

RCRA FACILITY INVESTIGATION
NSA MEMPHIS
MILLINGTON, TENNESSEE

SWMU 9
SEWAGE LAGOONS

DWG DATE: 12/10/96

DWG NAME: 94GL904

LOGGED BY:
GEOLOGICAL LOGGING SYSTEMS

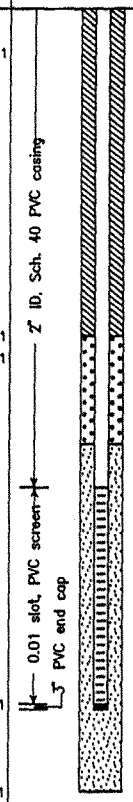
EnSafe/Allen & Hoshall

Monitoring Well 009G04DA

Project: NSA Memphis	Location: Millington, TN. SWMU #9 (Sewage Lagoons)
Project No.: 0106-08420	Surface Elevation: 268.15 feet msl
Started at 0745 on 2-15-96	TOC Elevation: 270.09 feet msl
Completed at 1000 on 2-15-96	Depth to Groundwater: 19.89 feet Measured: 4/8/96
Drilling Method: Rotasonic-4" inner core barrel/6" OD casing	Groundwater Elevation: 250.20 feet msl
Drilling Company: Alliance Environmental, Inc.	Total Depth: 76 feet
Geologist: J.A. Kingsbury	Well Screen: 62 to 72 feet

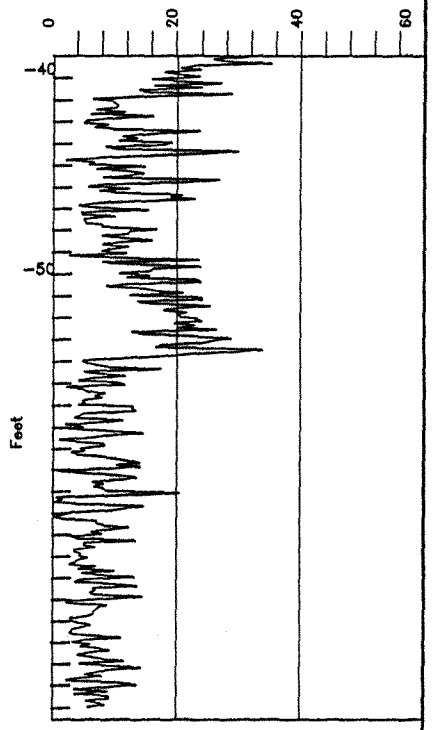
DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
40			5	60	BG		ML		
					BG			(42-55') Sand and gravel; gravel is up to 2" in longest dimension. Yellowish-gray to light olive gray in color.	226.1
45					BG				
					BG			Minor clay fraction in sand and gravel from 46' to 52'. Yellowish- gray to very light gray in color.	
					BG		SW GW		
50			6	90	BG			Sand and gravel, yellowish-gray to light yellowish-brown from 52' to 56'.	
					BG				
55					BG		SM		213.1
					BG		GC	Sand and gravel with interstitial silt and clay. Dark orangish-yellow to reddish-brown from 55' to 56'.	212.1
					BG			Sand and gravel with minor clay, gravel is up to 3" in longest dimension, dark yellowish-brown to reddish-brown from 56' to 72'.	
60			7	90	BG				
					BG		SW GW		
65					BG				
					BG				
					BG				
70			8	80	BG				
					BG			Cockfield Formation: Fine to medium-grained sand, very light gray to very light olive gray, micaceous and finely lignitic.	196.1
75					BG		SP		
								Soil boring terminated at 76'.	192.1
80									

WELL DIAGRAM



GAMMA RAY LOG

COUNTS PER SECOND



CASING TYPE: 2" PVC

TOP OF LOG = GROUND SURFACE

DATE LOGGED: 05/22/96

NOTES

RCRA FACILITY INVESTIGATION
NSA MEMPHIS
MILLINGTON, TENNESSEE

SWMU 9
SEWAGE LAGOONS

DWG DATE: 12/10/96

DWG NAME: 94GL904A

LOGGED BY:
GEOLOGICAL LOGGING SYSTEMS

GEOLOGICAL LOGGING SYSTEMS

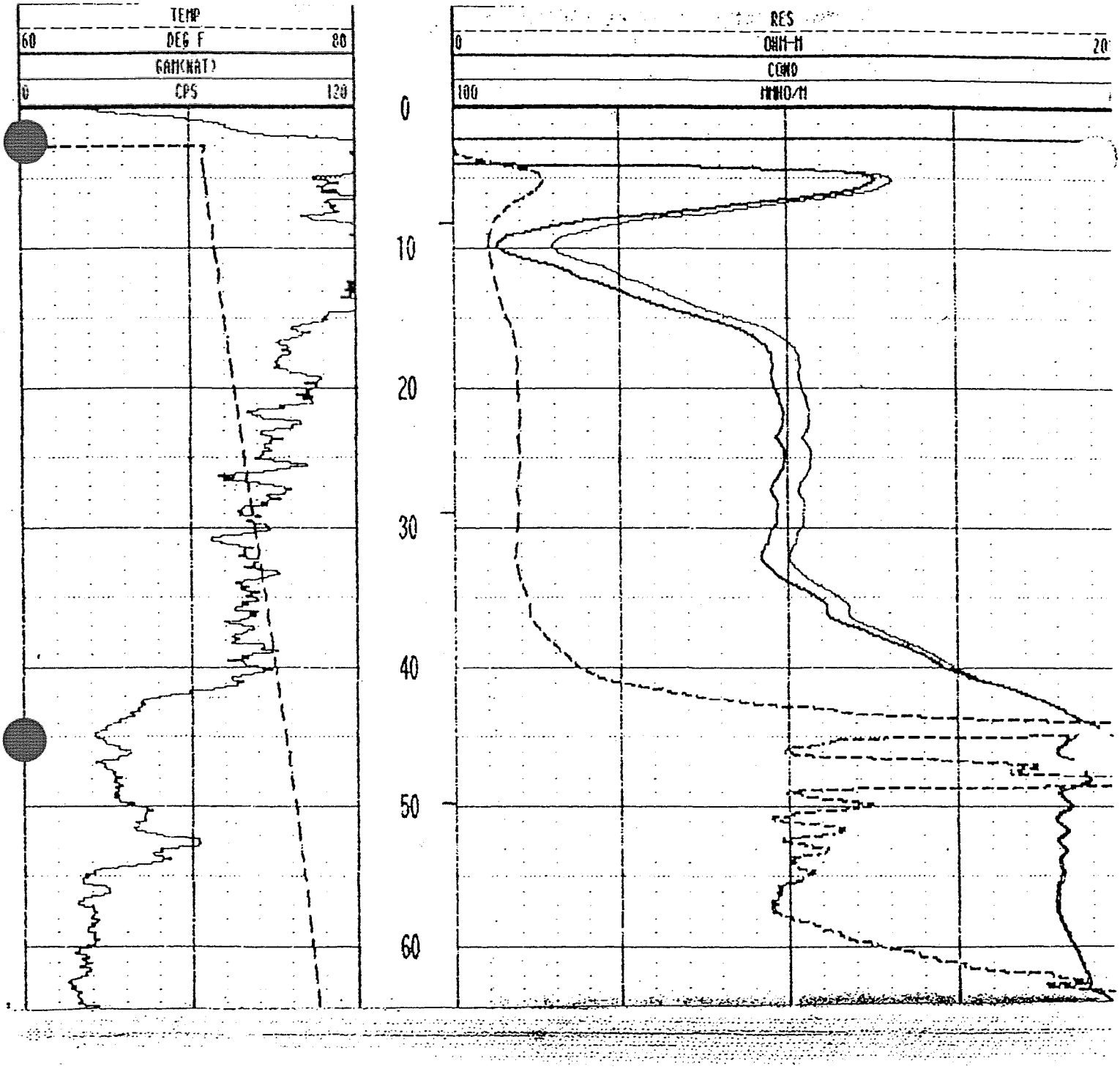
009G04DA

COMPANY	: ENSAFE,ALLEN & HOSHALL				OTHER SERVICES:	
WELL	: 009G04DA				9511	
LOCATION/FIELD	: NAS MEMPHIS				RUN ONE	
COUNTY	: SHELBY				OPEN	
STATE	: TENNESSEE					
SECTION	:	TOWNSHIP	:		RANGE	:
DATE	: 05/23/96	PERMANENT DATUM	:	GL	ELEVATIONS	
DEPTH DRILLER	: 72	ELEV. PERM. DATUM	:		KB	:
LOG BOTTOM	: 69.70	LOG MEASURED FROM	:	GL	DF	: -
LOG TOP	: -1.60	DRL MEASURED FROM	:	GL	GL	: 268.1
CASING DRILLER	: 72	LOGGING UNIT	:	05		
CASING TYPE	: PVC	FIELD OFFICE	:	BLUEFIELD		
CASING THICKNESS	: .25	RECORDED BY	:	J T GILBERT		
T SIZE	: 8	BOREHOLE FLUID	:	WATER	FILE	: ORIGIN
MAGNETIC DECL.	: -	RM	:		TYPE	: 9511C
MATRIX DENSITY	: 2.65	RM TEMPERATURE	:		LOG	: 0
FLUID DENSITY	: 1.2	MATRIX DELTA T	:		PLOT	: 9510C
NEUTRON MATRIX	: SANDSTONE	FLUID DELTA T	:		THRESH	: 9000

REMARKS :

ELECTRIC LOG INTERPRETATION IS EMPIRICAL IN NATURE. EXTREME HOLE COND WILL MAKE COMPLETELY ACCURATE INTERPRETATIONS DIFFICULT.

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS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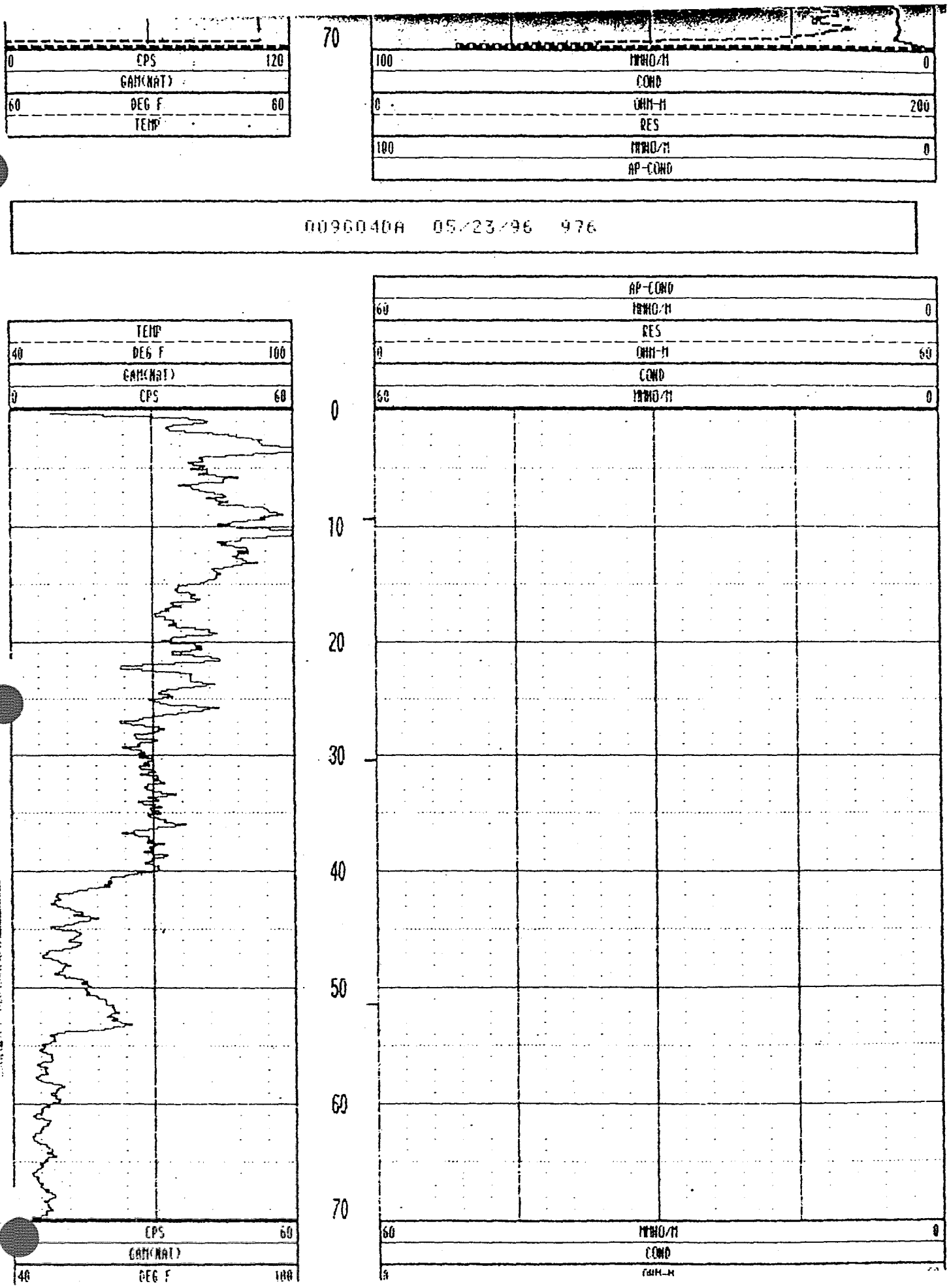
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CPS
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60
MMHO/M
0
COND
0
OHM-M

TRI STATE
TESTING SERVICES, INC.

Measurement of Hydraulic Conductivity

Client: EnSafe/Allen & Hoshall

Date of Report: 02/29/96 Project No.: E-3-157

Client's Project No.: 0106090000

Sample I.D.: 009S01DA18

Soil Description: Tan & Light Gray Silty Clay

Test Media: City of Memphis Water

	Pre-Test	Post Test
Wet Density (Lbs/ft^3)	122.1	120.5
Dry Density (Lbs/ft^3)	91.3	91.0
Moisture (% Dry Wt)	33.8	32.4
Porosity (n)	.43	.44
Degree of Saturation (%)	1.0	1.0
Specific Gravity (ASTM D-854)	2.59	---

Permeability

Temperature Correction, $R_t = 1.043$

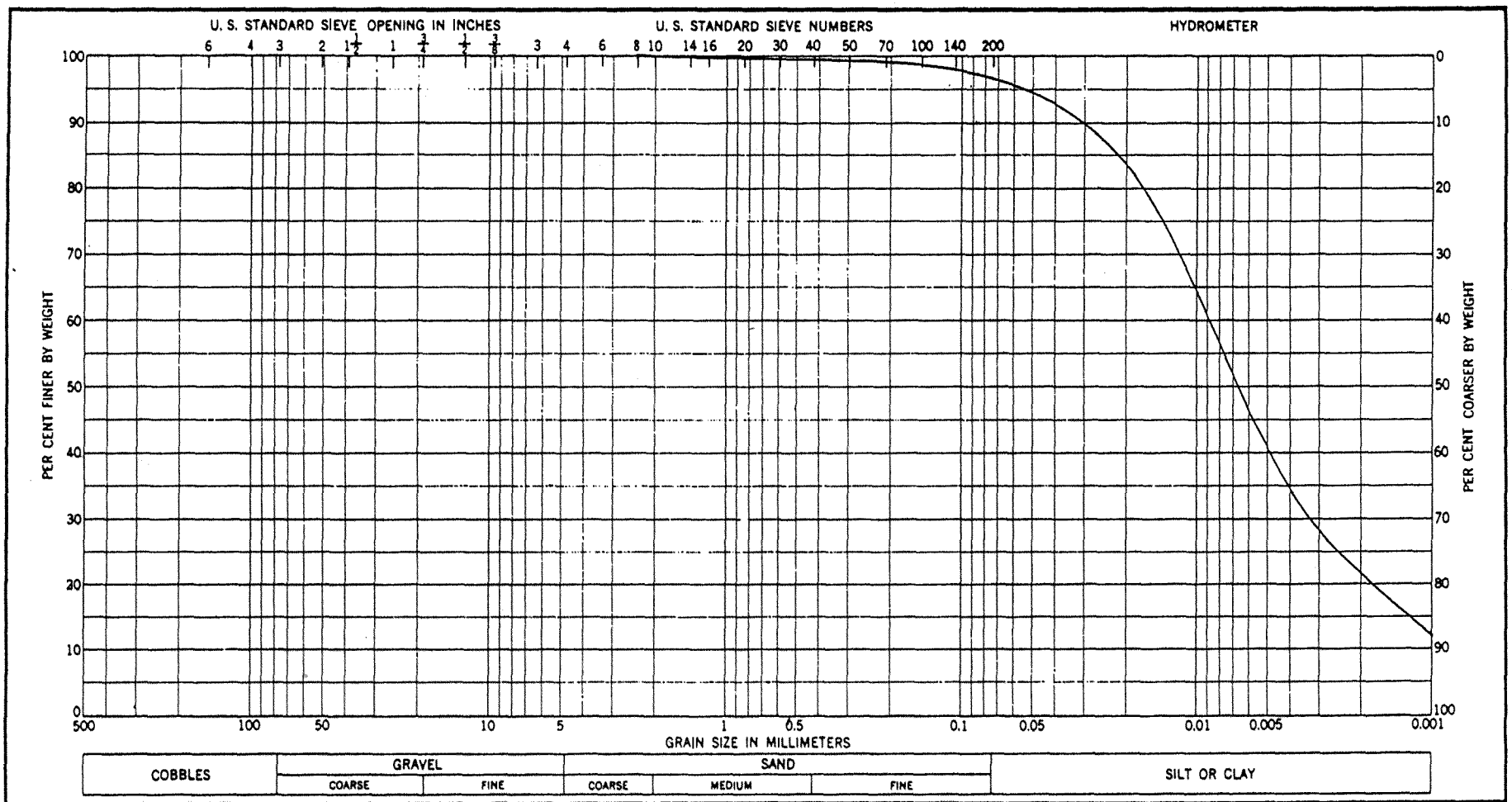
$K_1 = 9.0 \times 10^{-7}$ cm/sec
$K_2 = 8.5 \times 10^{-7}$ cm/sec
$K_3 = 9.4 \times 10^{-7}$ cm/sec
$K_4 = 9.9 \times 10^{-7}$ cm/sec

Coefficient of Permeability, $K_{20} = 9.6 \times 10^{-7}$ cm/sec

Tested in accordance with ASTM D-5084-90.

Lab No. P-96-011 Reviewed By: David D. McCray

6756 Buckles Cove Memphis, TN 38133 901-385-1199 Fax 901-386-6614



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
009S01DA18	16'-18'		34			

GRADATION CURVES

Project EnSafe/A&H # 010609000

Area

Boring No.

Date 02/29/96

TRI-STATE TESTING SERVICES, INC.

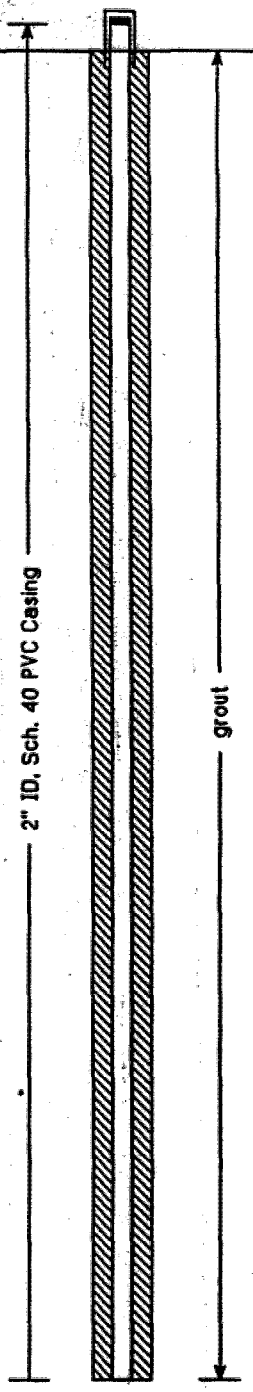
EnSafe/Allen & Hoshall

Monitoring Well 009G01DA

Project: *NSA Memphis*	Location: *Millington, TN. SHMU #9 (Sewage Lagoons)*
Project No.: *0106-2211*	Surface Elevation: *269.69 feet msl*
Started at *1230 on 2-15-96*	TOC Elevation: *271.62 feet msl*
Completed at *1500 on 2-15-96*	Depth to Groundwater: *19.87 feet* Measured: *4/8/96*
Drilling Method: *Rotasonic – 4" inner core barrel/6" OD casing*	Groundwater Elevation: *251.75 feet msl*
Drilling Company: *Alliance Environmental, Inc.*	Total Depth: *66 feet*
Geologist: *J.A. Kingsbury*	Well Screen: *46 to 56 feet*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
0					BG			(0-39') Upper Alluvium (see descriptions below).	
			1	50	BG		ML CL	(0-6') Silt and clay, brown to dark yellowish-brown in color with some organic material.	
5					BG				263.7
					BG			(6-39') Silt (see descriptions below).	
					BG			(6-16) Medium brown in color, with some iron, organic material and dark orangish-yellow staining, moist.	
10			2	40	BG				
					BG				
15					BG			Shelby Tube sample collected from 16-18' for geotechnical analysis. (18-24') Mottled yellowish-brown and yellowish-gray in color with dark orangish-yellow to reddish-brown iron staining.	
					BG				
20			3	70	BG				
					BG		ML		
25					BG			(24-26') Light olive gray to greenish-gray in color. Wet.	
					BG			(26-29') Greenish-gray in color.	
30			4	90	BG			(29-39') Sandy silt with common snail shells. Greenish-gray to olive gray in color between 29' and 34'.	
					BG				
35					BG			Brownish-gray in color between 34' and 39'. Some snail shells present.	
					BG				
40					BG		SP	(39-56') Deeper Alluvium (see descriptions below).	230.7

WELL DIAGRAM



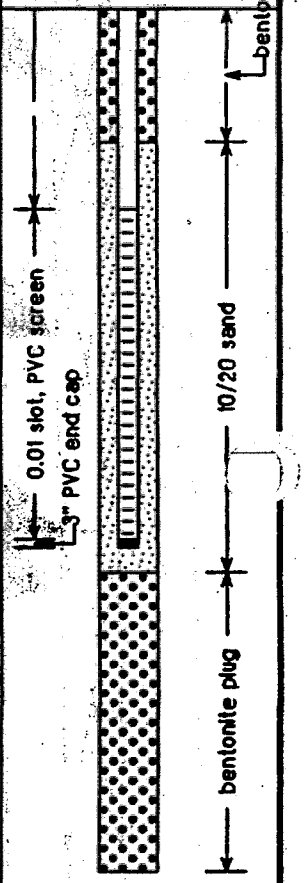
EnSafe/Allen & Hoshall

Monitoring Well 009G01DA

Project: NSA Memphis	Location: Millington, TN. SWMU #9 (Sewage Lagoons)
Project No: 0106-2211	Surface Elevation: 269.69 feet msl
Started at 1230 on 2-15-96	TOC Elevation: 271.62 feet msl
Completed at 1500 on 2-15-96	Depth to Groundwater: 19.87 feet Measured: 4/8/96
Drilling Method: Rotasonic - 4" inner core barrel/6" OD casing	Groundwater Elevation: 251.75 feet msl
Drilling Company: Alliance Environmental, Inc.	Total Depth: 66 feet
Geologist: J.A. Kingsbury	Well Screen: 46 to 56 feet

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
45			5	90	BG		SP	(39-42') Coarse-grained sand, light olive gray in color.	227.7
					BG		GW	(42-42.5') Gravel lense.	227.2
							SP		226.7
							ML	(42.5-43') Coarse-grained sand.	
					BG			(43-45') Silt, very light gray to moderate gray in color.	224.7
					BG		SW	(45-48') Sand with some gravel, yellowish-gray in color.	221.7
50			6	70	BG			(48-56') Sand and gravel. Gravel is up to 3" in longest dimension. Dusky yellow to yellowish-gray in color.	
					BG		SW/GW		
55					BG				
					BG			Cockfield Formation: Fine-grained sand, light olive gray, finely lignitic and micaceous.	213.7
60			7	90	BG		SP		
					BG				
					BG				
65					BG				
								Terminated soil boring at 66'.	203.7
70									
75									
80									

WELL DIAGRAM



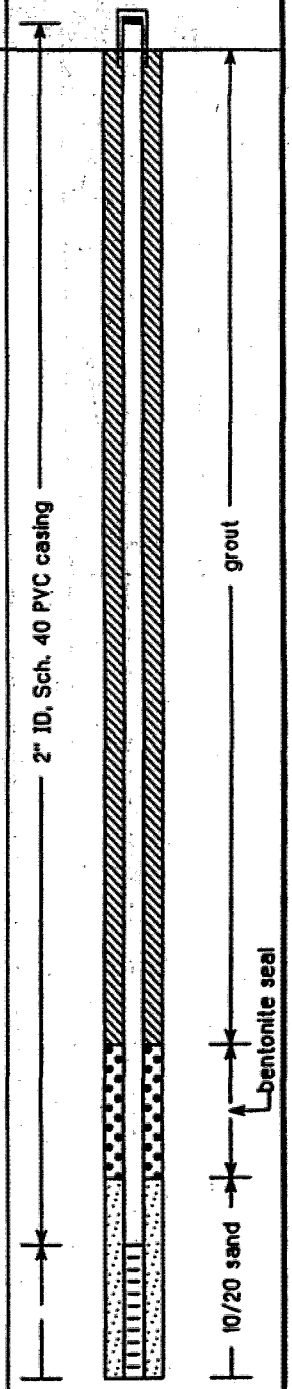
EnSafe/Allen & Hoshall

Monitoring Well 009G02DA

Project: *NSA Memphis*	Location: *Millington, TN. SWMU #9 (Sewage Lagoons)*
Project No.: *0106-2211*	Surface Elevation: *268.85 feet msl*
Started at *0930 on 2-16-96*	TOC Elevation: *270.80 feet msl*
Completed at *1100 on 2-16-96*	Depth to Groundwater: *11.65 feet* Measured: *4/8/96*
Drilling Method: *Rotasonic - 4" inner core barrel/6" OD casing*	Groundwater Elevation: *259.15 feet msl*
Drilling Company: *Alliance Environmental, Inc.*	Total Depth: *56 feet*
Geologist: *J.A. Kingsbury*	Well Screen: *36 to 46 feet*

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
0					BG			(0-40') Upper Alluvium (see descriptions below).	
			1	83	BG			(0-4') Fill material. Silt, moderate brown in color with some iron-staining. Wood fragments that appear to be burnt.	
5					BG			(4-40') Silt (see descriptions below).	
					BG			(4-6') Light olive gray to light brown in color. Dry.	
					BG			Clayey silt. Moderate yellowish-brown to light gray in color, mottled with some dark orangish-yellow-colored material. Moist. Organic material present from 6' to 18'.	
10			2	80	BG				
					BG				
15					BG			Increased iron staining from 15' to 16'.	
					BG				
					BG			Silt, greenish-gray to olive gray in color from 18' to 28'. Wet, with snail shells throughout.	
20			3	70	BG		ML		
					BG				
25					BG				
					BG				
					BG			Color change to brownish-gray. Thin sand lenses, occasionally as thick as 6", are present from 28' to 40'.	
30			4	90	BG				
					BG				
35					BG				
					BG			Shelby Tube collected from 36-38'.	
					BG				
40					BG		SP		228.9

WELL DIAGRAM



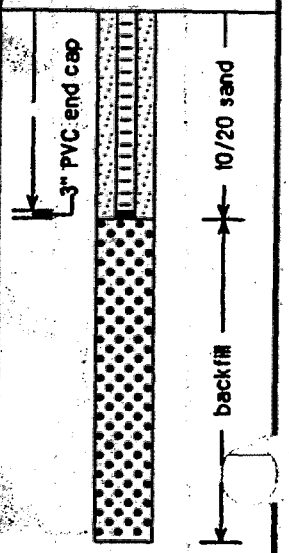
EnSafe/Allen & Hoshall

Monitoring Well 009G02DA

Project: NSA Memphis	Location: Millington, TN. SWMU #9 (Sewage Lagoons)
Project No: 0106-2211	Surface Elevation: 268.85 feet msl
Started at 0930 on 2-16-96	TOC Elevation: 270.80 feet msl
Completed at 1100 on 2-16-96	Depth to Groundwater: 11.65 feet Measured: 4/8/96
Drilling Method: Rotasonic - 4" inner core barrel/6" OD casing	Groundwater Elevation: 259.15 feet msl
Drilling Company: Alliance Environmental, Inc.	Total Depth: 56 feet
Geologist: J.A. Kingsbury	Well Screen: 36 to 46 feet

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
45			5	100	BG		SP	(40-46.5') Deeper Alluvium (see descriptions below).	228.9
					BG			(40-46') Coarse-grained sand, yellowish-gray to dusky yellow. Some gravel (< 1" in longest dimension) is present from 45' to 46.5.	
					BG				
					BG		SM	(46-46.5') Silt and sand, olive-gray in color.	222.9 / 222.4
50					BG		CL	Cockfield Formation: Clay, dark brown in color, hard. Fine-grained sand streaks are present from 46.5' to 56'.	
			6	110	BG				
					BG		SC	The percentage of sand incresases to greater than 50 percent from 52' to 56'.	216.9
55					BG				
								Soil boring terminated at 56'.	212.9
60									
65									
70									
75									
80									

WELL DIAGRAM



EnSafe/Allen & Hoshall

Monitoring Well 009G03DA

Project: NSA Memphis	Location: Millington, TN. SWMU #9 (Sewage Lagoons)
Project No.: 0106-08420	Surface Elevation: 267.18 feet msl
Started at 1300 on 1-31-96	TOC Elevation: 269.05 feet msl
Completed at 1200 on 2-1-96	Depth to Groundwater: 15.79 feet Measured: 4/8/96
Drilling Method: Hollow-Stem Auger/3" diameter split spoon	Groundwater Elevation: 253.26 feet msl
Drilling Company: Alliance Environmental, Inc.	Total Depth: 62 feet
Geologist: J.A. Kingsbury	Well Screen: 45 to 55 feet

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
			1	75	BG		ML	(0-34') Upper Alluvium (see descriptions below).	
			2	92	BG			(0-2') Clayey silt. Light brown to light yellowish-brown and brownish- orange in color.	
5			3	67	BG			(2-4') Silt, light brown in color. Some debris with burnt wood are also present. Appears to be fill.	263.2
			4	83	BG		ML/CL	(4-6') Silt and clay, light gray to moderate gray color with black plant debris. Organic odor.	
			5	96	BG			From 6' to 10', silt and clay is light gray to greenish-gray in color with moderate brown specks of material. Slightly moist from 6' to 8', and moist from 8' to 10'.	
10			6	79	BG				257.2
			7	71	BG		ML	(10-14') Silt, greenish-gray to light gray/brown color. Moist.	
									253.2
15			8	92	BG			(14-34') Silt and clay, greenish-gray in color. Moist. Prevalent iron staining from 16' to 20'.	
			9	71	BG				
			10	100	BG			Abundant organic debris from 18' to 19'.	
20			11	71	BG			Greenish-gray to olive gray in color from 20' to 22'.	
			12	83	BG			Light olive gray to light greenish-gray from 22' to 34'. Moist. Some organic specks of material present.	
25			13	67	BG		ML/CL		
			14	83	BG				
			15	100	BG				
30			16	92	BG				
			17	100	BG			With minor amount of sand near 34'.	
									233.2
35			18	83	BG		SW	Contact with Deeper Alluvium deposits estimated at 34'.	

WELL DIAGRAM

2" ID, Sch. 40 PVC Casing

bentonite grout

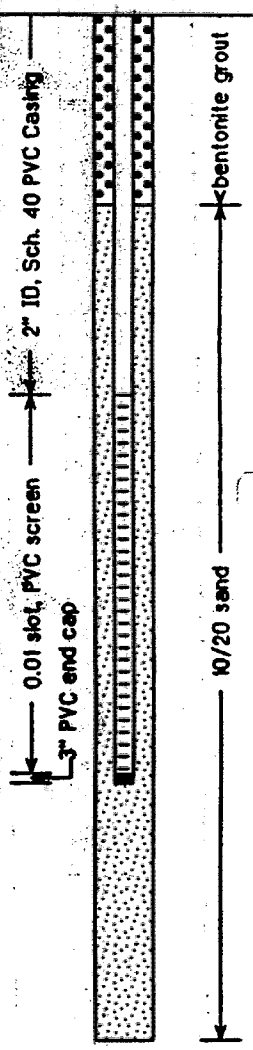
EnSafe/Allen & Hoshall

Monitoring Well 009G03DA

Project: NSA Memphis	Location: Millington, TN. SWMU #9 (Sewage Lagoons)
Project No.: 0106-08420	Surface Elevation: 267.18 feet msl
Started at 1300 on 1-31-96	TOC Elevation: 269.05 feet msl
Completed at 1200 on 2-1-96	Depth to Groundwater: 15.79 feet Measured: 4/8/96
Drilling Method: Hollow-Stem Auger/3" diameter split spoon	Groundwater Elevation: 253.26 feet msl
Drilling Company: Alliance Environmental, Inc.	Total Depth: 62 feet
Geologist: J.A. Kingsbury	Well Screen: 45 to 55 feet

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
							SW	(34-37') Sand, fine to coarse-grained, medium olive gray in color. Some silt lenses present.	
			19	100	BG		ML	(37-38') Silt, light olive gray.	230.2
			20	100	BG		SW	(38-39.5') Sand.	229.2
40			21	100	BG		ML	(39.5-40') Silt.	227.7
							SW	(40-42') Sand, fine to coarse-grained, light olive gray in color at 40' changing to yellowish brown/gray near 42'.	227.2
			22	100	BG		SW GW		225.2
			23	92	BG		SP	(42-43') Sand and gravel, light olive gray to yellowish-gray.	224.2
45								(43-45') Coarse-grained sand, yellowish-gray.	222.2
			24	100	BG		SC GC	(45-49') Sand and gravel in a clay matrix. Yellow gravel, light gray clay.	
			25	100	BG			Sand and gravel with some clay, light olive gray to yellowish-gray in color.	218.2
50			26	100	BG		SW GW	(49-53') Sand and gravel. Yellowish-brown to reddish-brown.	
			27	100	BG				214.2
			28	0	BG			No sample recovery from 53' to 60'.	
55									
60									207.2
			29	100	BG		SP	Cockfield Formation: very fine-grained sand, light gray in color, finely lignitic.	208.2
							ML CL	Silt and clay, light brown to light gray.	205.2
								Terminated soil boring at 62'.	
65									
70									

WELL DIAGRAM



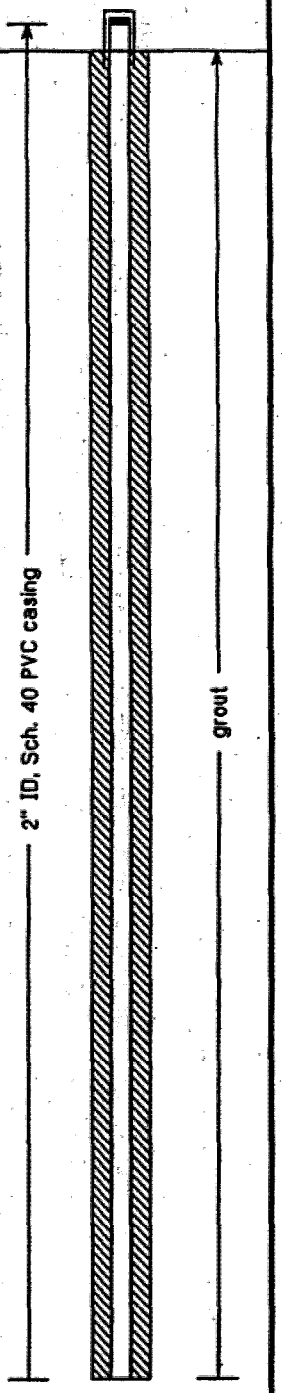
EnSafe/Allen & Hoshall

Monitoring Well 009G04DA

Project: NSA Memphis	Location: Millington, TN SWMU #9 (Sewage Lagoons)
Project No: 0106-08420	Surface Elevation: 268.15 feet msl
Started at 0745 on 2-15-96	TOC Elevation: 270.09 feet msl
Completed at 1000 on 2-15-96	Depth to Groundwater: 19.89 feet Measured: 4/8/96
Drilling Method: Rotasonic - 4" inner core barrel/6" OD casing	Groundwater Elevation: 250.20 feet msl
Drilling Company: Alliance Environmental, Inc.	Total Depth: 76 feet
Geologist: J.A. Kingsbury	Well Screen: 62 to 72 feet

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
0					BG		ML	(0-41') Upper Alluvium (see descriptions below).	
					BG			(0-6') Clayey silt, brown in color. Appears to be fill material used during levee construction.	
5					BG				
			1	50	BG				262.1
					BG			Slightly silty clay, brownish-gray in color. Very stiff.	
10					BG				
			2	85	BG		CL	Increasing silt fraction. Mottling with olive gray-colored silt. Dark greenish-yellow staining is present with iron/organic specks.	
					BG				
15					BG				
					BG				252.1
					BG			(16-42') Silt (see descriptions below).	
					BG			(16-22') Yellowish-brown to yellowish-gray in color with dark orangish-yellow staining. Moist to wet.	
20					BG				
			3	100	BG			(22-26') Color change to predominantly gray. Wet.	
					BG				
25					BG			(26-34') Olive gray to greenish-gray in color, with common snail shells. Wet.	
					BG		ML		
					BG				
30					BG				
			4	120	BG				
					BG			Increasing clay fraction from 34' to 36'. Brownish-gray in color.	
35					BG				
					BG			(36-38') Brownish-gray in color, dry.	
					BG			(38-42') Contains some scattered gravel and a few sand lenses. Contact with Deeper Alluvium deposits (41-72') estimated at 41'.	
40									

WELL DIAGRAM



EnSafe/Allen & Hoshall

Monitoring Well 009G04DA

Project: NSA Memphis	Location: Millington, TN. SWMU-#9 (Sewage Lagoons)
Project No.: 0106-08420	Surface Elevation: 268.15 feet msl
Started at 0745 on 2-15-96	TOC Elevation: 270.09 feet msl
Completed at 1000 on 2-15-96	Depth to Groundwater: 19.89 feet Measured: 4/8/96
Drilling Method: Rotasonic - 4" inner core barrel/6" OD casing	Groundwater Elevation: 250.20 feet msl
Drilling Company: Alliance Environmental, Inc.	Total Depth: 76 feet
Geologist: J.A. Kingsbury	Well Screen: 62 to 72 feet

DEPTH IN FEET	LITHOLOGIC SAMPLE	ANALYTICAL SAMPLE	SAMPLE NO.	% RECOVERY	PID (ppm)	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	ELEV. (ft-msl)
			5	60	BG		ML		
					BG				228.1
45					BG			(42-55') Sand and gravel; gravel is up to 2" in longest dimension. Yellowish-gray to light olive gray in color.	
					BG			Minor clay fraction in sand and gravel from 46' to 52'. Yellowish- gray to very light gray in color.	
					BG		SW GW		
50			6	90	BG				
					BG			Sand and gravel, yellowish-gray to light yellowish-brown from 52' to 56'.	
55					BG				213.1
							SM GC	Sand and gravel with intersitial silt and clay. Dark orangish-yellow to reddish-brown from 55' to 56'.	212.1
					BG			Sand and gravel with minor clay, gravel is up to 3" in longest dimension, dark yellowish-brown to reddish-brown from 56' to 72'.	
60			7	90	BG				
					BG		SW GW		
65					BG				
					BG				
70			8	80	BG				
					BG			Cockfield Formation: Fine to medium-grained sand, very light gray to very light olive gray, micaceous and finely lignitic.	198.1
75					BG		SP		
								Soil boring terminated at 76'.	192.1
80									

WELL DIAGRAM