240IHSSF180

DocumentID	NONCD0002818
Site Name	DUPONT-KENTEC
DocumentType	SITE ASSESSMENT RPT (SAR)
RptSegment	1
DocDate	4/8/1991
DocRcvd	2/20/2007
Box	SF180
AccessLevel	PUBLIC
Division	WASTE MANAGEMENT
Section	SUPERFUND
Program	IHS (IHS)
DocCat	FACILITY

Kentec Groundwater Assessment

prepared for
DuPont–Kentec

April 1991

R-12003-K REV. 1990

DU PONT

ESTABLISHED 1802

E. I. du Pont de Nemours & Company
INCORPORATED
Kinston Plant
P.O. Box 800
Kinston, North Carolina 28502-0800
Phone (919) 522-6111

FIBERS DEPARTMENT

RECEIVED
WASHINGTON OFFICE
APR 9 1991
D. E. M.

April 8, 1991

Guy, you & I need to review this and be prepared to discuss during our meeting on 4/19/91 with Dupont. Please review ASAP. Thanks

Mr. W. A. Hardison, Groundwater Supervisor
N.C. Department of Environment, Health, and Natural Resources
P.O. Box 1507
Washington, NC 27889

Subject: Du Pont Kentec
Route 3, Box 118
Grifton, NC
Lenoir County

Dear Mr. Hardison:

In accordance with the Notice of Violation received on February 12, 1991, we submit this Site Assessment for our Kentec facility.

Our preliminary assessment detected trace amounts of groundwater contamination in shallow monitoring wells near the eastern property boundary. We have been unable to define the horizontal extent of the contaminant plume due to a delay in obtaining permission to install shallow monitoring wells on adjacent property.

Several of the neighborhood property owners have chosen legal representation and we are currently negotiating with their attorney for permission to install the monitoring wells. As soon as permission is obtained, we will complete the Site Assessment and send you a memorandum, summarizing the results.

In the Executive Summary of the Site Assessment, there is a recommendation to install additional deep wells to demonstrate the absence of deep groundwater contamination. These wells have been installed, sampled, and lab analyses, just received by telephone, indicate no traces of contamination. Additionally we sampled three deep residential wells, still in use for drinking water, and they showed no traces of contamination. These data were received too late to be included in this Site Assessment, but as soon as we receive the laboratory report we will submit an addendum.

We appreciate your cooperation as we initiate this remediation effort and we remain committed to its successful conclusion. Your understanding of the complexity of resolving situations which are the result of past disposal practices is commendable. When you consider disposal practices that were acceptable to the community and to regulatory officials a few years ago are thought to be unsound today, it underscores the need for cooperation between all parties to be sure we do the right things now. We look forward to continuing this spirit of cooperation that has been evident so far.

If there are any questions about this material, please feel free to call me on (919) 522-6263.

Sincerely,

Jerry D. Henderson
Manager, Groundwater Project

/pwo
EC7:WW

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WDCR337/087.51

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WDCR344/068.51

WDCR344/068.51

EXECUTIVE SUMMARY

INTRODUCTION

This report presents the results of three phases of a groundwater assessment conducted between April 1987 and December 1990 at the Du Pont Kentec facility.

Kentec began operation in 1969 as a parts-cleaning facility for the Du Pont Kinston Plant. The facility was owned and operated by James Enterprises from 1969 until late 1981. Du Pont purchased Kentec from James Enterprises in late 1981. Between 1969 and 1982, the Kentec facility discharged approximately 2,000 gallons per day of rinsewater containing triethylene glycol (TEG) and 1,4-dioxane to a drainageway immediately south of the main facility building. The rinsewater was treated biologically in a permitted drainfield system on the site between 1982 and 1986. Rinsewater has been shipped offsite for treatment and disposal since the closure of the drainfields in 1986.

The general purposes of the groundwater assessment at the Kentec facility were to evaluate 1) contamination of surficial groundwater and surface water on and near the facility, 2) the potential for contamination of deeper groundwaters, and 3) the potential effects of surface water contamination on biota in the water. During the three phases of the assessment, a network of monitoring points was established and sampled (Figure ES-1). The third phase of the assessment was conducted in conjunction with an audit of wastewater-handling practices at the Kentec facility; a primary objective of the audit was to complete the identification of potential sources of contamination on the facility. The results of the audit were used to guide the third phase of the assessment and to design immediate corrective actions at a number of locations on the facility.

POTENTIAL SOURCES OF CONTAMINATION

Seven potential sources of contamination, past and present, were identified on the Kentec facility during the course of the assessment. Sampling indicated that two of these (the former rinsewater drainfields and a powdered metal burial area) are not currently sources of significant groundwater contamination; the rinsewater drainfields were probably significant sources of contamination during their operation. Four of the remaining five potential sources (the former discharge area for rinsewater, rinsewater settling tanks, a wet well, and underground piping associated with the wet well) were considered to be current sources of contamination. Du Pont took corrective actions (replacement, retrofitting, or removal of the structures and removal of soils) to stop releases from these areas in the winter of 1990-1991. The seventh potential source (cracks in concrete diking in some containment areas) was not obviously associated with groundwater contamination. Du Pont took the precautionary step of sealing the cracks and the containment surfaces in the winter of 1990-1991.

GROUNDWATER

The hydrogeologic system at the site is within a series of unconsolidated sedimentary rocks. The surficial aquifer (water-bearing unit) at the site consists of a layer of sand and silty sand approximately 4 to 10 feet thick. The depth to the water table is approximately 4 feet. Beneath this uppermost layer lies the Peedee formation; the upper part of the Peedee consists of a 20-foot-thick, clayey, sandy silt layer overlying a sandy aquifer.

Surficial groundwater is reportedly not used for potable supply in the vicinity of the Kentec site. The Peedee aquifer is used locally and regionally for water supply.

Surficial groundwater beneath the Kentec facility was found to be contaminated, primarily by the three organic compounds 1,4-dioxane, 1,1-dichloroethylene (DCE), and 1,1-dichloroethane (DCA) (see Figure ES-2). The maximum concentrations of contaminants detected on the site are compared to the relevant state and federal standards in Table ES-1; the concentrations of 1,4-dioxane and DCE exceed the state standard at some locations along the boundary of the facility. TEG, which is present in Kentec's rinsewater, was detected in the environment only sporadically and at relatively low concentrations. It is believed that TEG has degraded over time to smaller-chain glycols and carbon dioxide.

The majority of surficial groundwater contamination appears to have originated in an area near the northeastern corner of the main Kentec building. The distribution of this contamination is complex, in part because groundwater flows radially away from the area. Groundwater contaminated with 1,4-dioxane flows westward from the north-eastern corner and discharges to the drainageway which passes west of the Kentec buildings. Lower concentrations of 1,4-dioxane are found in surficial groundwaters north of the area. Groundwater contaminated with 1,4-dioxane, DCA, and DCE flows south and east from the northeastern corner, to the boundaries of the Kentec property; the information currently available is insufficient to define the extent of contamination beyond the property boundaries.

There is a second, separate area of high 1,4-dioxane concentrations in surficial groundwater at the southeast end of the main Kentec building; this contamination migrates south and west, discharging into the drainageway to the south.

Iron and manganese appear to be naturally abundant in the soils of the area. However, highest iron concentrations in groundwater appear to correlate with the highest 1,4-dioxane concentrations. ?

Some of the surficial groundwater beneath the Kentec site flows downward toward the upper part of the Peedee aquifer. The rate of flow is slow relative to the rate of horizontal flow in the surficial aquifer, because a relatively impermeable layer intervenes between the two aquifers.

No significant contamination was detected in monitoring and residential wells of the Peedee aquifer. However, low concentrations of 1,4-dioxane were detected in 2 of 3 samples collected in an inactive production well (PW1) on the Kentec facility; it is believed that the well was improperly sealed during installation, allowing contaminants to migrate along the well casing. The network of monitoring wells on the site is currently insufficient to determine whether the Peedee aquifer is contaminated downgradient of the production well. Du Pont abandoned the well in the winter of 1990, using procedures designed to prevent flow along the annulus of the well.

SURFACE WATER

1,4-Dioxane was detected in surface water and sediment samples downstream of the Kentec facility (see Figure ES-2). The other major contaminants (DCE and DCA) do not appear to be migrating to the drainage system in detectable amounts. The primary source of contamination in surface waters adjacent to the facility appears to be discharge of contaminated surficial groundwater; analyses of sediment samples suggest that the sediment is a not a major source of contamination.

1,4-Dioxane is migrating through the surface drainages on and near the site to Beaverdam Branch. However, the concentrations of 1,4-dioxane in the branch are very low: 1,4-dioxane was observed only once in a downstream sample from Beaverdam Branch, at a concentration near the detection limit.

Elevated counts of coliform bacteria found in surface waters on the site do not appear to be associated with operations at the Kentec facility.

BIOMONITORING

The elevated concentrations of 1,4-dioxane observed in surface water samples did not appear to have adverse effects upon the biological community in the vicinity of the site. There was little difference in biological activity between locations where the concentration of 1,4-dioxane was elevated and locations where it was low. Bioassay test results confirmed that there was no acutely toxic effect of the organic compounds found in the surface water during the study. Although the biomonitoring study indicated a diversity of benthic populations at the site, the primary organisms were pollution-tolerant types.

RECOMMENDATIONS

The recommendations offered in this report are intended to bring to conclusion the investigative phases of the groundwater assessment and begin to address the need for remediation at the site. Three general issues are addressed by the recommendations: 1) characterization of the extent of contamination in the surficial aquifer beyond the boundaries of the Kentec property, 2) study of the Peedee aquifer, particularly in the vicinity of and downgradient of PW1, to demonstrate the presence or absence of contamination, and 3) development of a remediation plan for surficial groundwater onsite.

Specific recommendations are given below:

- Install a series of monitoring wells offsite to define the extent of contaminant migration in the surficial aquifer beyond the boundaries of the Kentec property.

- Sample new and existing monitoring wells and drainageways for volatile organic compounds (VOCs) and 1,4-dioxane.

- Install and sample three 100-foot monitoring wells: one near PW1, one at MW11, and one at MW10. Install a 50-foot monitoring well at MW11 to complete the monitoring array for the 50-foot zone in the Peedee Formation.

- Evaluate the data collected in these efforts to determine if it is necessary to remediate surficial groundwater offsite or deeper groundwater.

- Perform a feasibility study of remediation alternatives, as appropriate to North Carolina groundwater regulations, to stop further offsite migration of contaminated shallow groundwater.

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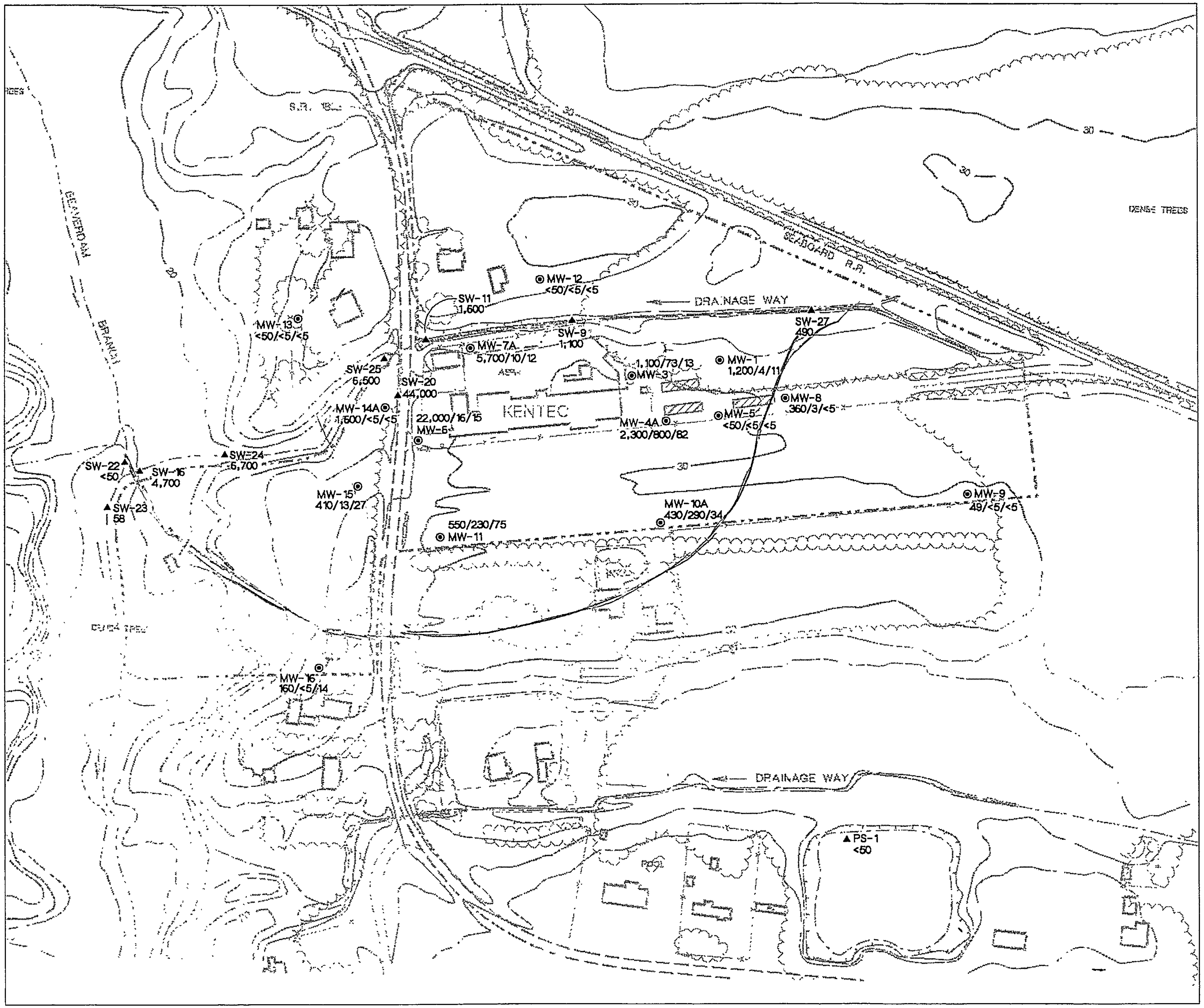

LEGEND

▲ SURFACE WATER SAMPLE

1,100 1,4-DIOXANE CONCENTRATION IN ug/l

⊙ MONITORING WELL

1,100/73/13 1,4-DIOXANE/1,1-DICHLOROETHANE/ 1,1-DICHLOROETHYLENE CONCENTRATIONS IN ug/l

NOTE: BASE MAP COMPILED FROM AERIAL PHOTOGRAPHY FLOWN ON 2/10/89.

0 100 200 300

SCALE: 1"=200'

Figure ES-2

CONCENTRATIONS IN SURFICIAL GROUNDWATER AND SURFACE WATER JANUARY 1990

CH2M HILL

2398fc16.dgn 04-Apr-1991

Table ES-1
MAXIMUM ORGANIC CONCENTRATIONS IN WATER AND APPLICABLE STATE AND FEDERAL STANDARDS OR GUIDELINES
(μg/1)

	Observed Concentration				Standard or Guideline			
						Safe Drinking Water Act		
Compound	Deep Groundwater Onsite	Surficial Groundwater Onsite	Surficial Groundwater Property Boundary	Surface Water	NC[a] Groundwater Standard	Maximum Contaminant Level (MCL)	Maximum Contaminant Level Goal (MCLG)	EPA Health Advisory 10-Kg Child 1 day dose
1,1 DCA	-	900*	290	14*	/	/	/	/
1,1 DCE	-	82	75	-	7	7	7	2,000
1,4-Dioxane	110	33,000*	550	44,000	7	/	/	4,000
Vinyl Chloride	-	6	-	-	0.015	2	0	3,000
TCE	-	-	-	5	2.8	5	0	/
Carbon Disulfide	-	20	-	130	/	/	/	/
Chloroethane	-	150	190	34	/	/	/	/
TEG	1,900	810	-	53,000	/	/	/	/

- Undetected, Below Method Detection Limit
* Concentration observed during Phase 2, all other concentrations observed during Phase 3
/ No standard developed for this compound
a North Carolina Administrative Code T15A:02L.0100, .0200, .0300

WDCR344/071.51

Chapter 1
BACKGROUND AND SITE HISTORY

INTRODUCTION

CH2M HILL conducted a groundwater assessment of the Du Pont Kentec facility near Kinston, North Carolina (Figure 1-1), in three phases between April of 1987 and December of 1990. The primary purposes of this report are to describe the third phase of investigation and to characterize the nature and extent of groundwater contamination in the shallow (surficial) aquifer beneath the Kentec property. The first two phases of the assessment are detailed in two previous reports (CH2M HILL, 1987, 1988); data and other pertinent information from these reports are summarized here. Subsequent reports will address (1) groundwater conditions beyond the boundaries of the facility and in the deeper aquifer, and (2) groundwater remediation strategies.

The rest of this chapter summarizes the chronology of and rationale for the three phases of the groundwater assessment, with particular attention to surficial groundwater on the Kentec property. Chapter 1 concludes with a discussion of an audit of waste-handling practices at the Kentec facility, which was conducted in conjunction with the Phase 3 groundwater investigations. Chapter 2 of this report describes the geology of the site and surrounding areas. Chapter 3 discusses the hydrogeology of the site. Chemical analyses of samples taken at the site are presented and interpreted in Chapter 4. Chapter 5 presents the conclusions of the assessment, and Chapter 6 gives recommendations for future activities at Kentec. The appendices give detailed descriptions of field procedures, other studies that were part of the Phase 3 effort, and data collected during Phases 1 and 2.

CHRONOLOGY OF ASSESSMENT

BACKGROUND

The Kentec facility (Figure 1-2) began operation in 1969 as a parts cleaning facility for the Du Pont Kinston Plant. The facility was owned and operated by James Enterprises from 1969 until late 1981. Du Pont purchased Kentec from James Enterprises in late 1981. The major items cleaned at Kentec include packs, powdered metal, and spinerettes, all of which are employed in the production and spinning of Dacron®. Triethylene glycol (TEG) is used to remove accumulated Dacron® polyesters, reagents, and byproducts from the parts. Spent TEG is recovered and transported offsite for recycling. The parts are then rinsed with water to remove any traces of TEG and Dacron®. Constituents likely to be in this rinsewater include polyethylene glycols (such as TEG), 1,4-dioxane (a byproduct of heating TEG), and byproducts of esterification and polymerization of Dacron®. 1,1,1-Trichloroethane (TCA) is used in the ultrasonic room as a drying agent, but is reportedly not discharged directly from the cleaning areas to the Kentec rinsewater system.

Until 1982, the Kentec facility discharged approximately 2,000 gallons per day of rinsewater containing TEG and 1,4-dioxane to a drainageway lying between the plant and State Route 1802. A biological treatment facility comprising three subsurface drainfields was permitted and installed onsite in June 1982. The drainfields were closed in February 1986, because their retention time was insufficient to allow degradation of the organic compounds. Drainfield A (Figure 1-2) is reportedly the only one of the three that received rinsewater. Rinsewater has been shipped offsite for treatment and disposal since February 1986.

A tank truck spilled process TEG between State Road 1802 and the southwest side of the plant on April 7, 1987. Du Pont sampled water and contained and removed the water and soil from the spill area between April 7 and 8, 1987.

PHASE 1

In November 1986, CH2M HILL was contracted to assess possible groundwater contamination resulting from the disposal of rinsewater in Drainfield A. Six shallow monitoring wells (MWs 1 through 6) were installed in April of 1987 to study the drainfield (Figure 1-3). Surface water and soils were sampled in and near the drainageways at the site (Figure 1-4).

1,4-Dioxane was observed in groundwater samples from all of the monitoring wells. Some additional volatile organic compounds (VOC) were detected at MW6. The concentrations of iron and manganese were elevated in all groundwater samples. Chemical oxygen demand (COD), an indicator of organic contamination, and coliform bacteria were elevated in surface water samples on and off the Kentec property.

The Phase 1 report recommended (1) an inventory of all nearby residences to determine if property owners were using shallow well water; (2) sampling and analysis of surface waters adjacent to the property; (3) additional sampling of groundwater from the monitoring wells for 1,4-dioxane, VOC and TEG; (4) additional sampling of surface water for coliforms; and (5) installation of a background monitoring well.

PHASE 2

Phase 2 of the assessment was conducted from May to October of 1988. Nearby residences were inventoried. None of the residents reported using shallow groundwater for potable purposes; some reported using shallow groundwater to water lawns. Two shallow monitoring wells (MWs 7 and 8) were installed on the Kentec property, and additional samples of groundwater and surface water were obtained. Five of the wells were tested to measure hydraulic conductivity.

1,4-Dioxane was detected in all of the monitoring wells, including MW8, which was originally intended as a background well. 1,1-Dichloroethane (DCA) and

1,1-dichloroethylene (DCE), which are both natural degradation products of TCA, were detected at MW3 and MW4; they had not been detected there during Phase 1. The major constituent of the rinsewater, TEG, was not detected near the drainfield.

The Phase 2 report recommended (1) analysis of soil samples from the drainfield area, (2) expansion of the monitoring program to include deeper wells and additional downgradient shallow wells, (3) analysis of additional surface water and sediment samples, (4) sampling of any residential wells downgradient of Kentec, even if not in use, and (5) preparation of a topographic map of the site.

PHASE 3

The current phase of the assessment began in October of 1989. The recommendations of the Phase 2 report were implemented. In addition, a biomonitoring study was conducted in surface waters adjacent to the facility, to evaluate potential impacts of the Kentec discharges. A facility audit was also conducted to identify potential sources of groundwater contamination at Kentec. Between Phases 2 and 3, Du Pont acquired property adjacent to Kentec; the current property boundary is shown in Figure 1-2.

The chronology of field activities for Phase 3 is given in Table 1-1. The results of the Phase 3 investigation are summarized and interpreted in the remaining chapters of this report. Detailed discussions of drilling and well installation, sampling procedures, hydraulic conductivity tests, water quality analyses, and the biomonitoring study are given in Appendices A through E, respectively.

FACILITY AUDIT

On July 23, 1990, CH2M HILL audited wastewater sources, wastewater handling operations, and physical facilities at Kentec. There were two primary objectives of the audit: 1) to identify potential sources of groundwater contamination from existing and past operations, and 2) to identify methods that could be used to confirm and quantify potential contaminant sources. In addition, Du Pont used the results of the audit to guide immediate corrective actions at some locations.

The audit indicated a number of potential sources of groundwater contamination. These potential sources, together with sampling results and corrective actions, are described below. Sample locations are shown in Figure 1-5 and analytical results are given in Table 1-2. A summary of corrective actions is given in Table 1-3.

DRAINFIELDS

The three drainfields, installed in 1982 and unused since 1986, were considered a possible source of continuing releases to groundwater. A water sample was collected from each of the three drainfield distribution boxes (A,B, and C) and two soil samples (DL-1 and DL-2) were collected directly beneath Drainfield A.

Elevated concentrations of contaminants were not detected in these samples or in the 10 drainfield soil samples collected earlier during Phase 3 (Appendix D, Table D-5). ("Elevated" concentrations are defined here as concentrations sufficient to cause groundwater contamination similar to that seen in adjacent monitoring wells.)

RINSEWATER SETTLING TANKS (UNDERGROUND)

Two underground concrete tanks (ST1 and ST2), located adjacent to the southern end of the main Kentec building, were used as settling chambers to remove filter wash grit solids from the rinsewater. At the time of the audit they were no longer in service; however, they had not been cleaned out and each was nearly full of solids. A third tank (ST3), located approximately 100 feet from ST1 and ST2, was permitted as a septic tank in 1982 and disconnected in 1988. This tank was one-half full of liquid.

Samples of the solids were collected from ST1 and ST2, and one liquid sample was collected from ST3. Analysis of the samples indicated elevated concentrations of organic compounds, including TEG, 1,4-dioxane, TCA, DCA and DCE.

Du Pont contracted to have the solids and liquid pumped out of the tanks and hauled offsite for treatment and disposal. After the tanks were removed, the soil beneath and adjacent to the tanks was sampled and analyzed. At ST1 and ST2, one pair of soil samples was collected from each tank location. One member of each pair was a composite of soil from around the joint connecting the two halves of the tank, while the other (ST1-2 and ST2-2) was collected from directly beneath the tank. ST3-1 was collected from the tank's effluent pipe and ST3-2 was collected from directly beneath the tank. Low concentrations of 1,4-dioxane were detected in all of the soil samples from ST1 and ST2. Soil was removed from the two locations for offsite disposal; the holes were then backfilled with clean sand.

WET WELL

A wet well located near the northeastern corner of the main Kentec building is a collection point for rinsewater piping. The wet well is constructed of reinforced concrete and has a standing rinsewater level typically above the level of the water table. Measurements of changes in water levels within the wet well and in two nearby piezometers (P4, P5) over a 24-hour period suggested that the wet well was leaking. Du Pont installed a fiberglass liner within the wet well to prevent any future leakage.

PIPING

The six-inch, PVC, underground pipe that conveys all rinsewater to the wet well was found to be cracked in two places. The cracked pipe was replaced and a soil sample was collected from beneath each of the two locations (SS1 and SS2) for analysis. The analyses did not indicate any substantial contamination remaining in the soil near these cracks.

The underground pipe for conveying rinsewater from the storage tank to the rail car was replaced with an above-ground line.

SUBSURFACE POWDERED METAL

In the early years of Kentec's operation under James Enterprises, uncleaned, powdered metal was disposed on the ground north of the main Kentec building. In the mid-1980s, this disposed metal was mined and reclaimed. During this audit, three soil borings (SB1, SB2, and SB3) were drilled to the water table in this area to determine whether contamination was evident in the soil. Two soil samples were collected from each boring and analyzed; no substantial contamination was found.

SURFACE DISPOSAL OF RINSEWATER

From 1969 until 1982, rinsewater from the facility was disposed in a drainageway between State Road 1802 and the facility. A spill of TEG occurred in the same area in April 1987. In November 1990, Du Pont excavated soil and sludge from this area and disposed it offsite. Two samples of the sludge (S1 and S2) were analyzed and found to be contaminated with the constituents typically found in the rinsewater (Table 1-2). After excavation, a sample of the remaining soil (S3) was collected and analyzed. The remaining soil had 2.7 mg/kg of 1,4-dioxane; this is lower than the concentration of 1,4-dioxane in the shallow groundwaters flowing through these soils.

CONTAINMENT AREAS

The cleaning areas in the main Kentec building and in the above-ground storage tank area are generally contained by concrete dikes to collect leaks or spills. There were cracks several locations in these concrete containments at the time of the audit. All cracks and dikes have recently been sealed with epoxy by Du Pont.

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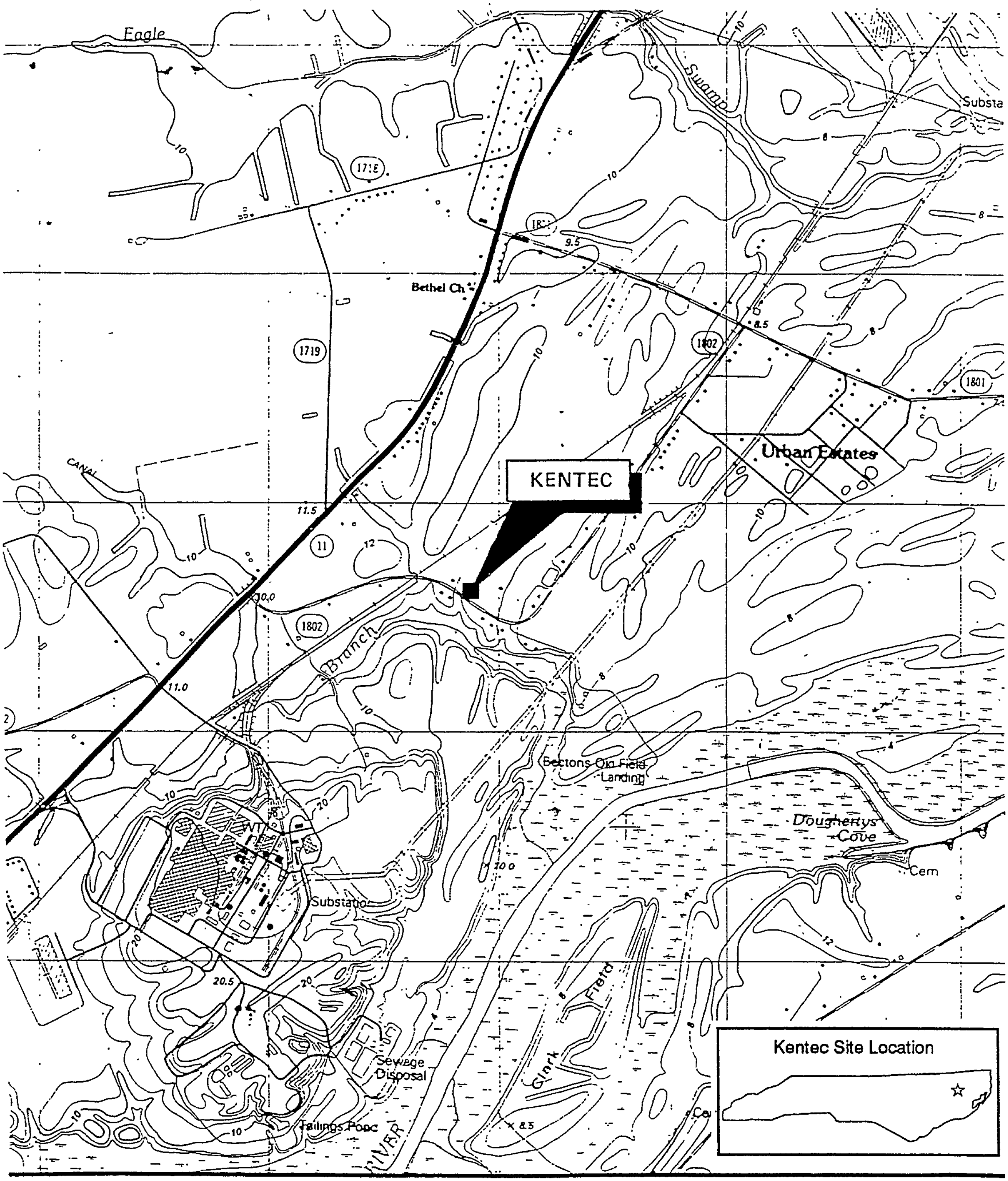


LEGEND

Source: USGS Grifton Quadrangle
North Carolina, 1983

Contour Interval — 2 Meters

SCALE:

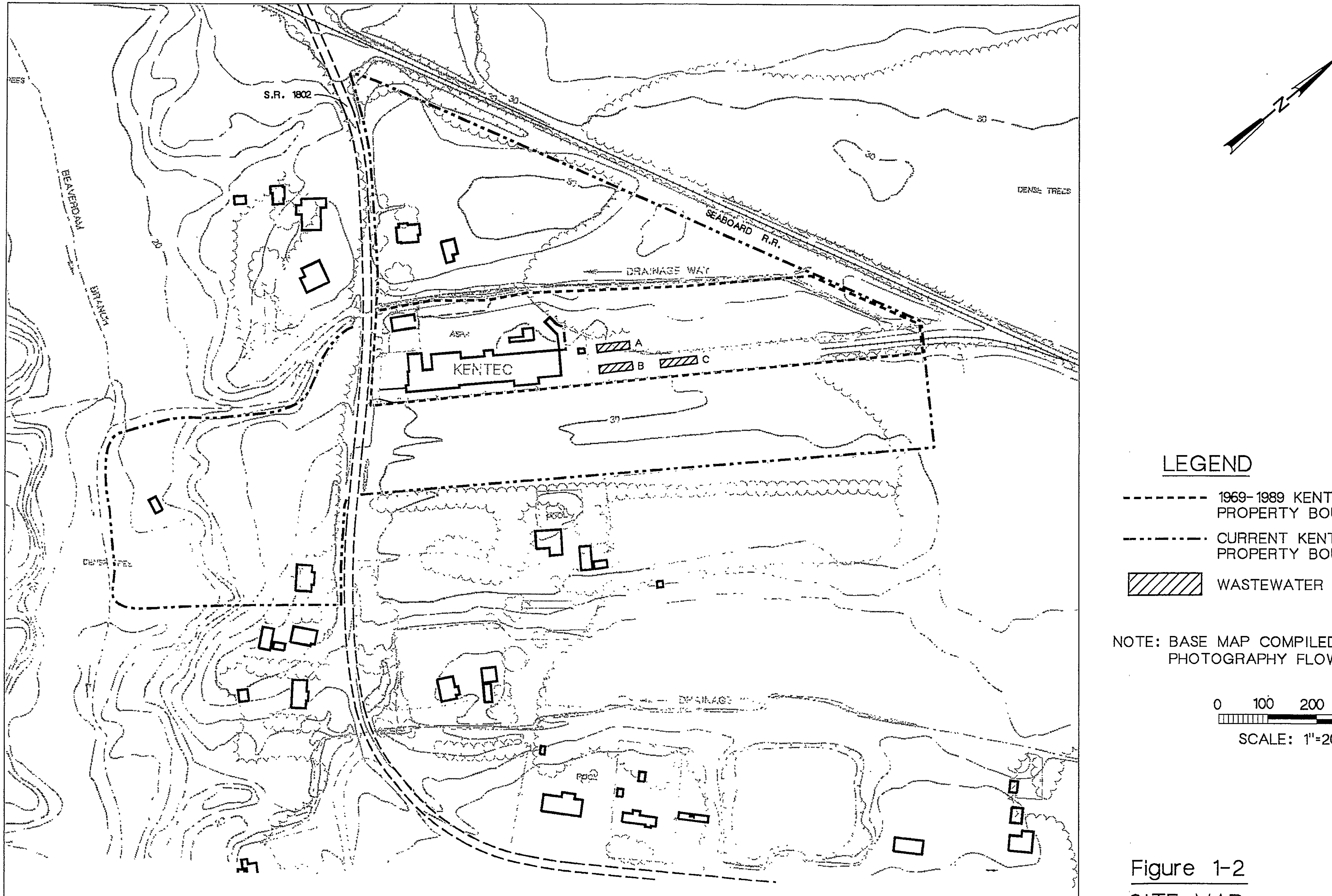
1000 0 1000

1 inch equals 1000 feet

- N -

Figure 1-1
KENTEC SITE LOCATION

CH2M HILL



LEGEND

- - - - - - 1969-1989 KENTEC PROPERTY BOUNDARY

-·-·-·- CURRENT KENTEC PROPERTY BOUNDARY

▨ WASTEWATER DRAINFIELD

NOTE: BASE MAP COMPILED FROM AERIAL PHOTOGRAPHY FLOWN ON 2/10/89.

0 100 200 300

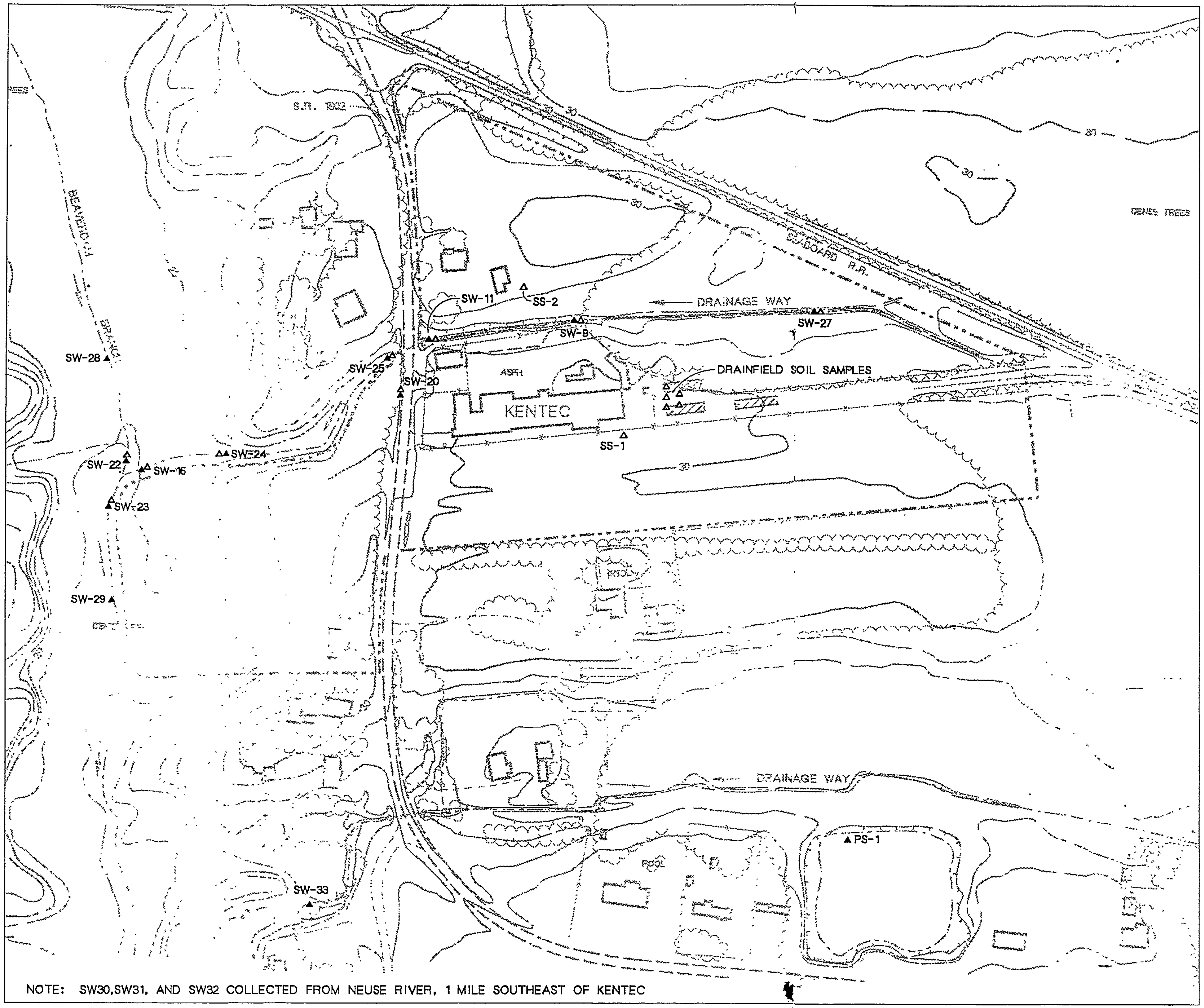
SCALE: 1"=200'

Figure 1-2

SITE MAP
Du Pont Kentec Facility

CH2M HILL

2398fc05.dgn 28-Mar-1991



LEGEND

▲ SURFACE WATER SAMPLE

△ SEDIMENT OR SOIL SAMPLE

NOTE: BASE MAP COMPILED FROM AERIAL PHOTOGRAPHY FLOWN ON 2/10/89.

0 100 200 300

SCALE: 1"=200'

Figure 1-4

SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

Du Pont Kentec Facility

CH2M HILL

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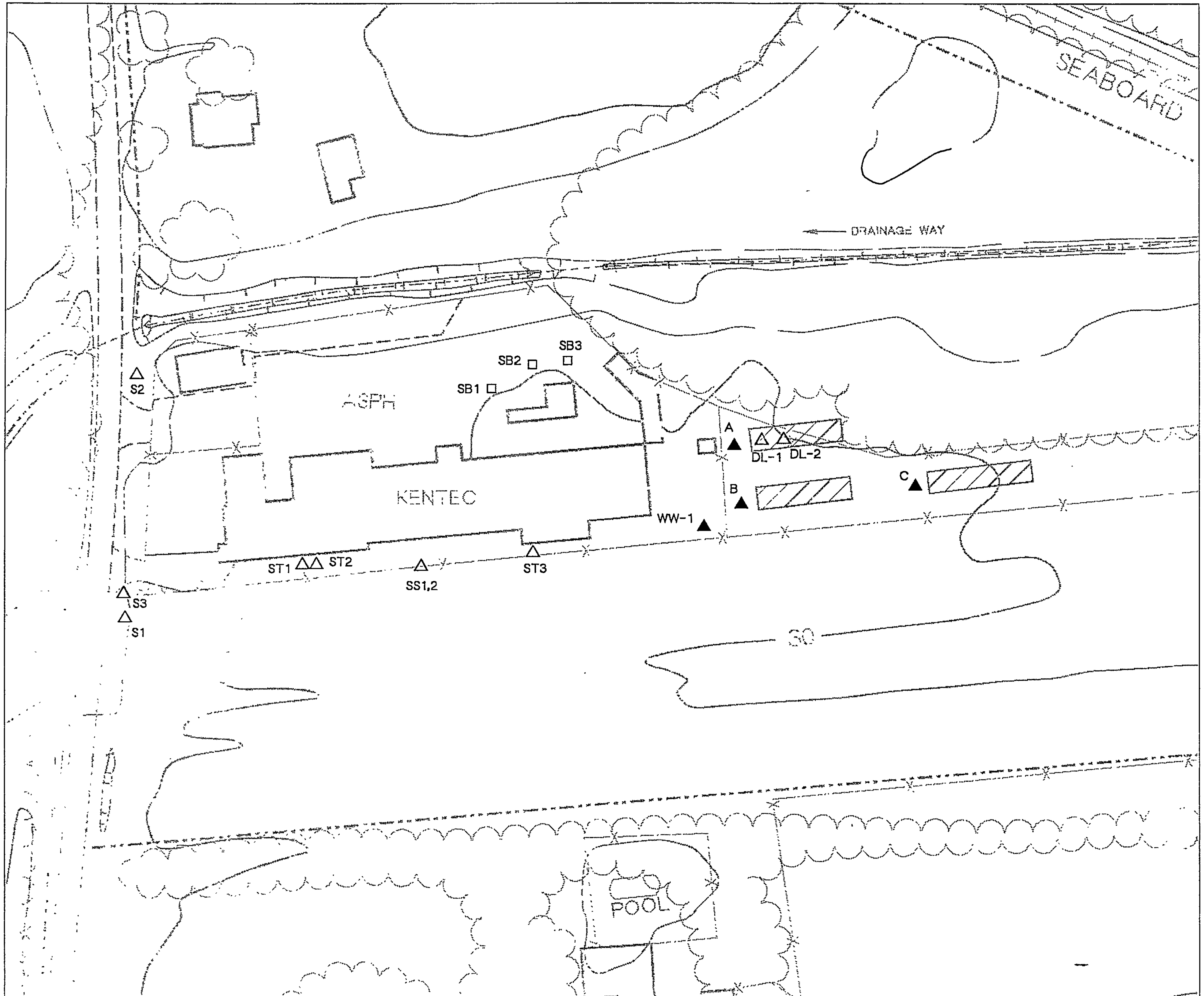

LEGEND

- ▲ WATER SAMPLE
- △ SOIL SAMPLE
- □ SOIL BORING

NOTE: BASE MAP COMPILED FROM AERIAL PHOTOGRAPHY FLOWN ON 2/10/89.

0 40 80 120

SCALE: 1"=80'

Figure 1-5

FACILITY AUDIT SAMPLING

Du Pont Kentec Facility

CH2M HILL

2398fc02.dgn 28-Mar-1991

Table 1-1
CHRONOLOGY OF PHASE 3 KENTEC FIELD WORK

October 2 - 18, 1989	Drilling and installation of shallow wells MW9 through MW13 and deep wells MW4B and MW7B.
November 13 - 14, 1989	Biomonitoring. Sediment and surface water sampling.
December 6 - 7, 1989	In-situ hydraulic conductivity tests of MW10A, MW4B, and MW7B.
January 22 - February 1, 1990	Drilling and installation of shallow wells MW14A, MW15, and MW16 and deep well MW14B. In-situ hydraulic conductivity tests of MW13, MW16, and MW14B.
February 5 - 14, 1990	Sampling of all monitoring wells except MW2 and MW10B.
July 30 - August 31, 1990	Installation of five piezometers (P1 through P5) and MW10B. Groundwater sampling (MWs 9, 10A, 11, 16, 4B, 7B, 10B, 14B and PW1). Surface water sampling in Beaverdam Branch. (SW22, 23, 28 and 29)
October 11, 1990	Resample PW1.
November 11 - 14, 1990	Resample groundwater at PW1 and RW2. Sample groundwater at RW3 and RW4. Neuse River (SW30 through 32) and Braxton Pond (SW33) water sampling.

Table 1-2
ORGANIC CHEMICAL ANALYSES
FACILITY AUDIT SAMPLING

	Water Samples (μg/l)						Soil/Sludge Samples (μg/kg)									
							Sludge Tank		Pipe Drainline Soil		Soil Borings[a]					
Analysis	**Wet Well**	**Rinse Water**	**Drainbox A**	**Drainbox B**	**Drainbox C**	**ST-3**	**ST-1**	**ST-2**	**SS1**	**SS2**	**SB1S**	**SB1D**	**SB2S**	**SB2D**	**SB3S**	**SB3D**
Acetone	150B	110B	7BJ	11B	8BJ	<10,000	230B	3,200J	17B	19B	64B	85B	54B	47B	51B	81B
1,1-Dichloroethane	32J	<5	<5	<5	<5	<5,000	78	11,000	<6	<6	<6	<6	<6	<6	<6	<6
1,1-Dichloroethylene	72	<5	<5	<5	<5	46,000	<6	5,400	<6	<6	<6	<6	<6	<6	<6	<6
1,4-Dioxane	27,000	2,500	<50	<50	<50	<50,000	2,400	<29,000	1,000	<52	120	560	240	910	<58	360
Methylene Chloride	18BJ	4BJ	7B	4BJ	7B	2,100BJ	43B	2,200BJ	72B	25B	53B	35B	24B	24B	15B	110B
Methyl Ethyl Ketone	160	<10	7B	<10	<10	<10,000	110	<5,800	<11	<11	7J	<12	7J	<12	<12	5J
1,1,1-Trichloroethane	630	<5	<5	<5	<5	120,000	3J	95,000	<6	<6	<6	<6	<6	<6	<6	<6
Toluene	<40	<5	1J	1J	4J	<5,000	2J	<2,900	34	2J	<6	<6	<6	<6	<6	<6
Ethylbenzene	<40	<5	<5	<5	<5	<5,000	2J	<2,900	<6	<6	<6	<6	<6	<6	<6	<6
Xylenes	<40	<5	<5	<5	<5	2,300BJ	6	<2,900	<6	<6	<6	<6	<6	<6	<6	<6
Triethylene Glycol	4,000,000	520,000	<1,000	<1,000	<1,000	360,000	43,000	60,000	3,100	<1,000	7,700	6,800	2,600	1,700	<1,200	<1,200

<5 = Below method detection limit shown.
"/ " = Sample not taken or analysis not performed.
"J" = Estimated value. Measured value is less than quantitative detection limit.
"B" = Compound was detected in associated laboratory blank.
[a]Soil samples were collected from 2-4 foot depth (designated "S") and 6-8 foot depth (designated "D").

Table 1-2
ORGANIC CHEMICAL ANALYSES
FACILITY AUDIT SAMPLING

	Drainfield A (ug/Kg)		Previous Surface Disposal Area (ug/Kg)			Soil Samples After Tank Removal (ug/Kg)					
	DL-1	DL-2	S1	S2	S3	ST1-1	ST1-2	ST2-1	ST2-2	ST3-1	ST3-2
Acetone	21B	8BJ	13B	53B	14BJ	47BJ	5BJ	7BJ	95B	45B	8BJ
1,1-Dichloroethane	<5	<5	<6	10	<12	<27	<5	<6	<14	2J	<6
1,1-Dichloroethylane	<5	<5	18	11	<12	<27	<5	<6	<14	<6	<6
1,4-Dioxane	<54	<54	<64	26,000	2,700	9,900	210	130	1,500	<63	<56
Methylene Chloride	64B	220B	98B	25B	260B	650B	120B	71B	430B	300B	72B
MethylEthyl Ketone	<11	<11	6BJ	28B	<25	<54	<11	<11	<28	<13	<11
1,1,1-Trichloroethane	<5	<5	20	4J	<12	<27	<5	<6	92	7	2J
Toluene	<5	2J	<5	16	<12	<27	<5	<6	<14	<6	<6
Ethylbenzene	<5	<5	<5	<5	<12	<27	<5	<6	<14	<6	<6
Xylenes	<5	2BJ	2J	<5	<12	9BJ	<5	<6	6BJ	2BJ	<6
Triethylene Glycol	<1,000	<1,000	36,000	78,000	<1,000	<1,000	4,000	<1,000	4,000	<1,000	<1,000

<5 = Below method detection limit shown.
"/ " = Sample not taken or analysis not performed.
"J" = Estimated value. Measured value is less than quantitative detection limit.
"B" = Compound was detected in associated laboratory blank.

Table 1-3
CORRECTIVE ACTIONS

Action	Completion Date
Remove Three Underground Settling Tanks.	December 20, 1990
Install Fiberglass Sleeve in Wet Well.	January 18, 1991
Replace Cracked Pipe Section, Install Above-Ground Rinsewater Line to Railcar.	February 22, 1991
Remove Buried Rinsewater Sludge.	November, 1990
Clean and Seal Dikes and Floors.	March 15, 1991

WDCR527/017.51

Chapter 2

GEOLOGY

This chapter discusses the physical setting of the Du Pont Kentec facility. The discussion is divided into sections on the geology of the region around the site, the topography of the site, and the geology of the site.

REGIONAL GEOLOGY

The Du Pont Kentec site is located along the inner margin of the central coastal plain, about 25 miles southeast of the piedmont. The sediments of the North Carolina Coastal Plain are a wedge-shaped sequence of marine and non-marine rocks that dip and thicken to the southeast. Approximately 800 feet of sediments overlie crystalline bedrock in the area near the Du Pont Kentec site (NCDNR&CD, 1985). These sediments are from Lower Cretaceous to Recent in age. They were deposited during successive periods of westward transgression and eastward regression of the sea. The major sedimentary units that overlie the bedrock, from oldest to youngest, are: (1) the Cape Fear Formation, (2) the Black Creek Formation, (3) the Peedee Formation, and (4) surficial deposits. This study involves sediments from the upper part of the Peedee Formation and from the surficial deposits overlying the Peedee.

The Peedee Formation consists of dark green or gray, medium- to coarse-grained quartz sands interlayered and mixed with marine clays and silts (Narkunas, 1980). The sand beds are commonly gray or greenish gray and contain varying amounts of glauconite. Thin beds of consolidated, calcareous sandstone and impure limestone are interlayered with the sands in some areas. Shells are common throughout the formation (Winner and Coble, 1989). The Peedee Formation is approximately 120 feet thick in the Kinston, North Carolina area (Nelson and Barksdale, 1965). In the region surrounding the study area, it is a major source of water for households not connected to public water systems.

The surficial deposits consist of thin beds of sand and clay that may attain a thickness of 10 to 20 feet locally (Nelson and Barksdale, 1965). These sediments do not appear to be a part of either the Beaufort Formation or the Castle Hayne Formation, two units that overlie the Peedee in some parts of North Carolina near Kinston.

SITE TOPOGRAPHY AND DRAINAGE

The topography of the Kentec site is shown in Figure 2-1, a map prepared for the Phase 3 investigations. The total relief of the mapped area is about 14 feet. Highest elevations (about 30 feet above mean sea level, or MSL) are in the broad, flat upland in the northern quadrant of the map. Lowest elevations (about 16 feet MSL) are in the valley of Beaverdam Branch, along the southwestern edge of the map.

Surface drainage from most of the Kentec facility is either to a natural drainageway lying just west of the Kentec buildings, or to a short, tributary ditch lying between the buildings and State Route 1802. The natural drainageway joins Beaverdam Branch south of Kentec; Beaverdam Branch continues south and east for approximately 1 mile, where it discharges into the Neuse River (see Figure 1-1). The flood plain of Beaverdam Branch is flat and marshy, particularly where it joins the drainageway. Another natural drainageway, also a tributary of Beaverdam Branch, lies approximately 500 feet east of Kentec; a small, man-made pond is just to the east of this second drainageway. Beaverdam Branch is perennial in the vicinity of the Kentec facility; the two drainageways flow intermittently.

SITE GEOLOGY

This discussion of the geology of the Kentec site is based on examination of surface landforms and on the interpretation of samples obtained during drilling for this assessment. Complete geologic logs of borings drilled at the site during all three phases of the investigation are included in Appendix A. Locations of geologic cross sections are shown in Figure 2-2, and the cross sections are presented in Figures 2-3 through 2-5.

Three distinct sedimentary units were encountered during drilling at the site. The uppermost unit consists of yellowish brown to yellowish orange, fine to very coarse sand and silty sand. This unit appears to be absent in the bed of the drainageway just west of the Kentec buildings, but is from 4 to 10 feet thick elsewhere at the site. The unit tends to be finer-grained and more silty in the upper 3 feet and denser and coarser at its base; it contained pebbles at and near its base in some boreholes. This uppermost unit is believed to correspond to the surficial deposits that overlie the Peedee Formation regionally.

Underlying these sands is a deposit of gray to greenish gray, stiff, clayey and sandy silts; there is a notable variation in the relative proportions of sand and clay from place to place in the unit. The deposit is flat-lying and is approximately 20 feet thick; its base lies at an elevation of approximately mean sea level. This unit appears to be part of the upper portion of the Peedee Formation.

The clayey, sandy silt is underlain by a deposit of loose, fine to medium, greenish-gray to dark gray, glauconitic sand with some interfingered sand and silt layers and fragments of calcareous sandstone and shells. The upper portion of this unit contains some stiff, clayey silts and clayey sands. This unit is also considered to be part of the Peedee Formation.

This report focuses on the uppermost unit, which contains the shallow aquifer beneath the Kentec site. Deeper units will be addressed in more detail in a subsequent report.

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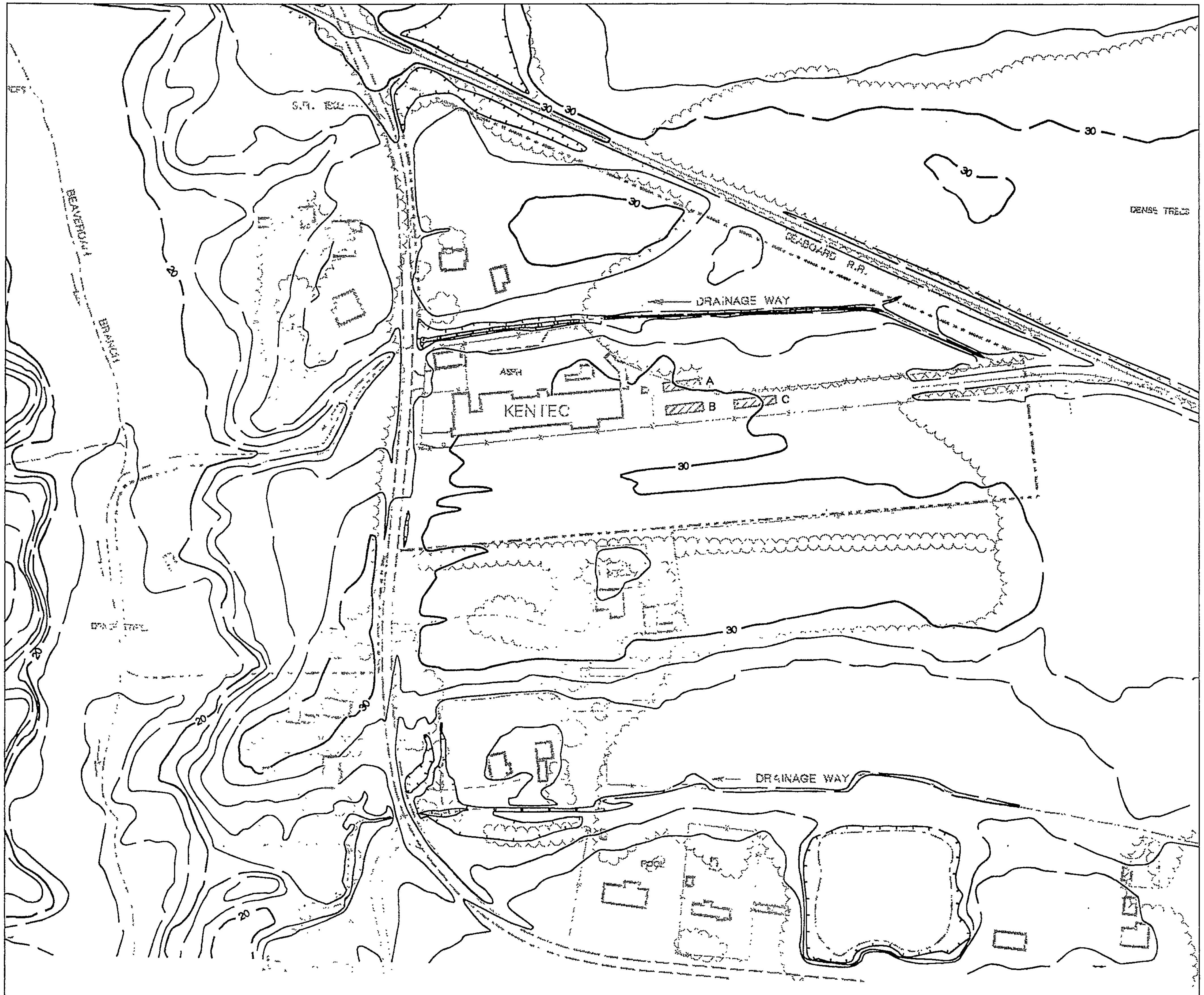


LEGEND

—·—·—·— CURRENT KENTEC PROPERTY BOUNDARY

——60—— GROUND SURFACE ELEVATION CONTOUR LINE (IN FEET ABOVE MSL) (CONTOUR INTERVAL IS 2 FEET)

NOTE: BASE MAP COMPILED FROM AERIAL PHOTOGRAPHY FLOWN ON 2/10/89.

0 100 200 300

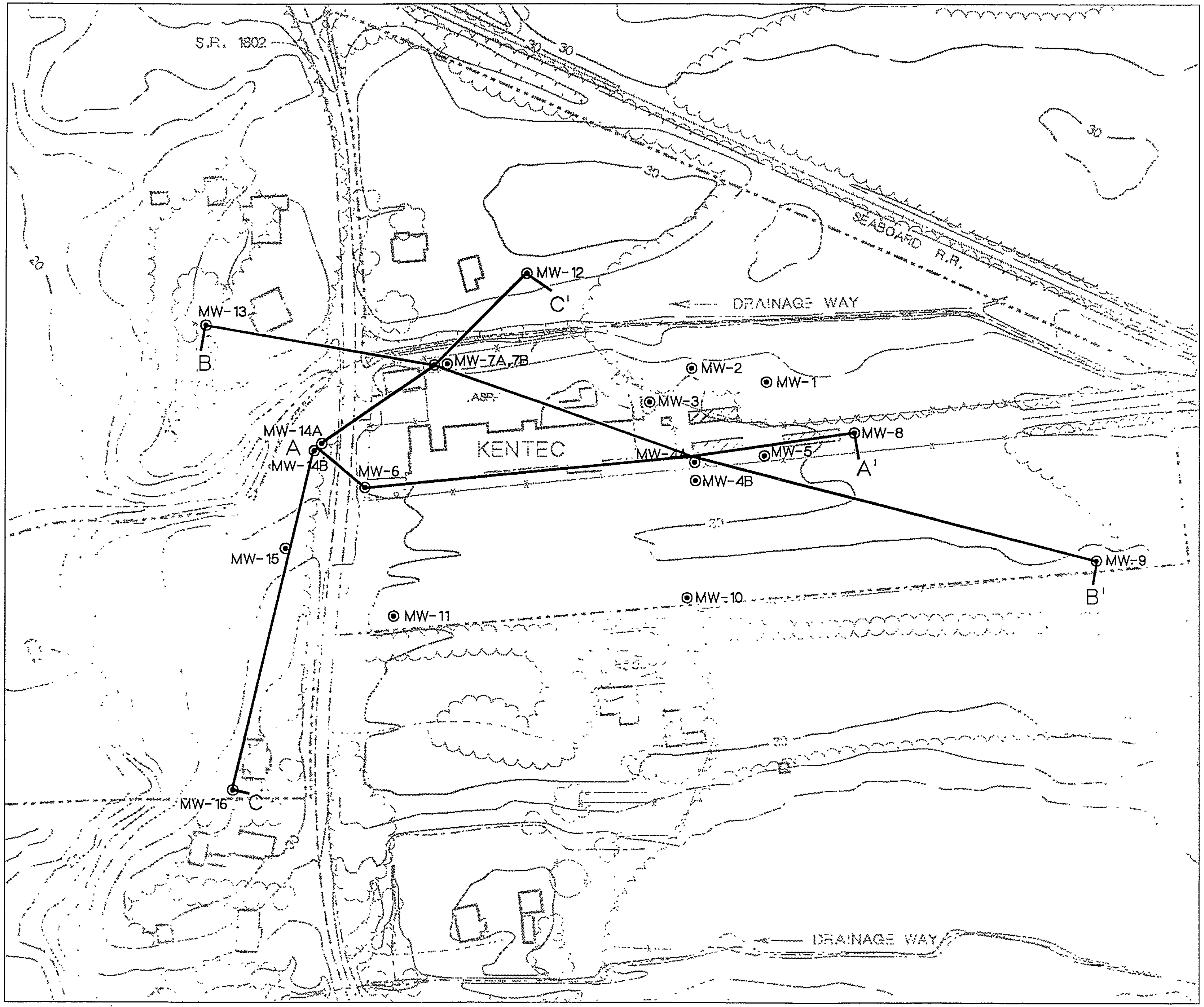
SCALE: 1"=200'

Figure 2-1

TOPOGRAPHY
Du Pont Kentec Facility

CH2M HILL

2398fc17.dgn 28-Mar-1991



LEGEND

◉ MONITORING WELLS

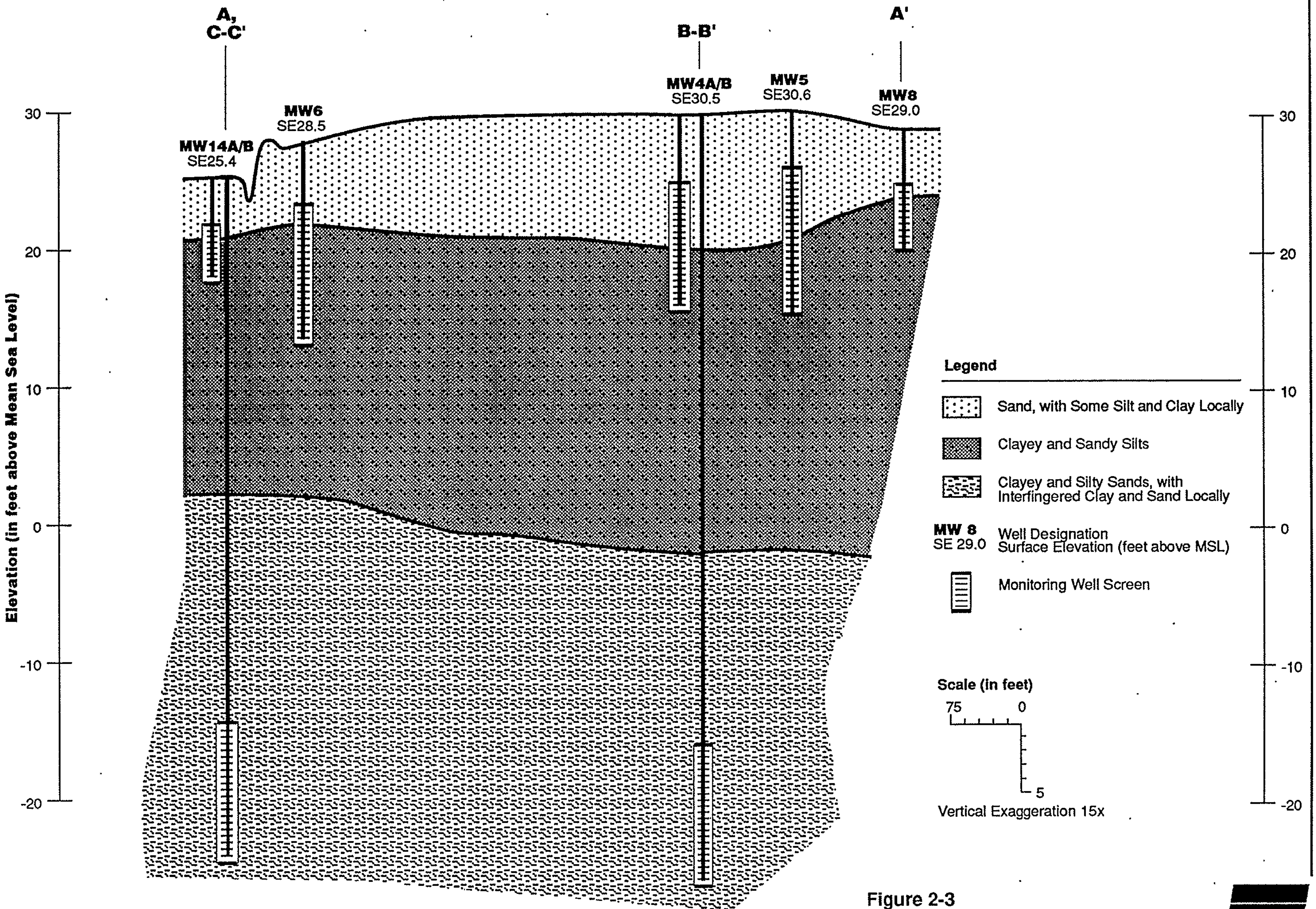
0 75 150 225
SCALE: 1"=150'

NOTE: BASE MAP COMPILED FROM AERIAL PHOTOGRAPHY FLOWN ON 2/10/89.

Figure 2-2
LOCATION OF GEOLOGIC CROSS SECTIONS
Du Pont Kentec Facility

CH2M HILL

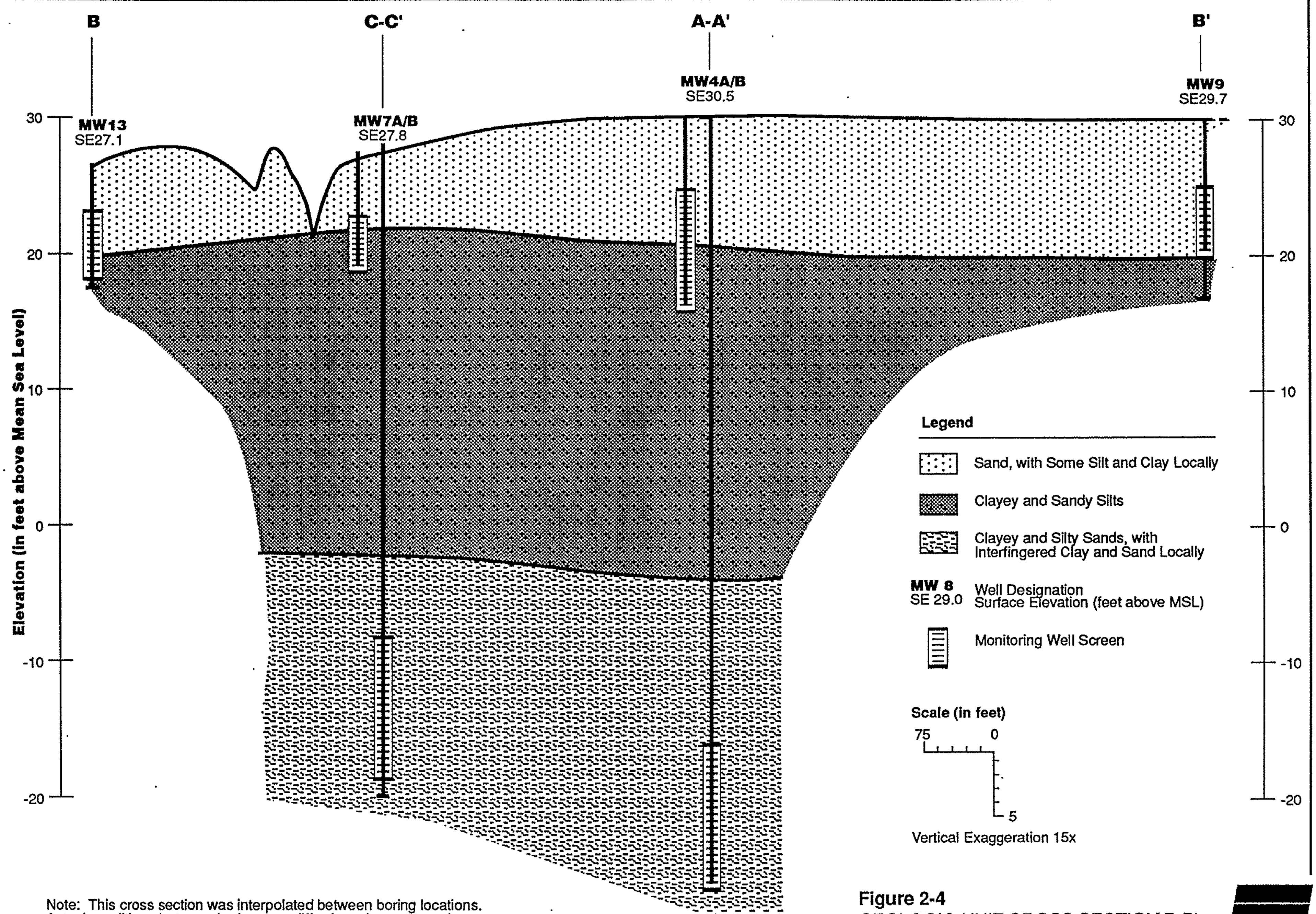
2398fc06.dgn 20-Mar-1991



Note: This cross-section was interpolated between boring locations.
Actual conditions between boring may differ from those shown here.

Figure 2-3
GEOLOGIC UNIT CROSS SECTION A-A'
DuPont Kentec Facility

CH2MHILL

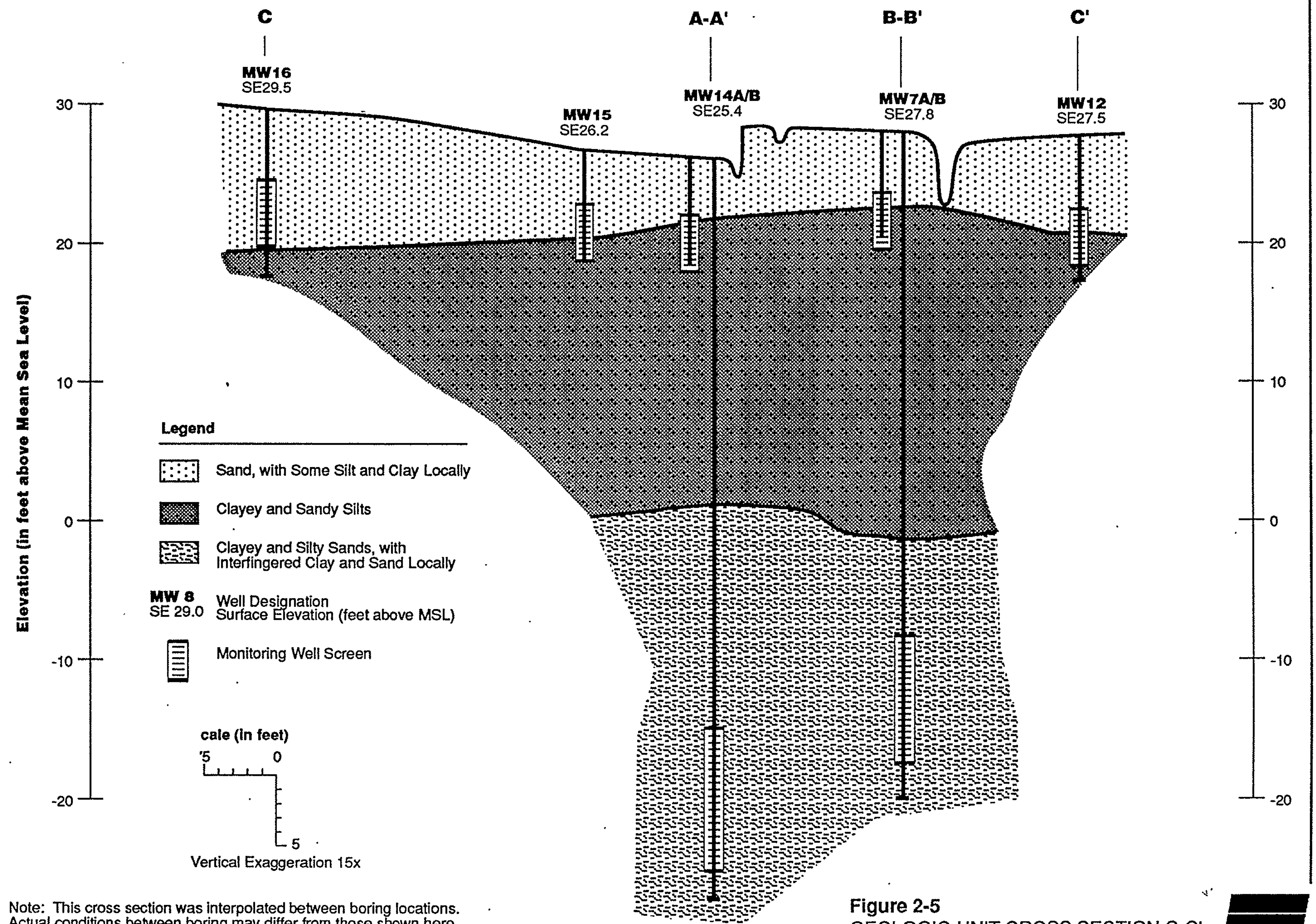


Note: This cross section was interpolated between boring locations. Actual conditions between boring may differ from those shown here.

Figure 2-4
GEOLOGIC UNIT CROSS SECTION B-B'
DuPont Kentec Facility

CH2M HILL

SAT 22398.F0.01/03



Note: This cross section was interpolated between boring locations. Actual conditions between boring may differ from those shown here.

Figure 2-5
GEOLOGIC UNIT CROSS SECTION C-C'
DuPont Kentec Facility

CH2M HILL

Chapter 3
HYDROGEOLOGY

INTRODUCTION

The regional hydrogeologic system of the North Carolina Coastal Plain in the area near Kentec comprises several aquifers within the geologic units discussed in Chapter 2. From shallowest to deepest, these are: (1) the surficial aquifer, (2) the Peedee aquifer, (3) the Black Creek aquifer, and (4) the Cape Fear aquifer (Winner and Coble, 1989). These aquifers are not co-extensive with the geologic units of the same name, however; they include only the more permeable zones within each unit. The aquifer of primary interest in this report is the surficial aquifer beneath the Kentec property. Subsequent reports will address both the upper part of the Peedee aquifer and that part of the surficial aquifer lying beyond the boundaries of the facility.

The groundwater monitoring system at the Kentec site currently consists of 16 shallow (surficial aquifer) wells, 5 shallow piezometers, and 4 deep (upper Peedee) wells (see Figure 1-3). Water-level measurements were obtained from extant wells on five occasions since November of 1989 (Table 3-1); in-situ measurements of hydraulic conductivity were obtained from 11 of the wells during Phases 2 and 3 of the assessment (Table 3-2). In addition, surface water levels were measured in the drainageway northwest of the Kentec buildings (Table 3-1); and Shelby Tube samples of the clayey, sandy silt that underlies the shallow aquifer were tested for vertical hydraulic conductivity in the laboratory (Table 3-3). Together with the topographic and geologic information provided in Chapter 2, these are the data which define the hydrogeology of the Kentec site.

SURFICIAL AQUIFER

As indicated in Table 3-1, the water table beneath the Kentec site is within the surficial sands, at depths ranging from approximately 3 to 8 feet below land surface. The highest water tables occurred in February of 1990, the lowest in November and December of 1989; the range of fluctuation was between approximately 1 and 1.5 feet at most wells. Fluctuations of this kind are typical of water-table aquifers, which usually show a direct response to seasonal variations in the amount of rainfall.

During all five periods of measurement, the highest water tables were consistently in an area just to the north and east of the main Kentec building, whereas the lowest water tables were in and adjacent to the drainageway which passes west of the buildings. This pattern, in which the shape of the water table mimics surface topography, is typical of shallow, unconfined aquifers.

The pattern is illustrated in Figure 3-1, an interpretive contour map of the water table (potentiometric surface) beneath the site in February of 1990. The figure indicates a groundwater mound in the vicinity of MW4A and MW5, suggesting that groundwater recharges through and flows radially outward from an area north and east of the main Kentec building. The figure also suggests that the drainageway west of the Kentec buildings is a groundwater divide, a zone of discharge which collects shallow groundwater that flows westward beneath the facility. Groundwater lying west of the drainageway flows eastward and also discharges in the drainageway.

As noted above, the water-level data indicate that shallow groundwaters lying east of the main Kentec building flow to the east and south, radially away from the groundwater mound. Because there are currently no monitoring wells east of the Kentec property, the directions of groundwater flow there cannot be defined. The hydrogeology of the area east and south of the Kentec facility will be addressed in a subsequent report.

Precipitation is the primary source of recharge for water-table aquifers in a natural setting. Narkunas (1980) noted that, in the coastal plain of North Carolina, approximately 20 percent (9 inches) of the average annual precipitation recharges the surficial aquifer. On the Kentec property, there are indications that leakage from the wet well near the northeast corner of the main building may also have recharged the surficial aquifer: piezometers installed in the aquifer to monitor the wet well indicated that it was leaking. This leakage, together with natural recharge, may have created the groundwater mound north and east of the building. Du Pont installed a liner to prevent leakage from the wet well in January of 1991. Consequently, the shape and position of the mound may change, or it may disappear entirely.

It is likely that the operation of Drainfield A (between 1982 and 1986) caused mounding of groundwater in the area north of the main Kentec building. This suggests that there may have been subtle variations in the directions of groundwater flow in the surficial aquifer, particularly in areas east of the main building. As discussed in Chapter 4, this may in turn have affected the distribution of contaminants in the surficial aquifer east of the facility.

The average velocity of groundwater flow between any two points may be estimated if the hydraulic conductivity and effective porosity of the aquifer are known, along with the hydraulic gradient between the points of interest. In a horizontally layered system, the horizontal hydraulic conductivity of the entire system may be approximated by taking the geometric mean of measurements at individual locations. The geometric mean of individual conductivity measurements taken in the shallow wells at Kentec (see Table 3-2) is 4 feet per day. (This may be somewhat lower than the actual conductivity of the aquifer, because some of the wells are screened through the surficial aquifer into the underlying, less permeable clayey sandy silt layer.) For the purpose of these calculations, the effective porosity of the surficial aquifer is assumed to be 30 percent, which is within a typical range for sands and silts.

The smallest hydraulic gradient measured at the Kentec site (0.0013) is in the area between MW8 and MW9; given the assumptions mentioned above, the average linear velocity of groundwater in this area is approximately 6 feet per year. The largest horizontal gradient measured in the surficial aquifer (0.12) is in the area between MW7A and the drainageway; the average groundwater velocity there is approximately 530 feet per year. Hydraulic gradients elsewhere in the surficial aquifer are typically about 0.014; this equates to an average linear velocity of about 60 feet per year.

DEEPER GROUNDWATERS

As mentioned elsewhere in this report, groundwaters lying beneath the surficial aquifer will be addressed in detail in a subsequent report. The following paragraphs provide a brief review of currently available data.

Figure 3-2 shows the potentiometric surface of the upper portion of the Peedee aquifer observed in the four deep wells on the Kentec site on November 15, 1990. The lateral direction of groundwater flow in the Peedee is generally southward. More data would be required to define the directions of flow more precisely.

Table 3-3 shows that the hydraulic heads in the shallow wells MW4A, MW7A, and MW14A were consistently greater than the hydraulic heads in the corresponding deep (B) wells. The vertical gradients at these well-pair locations ranged from 0.014 at MW14 to 0.12 at MW4 (see Table 3-4). At all three wells, the vertical hydraulic gradient indicated downward flow from the surficial aquifer into the Peedee aquifer; the largest gradients were apparently associated with the recharge zone (mound) northeast of the main building. The actual amount of downward flow and, therefore, the potential for downward migration of contaminants, depends on the vertical hydraulic conductivity of the intervening clayey, sandy silt unit.

In a horizontally layered system, the vertical hydraulic conductivity of the entire system may be approximated by taking the harmonic mean of conductivities measured at individual locations. The harmonic mean of individual conductivity measurements in the clayey silt layer (see Table 3-3) is $2x10^{-3}$ feet per day. Assuming a porosity of 40 percent (based on laboratory analyses of Shelby Tube samples), the average linear velocity of downward flow through the clayey silt unit is estimated to range from 0.03 feet per year at MW14 to 0.3 feet per year at MW4.

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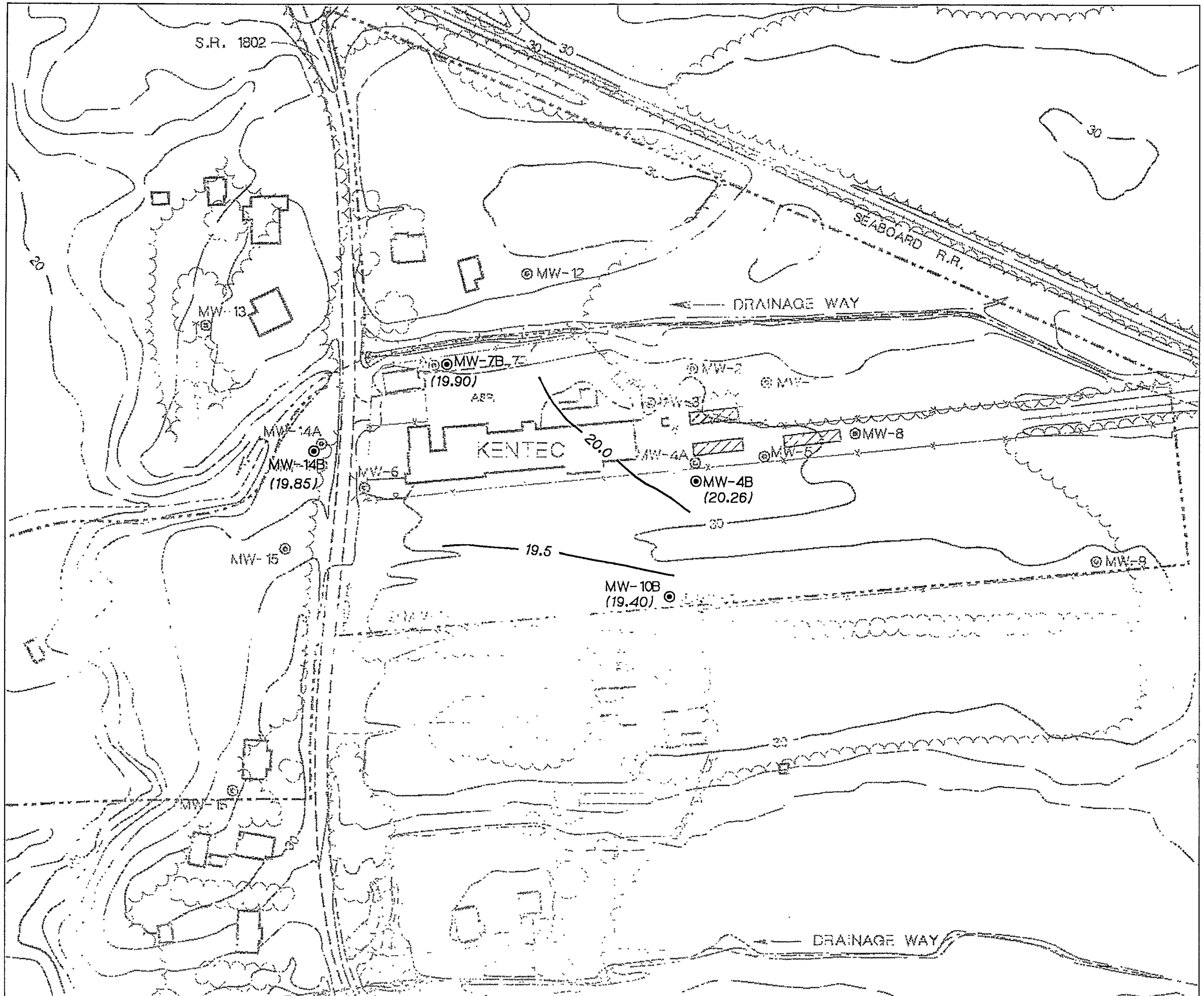

LEGEND

◉ DEEP MONITORING WELL

(20.26) WATER LEVEL MEASURED

— 20.0 — EQUIPOTENTIAL LINE (IN FEET ABOVE MSL)

EQUIPOTENTIAL LINES ARE INTERPOLATED BETWEEN DATA POINTS.

0 75 150 225

SCALE: 1"=150'

NOTE: BASE MAP COMPILED FROM AERIAL PHOTOGRAPHY FLOWN ON 2/10/89.

Figure 3-2

POTENTIOMETRIC SURFACE IN THE PEEDEE AQUIFER NOVEMBER 15, 1990

Du Pont Kentec Facility

Table 3-1
WATER-LEVEL ELEVATIONS
(in feet above mean sea level)

Monitoring Point	Ground Elevation	Elevation of Measuring Point	Elevation of Potentiometric Surface				
			11/13/89	12/07/89	02/01/90	08/30/90	11/15/90
MW1	29.0	31.22	25.12	25.16	26.97	25.42	25.33
MW2	30.0	32.23	25.17	25.14	26.90	/	25.41
MW3	29.5	29.62	25.30	25.31	26.90	25.87	/
MW4A	30.6	33.00	25.41	25.35	27.08	25.74	25.50
MW4B	30.4	33.23	20.73	20.55	22.14	19.92	20.26
MW5	30.6	32.82	25.23	25.28	27.07	25.43	25.47
MW6	28.5	30.71	23.69	23.49	24.48	23.82	23.76
MW7A	27.9	30.18	23.36	23.16	24.09	24.93	23.58
MW7B	27.8	30.53	20.70	20.53	22.13	19.87	19.90
MW8	29.0	31.18	24.92	25.08	26.84	25.08	25.10
MW9	29.7	32.78	24.10	24.25	26.65	24.44	24.69
MW10A	30.6	33.10	24.86	25.00	26.81	25.25	25.33
MW10B	30.6	32.43	/	/	/	18.67	19.40
MW11	30.1	32.82	24.62	24.45	26.20	25.08	25.36
MW12	27.5	30.03	24.40	24.40	26.11	25.67	25.69
MW13	27.1	32.78	23.73	23.16	23.44	/	/
MW14A	25.4	28.48	/	/	22.40	22.33	22.23
MW14B	25.3	27.33	/	/	21.83	19.59	19.85
MW15	26.2	28.96	/	/	24.05	23.91	23.60
MW16	29.5	29.50	/	/	25.37	24.68	/
P1	29.5	31.53	/	/	/	25.58	25.29
P2	29.4	31.14	/	/	/	25.53	25.05
P3	29.2	30.63	/	/	/	24.95	25.16
P4	31.3	33.16	/	/	/	25.81	25.63
P5	31.2	33.14	/	/	/	25.75	25.69
S1		23.83	/	/	22.70	/	22.85
S2		23.41	/	/	21.33	/	21.37
S3		23.92	/	/	/	23.54	23.54

*MW3 manhole redone 01/30/90. Measuring point before 01/30/90 Was 29.10.
S1 = Datum on top of black plastic pipe at north end of the drainageway west of Kentec office.
S2 = "Box datum" on top of concrete pipe going under SR1802, south end of drainageway, near office.
S3 = Top of culvert near RR spur.
"/" = Water-level measurement not taken.
A and B wells are paired; A is screened in the shallow aquifer, B in the upper part of the Peedee Aquifer. All piezometers (P1 through P51) are screened in the shallow aquifer.

Table 3-2 IN-SITU HYDRAULIC CONDUCTIVITY RESULTS, KENTEC PLANT	
Monitoring Well	**Hydraulic Conductivity (ft/day)**
Phase 2 Tests	
Surficial	
MW3	2
MW4	3
MW5	9
MW7	20
MW8	100
Phase 3 Tests	
Surficial	
MW10	3
MW13	0.1
MW16	3
Peedee	
MW4B	30
MW7B	90
MW14B	3

Table 3-3 RESULTS OF SHELBY TUBE ANALYSES			
Well	**Depth of Sample (ft)**	**Elevation of Sample (MSL)**	**Vertical Hydraulic Conductivity (ft/day)**
MW4B	17-19	11.4 to 13.4	0.1
MW7B	11-13	14.8 to 16.8	0.1
MW14B	15-17	8.3 to 10.3	0.0009

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Table 3-4
VERTICAL GRADIENTS AT DU PONT KENTEC
FEBRUARY 1, 1990

Well Pair	Hydraulic Head in Shallow Well (ft MSL)	Elevation of Screened Zone of Shallow Well (ft MSL)	Hydraulic Head in Deep Well (ft MSL)	Elevation of Screened Zone of Deep Well (ft MSL)	Distance Between Screen Centers (ft)	Downward Gradient*
MW4A/B	27.08	15.6 to 25.6	22.14	-25.6 to -15.6	41.2	0.12
MW7A/B	24.09	17.9 to 22.9	22.13	-18.2 to -8.2	33.6	0.058
MW14A/B	22.40	17.4 to 21.9	21.83	-25.3 to -15.3	40.0	0.014

*Gradient measured between centers of screened intervals.

WDCR478/014.51

Chapter 4
CHEMICAL ANALYSES

INTRODUCTION

During the Phase 3 investigation, groundwater, surface water, sediment, and soil samples were collected for chemical analysis. Groundwater samples were collected from 20 new and existing monitoring wells, four residential wells, and one inactive production well (see Figure 4-1). Sixteen surface water, 9 sediment, and 12 soil locations were sampled (see Figure 4-2). In addition, water, sludge, and soil samples were analyzed for the facility audit in July of 1990; the locations of the audit samples are shown in Figure 1-2 and are discussed in Chapter 1.

Tables 4-1 and 4-2 give the chemical analytical protocol for the Phase 3 samples. The protocol for each sample was based upon the analytical results from Phases 1 and 2. In general, all Phase 3 samples were analyzed for the major contaminants detected in previous work (TEG, 1,4-dioxane, TCA, DCA, and DCE). Iron, manganese, and total coliform bacteria were also analyzed in some samples. In addition, some of the surface water and sediment samples were analyzed for various nutrient parameters to support the biomonitoring study. Field duplicate, trip blank, and equipment blank samples were also analyzed, as were laboratory quality control blanks. Laboratory quality control blanks were also analyzed with each batch of samples.

The rest of this chapter presents and discusses the chemical analytical results, including relevant data from all three phases of the assessment. The chapter is divided into sections discussing: (1) soil, (2) surficial groundwater, (3) deep groundwater, (4) surface water and sediment, and (5) the biomonitoring study. All analytical data from the three phases are tabulated in Appendix D. The complete text of the biomonitoring study is given in Appendix E.

SOIL

As mentioned in Chapter 1, ten soil samples collected from five locations near Drainfield A at depths of 1 and 5 feet did not show significant organic contamination. Triethylene glycol (TEG) was the only contaminant detected, and only at low concentrations in two samples (400 and 300 ug/kg; see Appendix D, Table D-5). This indicates that there is no widespread source of organic contamination remaining in the soil at or above the water table at Drainfield A.

Two soil samples collected at ground surface in the fields on the Kentec property west of the drainageway (SS-1 and SS-2) had low concentrations of TEG (330 ug/kg and 2,200 ug/kg, respectively).

Iron and manganese concentrations were similar in all soil samples collected from the site (Table D-8), suggesting that surficial soils throughout the site are naturally high in iron and manganese.

SURFICIAL GROUNDWATER

Table 4-3 gives the concentrations of organic compounds detected in surficial groundwaters during all three phases of the assessment. In general, the concentrations of these compounds did not change significantly between 1987 and 1990; the concentration of DCA increased at MW3 and MW4A between 1987 and 1988. These data suggest that the source or sources of contamination are still present at the site, that the rate of contaminant migration is slow, and/or that the pattern of migration may have changed during the course of the assessment.

Figure 4-3 shows the distribution of the three major compounds detected: 1,4-dioxane, DCA, and DCE. Two source areas for the contamination are indicated: (1) in the vicinity of MW6, near the drainageway where rinsewater was disposed in the 1970s, and (2) near the northeastern corner of the main Kentec building, between the wet well and the drainfields. As discussed below, the distribution of contaminants in the surficial aquifer is generally consistent with the findings of the facility audit (see Chapter 1) and with the groundwater flow patterns observed at the site (see Chapter 3).

From the vicinity of MW6, contaminants are migrating westward and southward, toward the drainageway that passes west of the Kentec buildings. No groundwater contamination is evident in the two wells (MW12 and MW13) west of the drainageway, confirming that it is a discharge zone for the contaminants. As discussed below, this conclusion is supported by analyses of surface water samples from the drainageway and Beaverdam Branch.

There is a complex distribution of contaminants in groundwater near the northeastern corner of the main Kentec building. This is probably because of the multiplicity of possible sources there (Drainfield A, the wet well, and septic tank ST3), together with discontinuous mounding of groundwater around the drainfield (1982 through 1986), the septic tank (1982 through 1988), and perhaps the wet well. Because groundwater flows radially outward from this area, even a relatively small difference in the position of a contaminant source within the area could effect a significant difference in the direction of contaminant migration.

It is apparent that the majority of DCA and DCE migration has been to the south, with the current highest concentration (MW4) in the vicinity of the wet well and ST3. 1,4-Dioxane is more evenly distributed, with contamination extending in all directions from a zone of high concentration between Drainfield A and MW4. Organic contamination extends to the eastern and southern boundaries of the Kentec property. The extent of contamination beyond these boundaries is not currently defined; it will be addressed in a subsequent report.

The relatively high concentrations of acetone detected in some samples in 1987 are believed to have resulted from the use of acetone to clean the sampling equipment during that round of sampling.

Iron and manganese concentrations in groundwater samples are given in Table 4-4. In the surficial aquifer, the concentration of iron tended to correlate directly with the concentrations of organic compounds (highest in MW6 and MW7A, lowest in MW12 and MW13). There was no obvious correlation between the concentration of manganese and the concentration of organic compounds.

DEEPER GROUNDWATERS

As mentioned elsewhere in this report, groundwaters lying beneath the surficial aquifer will be addressed in detail in a subsequent report. The following paragraphs provide a brief review of currently available information.

Groundwater samples were collected from each of the four deep monitoring wells, four residential wells, and an inactive production well (PW1) installed in the Peedee aquifer at the Kentec facility (Table 4-5). Other than acetone and methylene chloride, TEG was the only organic compound detected in any of the four deep monitoring wells (MW-14B at 1,900 ug/l in January of 1990); TEG was not detected in MW-14B in July of 1990. Acetone and methylene chloride were detected in most of the samples at low concentrations, near laboratory blank levels. These two compounds are often introduced inadvertently into analytical equipment as a result of their widespread use in the laboratory. No contamination was detected in the four residential wells. Each of these wells is believed to be approximately 100 feet deep.

The inactive production well had 1,4-dioxane concentrations above the detection level of 50 μg/1 in two out of three rounds of sampling in 1990 (59 μg/l and 110 μg/l). This well was installed in the 1970s to a depth of 100 feet without an adequate seal in the well bore annulus. 1,4-Dioxane is believed to have migrated from the shallow aquifer to the Peedee aquifer along the well casing. In December of 1990, PW1 was abandoned by overdrilling the well casing, grouting inside the newly drilled well bore annulus, and grouting inside the old well casing. As a precautionary measure, Du Pont also abandoned a former residential well (RW-2) on the Kentec property, using the same procedures.

Although no contamination has been detected in Peedee aquifer monitoring wells, the direction of groundwater flow near PW1 is poorly defined; the existing deep wells may not be situated downgradient of PW1.

SURFACE WATER AND SEDIMENT

The concentrations of organic compounds detected in surface water samples during Phases 2 and 3 are given in Tables 4-6 and 4-7. All samples were collected when no stormwater runoff was evident in the drainage system. 1,4-Dioxane shows the highest concentrations; the other indicator compounds (DCE and DCA) do not appear to be migrating to the drainage system in detectable amounts.

Figure 4-4 shows the distribution of 1,4-dioxane in surface water in November 1989. All samples had 1,4-dioxane, except the sample from Beaverdam Branch upstream of its confluence with the drainageway (SW-22) and the sample from the offsite pond (PS-1). The pattern of 1,4-dioxane contamination in the drainageways is consistent with the distribution of this compound in groundwater: concentrations are highest near State Road 1802 and lowest north of the drainfield (SW-27).

The concentrations of 1,4-dioxane in sediment samples were generally less than in the associated surface water samples (Table 4-8). This suggests that the primary source of 1,4-dioxane in surface water is not 1,4-dioxane leached from the sediment. However, there were higher concentrations of 1,4-dioxane in the sediment from Beaverdam Branch than in the surface water.

The concentrations of total and fecal coliforms were elevated in surface water samples at all locations, including upstream and downstream locations in Beaverdam Branch (Appendix D, Table D-9). This suggests that elevated coliforms are probably the result of wildlife activity throughout the area; the current septic field for the Kentec facility (near piezometer P3) is not near the drainageway.

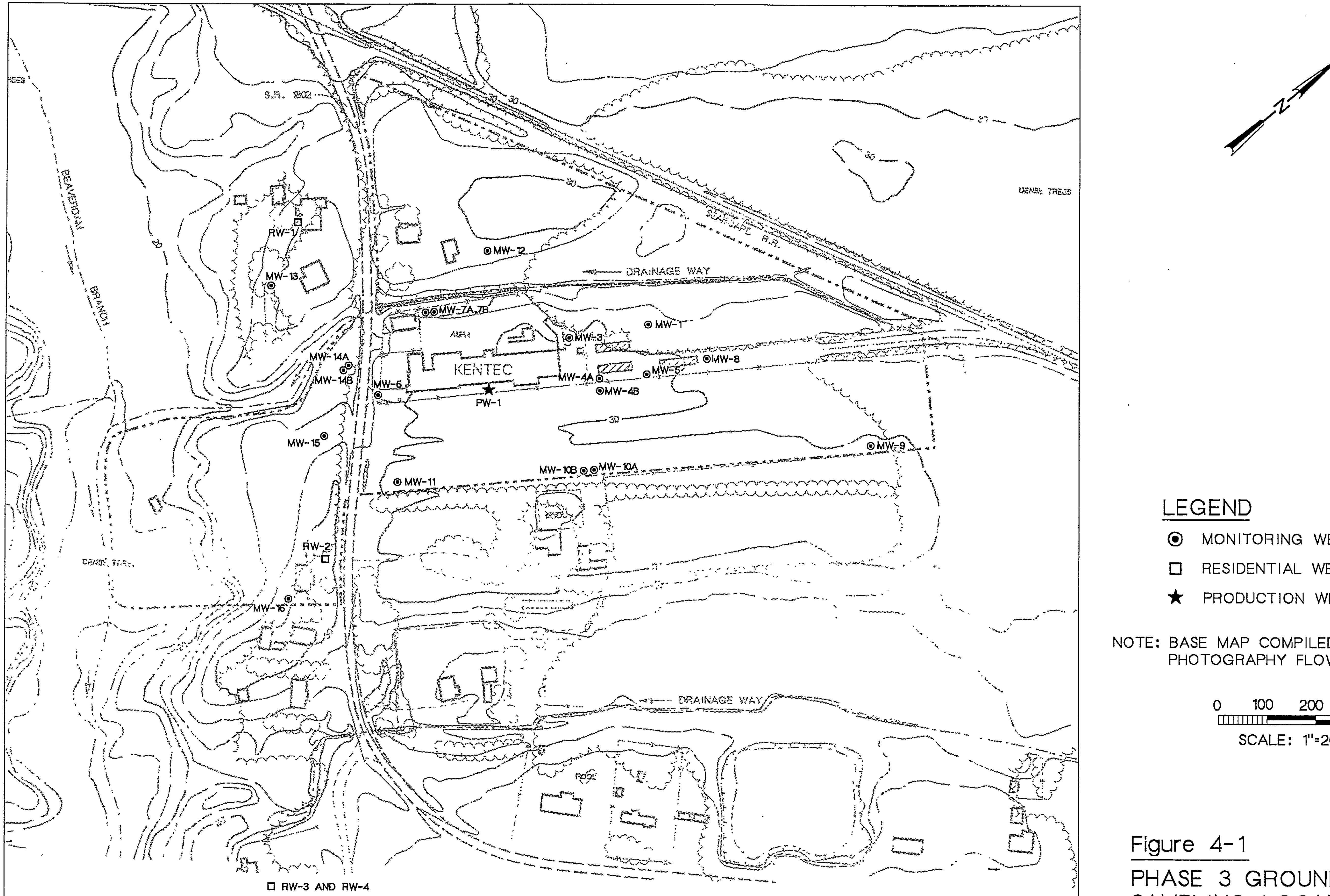
BIOMONITORING STUDY

A biomonitoring study was performed in the drainageway and in the marsh bordering Beaverdam Branch to evaluate the potential impacts of the Kentec discharges on the biological community. Three tasks were performed for this study: (1) comparison of algal community structure at upstream and downstream locations, (2) comparison of benthic macroinvertebrate populations at these locations, and (3) acute toxicity tests on the surface water from specific locations. A complete discussion of the biomonitoring study is given in Appendix E. The study concluded that the elevated concentrations of 1,4-dioxane observed in surface water samples do not appear to have affected the biological community adversely.

Bioassay test results confirm that the organic compounds found in the surface water samples did not have acutely toxic effects at the concentrations measured during the study.

Based upon the population diversity indices and the general pollution tolerances of the benthic macroinvertebrates collected, water quality in the entire drainage ditch area was considered fair. However, there appeared to be little difference in biological activity between surface water locations where the concentration of 1,4-dioxane was elevated and those where it was low. The maximum population diversity in the ditch was considered medium to high and typical of natural water bodies. However, the lack of organic pollution-sensitive organisms and the abundance of pollution-tolerant macro-invertebrates at most stations indicated a degree of organic enrichment. Potential sources of organic enrichment might include decaying leaves and vegetation, runoff from the adjacent agricultural property, and runoff or seepage from the Kentec facility.

WDCR527/037.51



LEGEND

- ◉ MONITORING WELL
- ☐ RESIDENTIAL WELL
- ★ PRODUCTION WELL

NOTE: BASE MAP COMPILED FROM AERIAL PHOTOGRAPHY FLOWN ON 2/10/89.

0 100 200 300

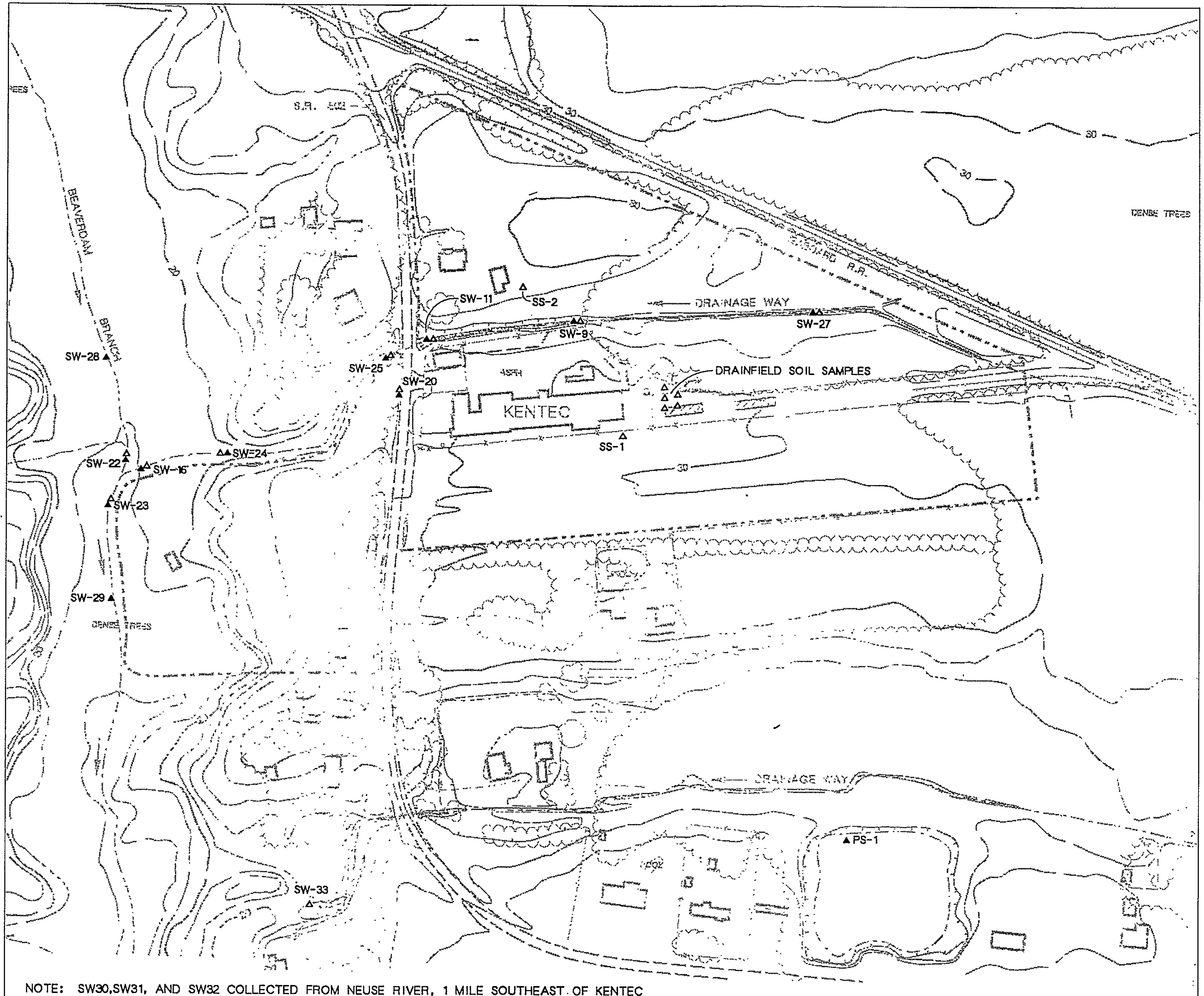
SCALE: 1"=200'

Figure 4-1

PHASE 3 GROUNDWATER SAMPLING LOCATIONS
Du Pont Kentec Facility

CH2M HILL

2398fc09.dgn 28-Mar-1991



N

LEGEND

▲ SURFACE WATER SAMPLE

△ SEDIMENT OR SOIL SAMPLE

NOTE: BASE MAP COMPILED FROM AERIAL PHOTOGRAPHY FLOWN ON 2/10/89.

0 100 200 300

SCALE: 1"=200'

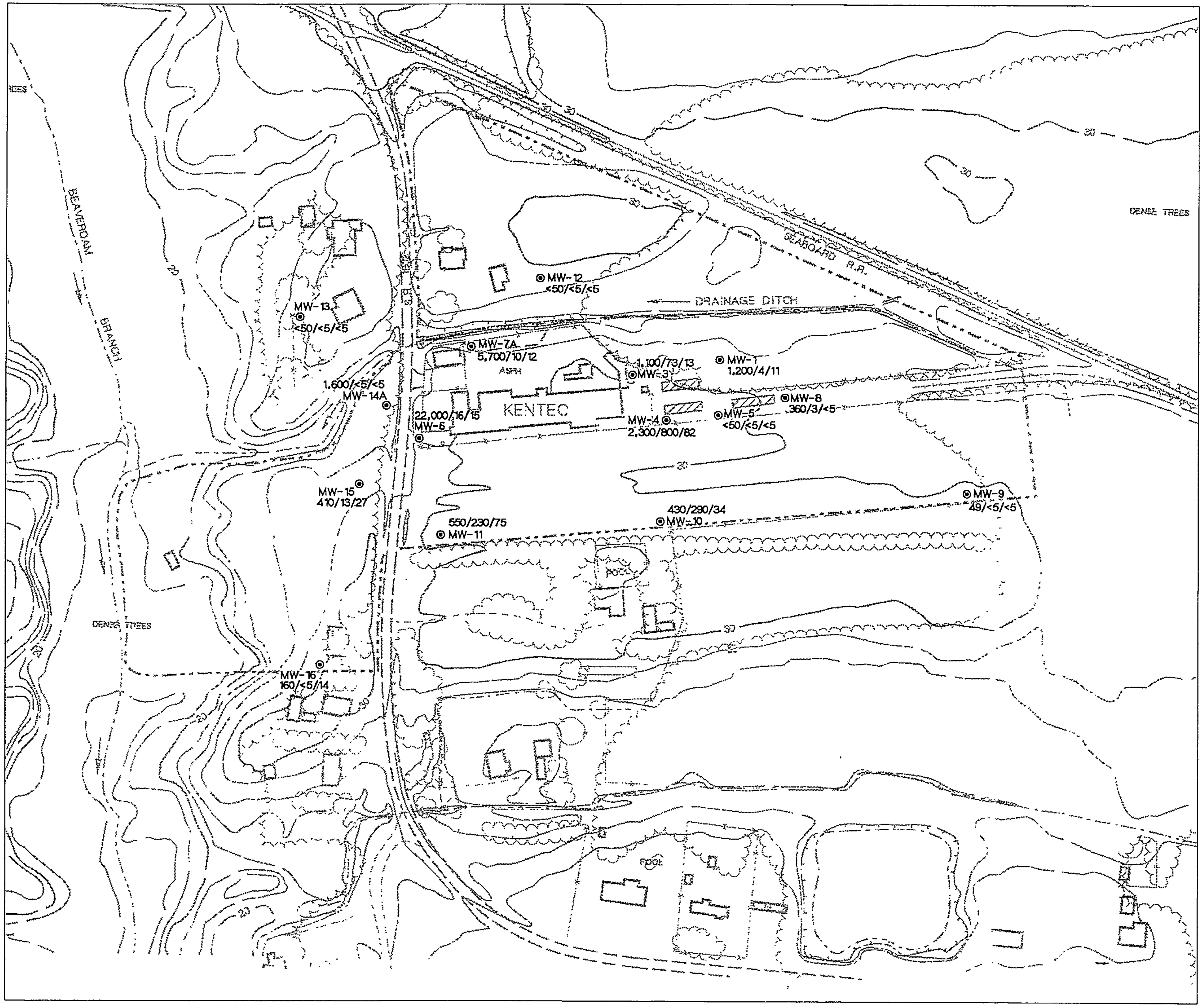
Figure 4-2

PHASE 3 SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

Du Pont Kentec Facility

CH2M HILL

2398fc10.dgn 28-Mar-1991



LEGEND

◉ MONITORING WELL

1,100/73/13 1,4-DIOXANE/1,1-DICHLOROETHANE/ 1,1-DICHLOROETHYLENE

CONCENTRATIONS IN ug/l

NOTE: BASE MAP COMPILED FROM AERIAL PHOTOGRAPHY FLOWN ON 2/10/89.

0 100 200 300

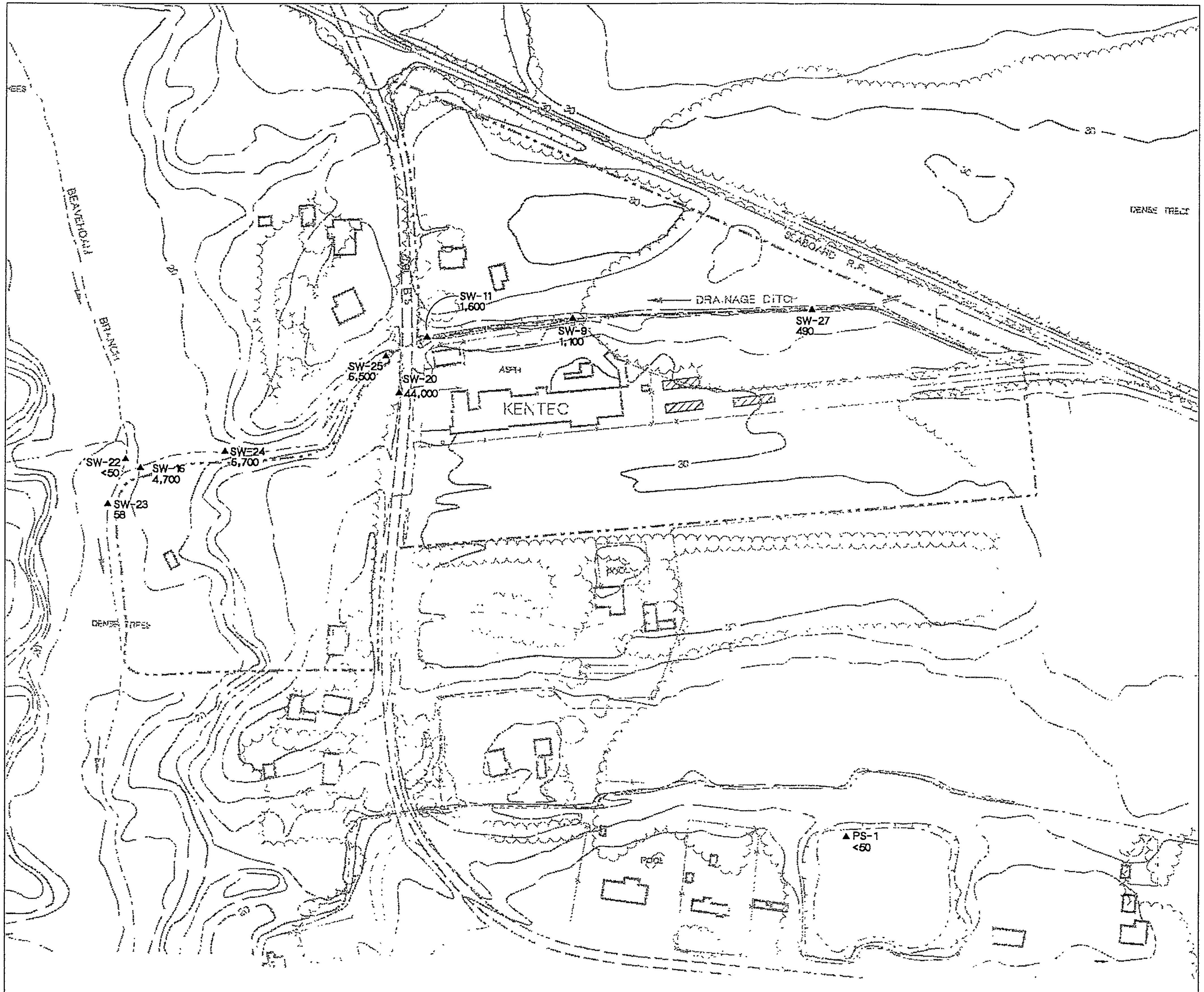
SCALE: 1"=200'

Figure 4-3

CONCENTRATIONS OF 1,4-DIOXANE, 1,1-DICHLOROETHANE & 1,1-DICHLOROETHYLENE IN SHALLOW GROUNDWATER JANUARY 1990

Du Pont Kentec Facility

CH2M HILL



N

LEGEND

▲ SURFACE WATER SAMPLE

1,100 1,4-DIOXANE CONCENTRATION IN ug/l

NOTE: BASE MAP COMPILED FROM AERIAL PHOTOGRAPHY FLOWN ON 2/10/89.

0 100 200 300

SCALE: 1"=200'

Figure 4-4

CONCENTRATION OF 1,4-DIOXANE IN SURFACE WATER NOVEMBER 1989
Du Pont Kentec Facility

CH2M HILL

Table 4-1
KENTEC CHEMICAL ANALYTICAL PROTOCOL

	VOCs	TOC	Fe, Mn	Triethylene Glycol	Ammonia-N	Nitrate/ Nitrite-N	Total Kjeldahl Nitrogen	Ortho Phosphate-P	Total Phosphate-P	pH, Solids	Fecal & Total Coliform
Monitoring Wells											
MW-1, MW-3 through MW-16	X	X[a]	X[a]	X							
Residential Wells											
RW-1, RW-2	X	X[a]	X[a]	X							
RW-3, RW-4	X										
Production Well											
PW-1	X			X							
Background Soils											
SS-1, SS-2	X			X							
Drainfield Soils											
DS-1A through DS-5B	X		X	X							
Surface Water											
SW-9, SW-11, SW-16, SW-22, SW-23, SW-25, SW-27	X	X[a]	X[a]	X	X[a]	X[a]	X[a]	X[a]	X[a]		X[a]
SW-20, SW-24	X		X	X							
SW-28, SW-29	X			X							
SW-30, SW-31, SW-32, SW-33	X										
Sediments											
SED-9, SED-11, SED-16, SED-22, SED-23, SED-25, SED-27	X		X	X			X		X	X	
SED-20, SED-24	X		X	X							

[a]Analysis performed only during the first time samples were collected in Phase 3. Additional rounds of sampling did not include this analysis.

Table 4-2 CHEMICAL CONSTITUENTS ANALYZED	
Volatile Organic Compounds (EPA Method 624)	
Acetone Benzene Bromodichloromethane Bromoform Bromomethane 2-Butanone Carbon Disulfide Carbon Tetrachloride Chlorobenzene Chloroethane 2-Chloroethylvinylether Chloroform Chloromethane cis-1,3-Dichloropropene Dibromochloromethane 1,1-Dichloroethane 1,2-Dichloroethylene (total) 1,2-Dichloropropane 1,2-Dichlorobenzene 1,4-Dioxane Methylene Chloride Styrene 1,1,2,2-Tetrachloroethane Tetrachloroethylene Toluene trans-1,3-Dichloropropene 1,1,1-Trichloroethane 1,1,2-Trichloroethane Trichloroethene Trichlorofluoromethane Vinyl Acetate Vinyl Chloride Xylenes (total)	**Other Organics** Triethylene Glycol Total Organic Carbon (EPA 415.2) **Inorganics & Other** Iron (EPA 200.7) Manganese (EPA 200.7) Ammonia (EPA 350.2) Nitrate/Nitrite-N (EPA 353.3) Ortho Phosphate-P (EPA 365.3) Total Phosphate-P (EPA 365.4) Total Kjeldahl Nitrogen (EPA 351.3) pH, Solid (EPA 150.1) Fecal & Total Coliform

Table 4-3
ORGANIC CHEMICAL ANALYSIS
SHALLOW GROUNDWATER SAMPLES (μg/ℓ)

Analysis	MW1			MW3			MW4A			MW5			MW6		
	5/87	6/88	1/90	5/87	6/88	1/90	5/87	6/88	1/90	5/87	6/88	1/90	5/87	6/88	1/90
Acetone	35	<10	<10	900	<50	<10	3,000	60	32	140	<10	<10	1,300	22	11
Carbon Disulfide	<5	<5	<5	<5	<25	<5	<5	<25	20	<5	<5	<5	<5	6	20
Chloroethane	<5	<10	120	11	<50	80	1.5	<50	150	<5	<10	<10	43	<10	95
1,4-Dichlorobenzene	/	<5	<5	/	<25	<5	/	<5	<5	/	<5	<5	/	<5	<5
1,1-Dichloroethane	<5	5	4J	1.6	280	73	<5	900	800	<5	<5	<5	11	<5	16
1,1-Dichloroethylene	<5	<5	11	<5	<25	13	<5	<25	82	<5	<5	<5	1.7	<5	15
1,4-Dioxane	1,700	2,000	1,200	1,000	5,900	1,100	1,900	5,400	2,300	300	230	<50	16,000	33,000	22,000
Methyl Ethyl Ketone	<10	<10	<10	<10	58	<10	<10	140	11	<10	<10	<10	130	<10	<10
Vinyl Chloride	<10	<10	<10	<10	<10	<10	<10	<10	6J	<10	<10	<10	<10	<10	<10
Triethylene Glycol (mg/l)	<10	<5	0.81	<10	<5	0.25	<10	<5	<0.25	<10	<5	<0.25	<10	<5	<0.25
TOC (mg/l)	110	24.9	70.1	65	55.6	26.8	83	313	352	26	19	68.5	609	100	69.1

<5 = Below method detection limit shown.
"/" = Sample not taken or analysis not performed.
"J" = Estimated value. Measured value is less than quantitative detection limit.
"B" = Compound was detected in associated laboratory blank.

Table 4-3
ORGANIC CHEMICAL ANALYSIS
SHALLOW GROUNDWATER SAMPLES (μg/l)

Analysis	MW7A		MW8		MW9		MW10A		MW11		MW12	MW13	MW14A	MW15	MW16	
	6/88	1/90	6/88	1/90	1/90	7/90	1/90	7/90	1/90	7/90	1/90	1/90	1/90	1/90	1/90	7/90
Acetone	<10	7J	<10	<5	5J	7BJ	9J	28B	13	18B	<5	<5	<5	7J	5J	8BJ
Carbon Disulfide	<5	<5	<5	4J	<5	<5	<5	<10	<5	2J	<5	<5	<5	<5	<5	<5
Chloroethane	<10	100	<10	12	<10	10	43	76	190	420	<10	<10	<10	74	<10	<10
1,4-Dichlorobenzene	7	4J	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1-Dichloroethane	9	10	<5	3J	<5	<5	290	250	230	160	<5	<5	<5	13	<5	<5
1,1-Dichloroethylene	<5	12	<5	<5	<5	<5	34	23	75	54	<5	<5	<5	27	14	6
1,4-Dioxane	11,000	5,700	<50	360	49J	52	430	340	550	680	<50	<50	1,600	410	160	100
Methyl Ethyl Ketone	<10	<10	<10	<10	<10	<10	7J	7J	9J	7J	<10	<10	<10	<10	<10	<10
Vinyl Chloride	<10	<10	<10	<10	<10	<10	<10	12J	<10	25	<10	<10	<10	<10	<10	<10
Triethylene Glycol (mg/l)	<5	<0.25	<5	<0.25	<0.25	<1,000	<0.25	<1,000	<0.25	<1,000	<0.25	<0.25	0.772	<0.25	<0.25	<1,000
TOC (mg/l)	31.9	75.0	10.7	15	41	/	72.2	/	94.9	/	6.2	29.0	51.6	21.7	2.3	/

<5 = Below method detection limit shown.
"/" = Sample not taken or analysis not performed.
"J" = Estimated value. Measured value is less than quantitative detection limit.
"B" = Compound was detected in associated laboratory blank.

Table 4-4
INORGANIC CHEMICAL ANALYSES
KENTEC GROUNDWATER SAMPLES
(mg/l)

	Iron	Manganese
Monitoring Wells		
MW1	7.490	0.550
MW3	9.710	0.180
MW4A	3.990	0.402
MW4B	0.550	<0.015
MW5	3.755	2.910
MW5 DUP	3.770	2.880
MW6	29.0	0.585
MW7A	39.3	0.400
MW7B	<0.1	<0.015
MW8	12.7	0.470
MW9	1.375	0.193
MW10	/	/
MW11	/	/
MW12	0.400	0.052
MW13	0.230	0.081
MW14A	7.2	0.150
MW14B	<0.1	<0.015
MW15	20.8	0.621
MW16	0.185	0.168
Residential Well		
RW-1	0.400	<0.015
RW-2	/	/
Equipment Blank		
EQ-2 (after MW7A)	0.470	<0.015

Notes:

Samples collected in January, 1990.
<5 = Below method detection limit shown.
"/ " = Sample not taken or analysis not performed

Table 4-5
ORGANIC CHEMICAL ANALYSES
PEEDEE AQUIFER GROUNDWATER
(μg/l)

	Monitoring Wells							Residential Wells					Production Well		
	MW4B		MW7B		MW10B	MW14B		RW1	RW2		RW3	RW4	PW1		
Analysis	**1/90**	**7/90**	**1/90**	**7/90**	**8/90**	**1/90**	**7/90**	**1/90**	**1/90**	**11/90**	**11/90**	**11/90**	**8/90**	**10/90**	**11/90**
Acetone	5J	8BJ	6J	7BJ	6BJ	<10	7BJ	<10	6BJ	5BJ	3BJ	3BJ	6J	3BJ	6BJ
Carbon Disulfide	<5	<5	<5	<5	5	<5	<5	<5	<5	<5	<5	<5	<5	3J	<5
1,4-Dioxane	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	110	59	<50
Methylene Chloride	<10	10B	<10	5B	13B	<10	9B	<10	<10	3BJ	9B	13B	6	4BJ	7B
Triethylene Glycol	<250	<1,000	<250	<1,000	<1,000	1,900	<1,000	<250	<250	/	/	/	<1,000	<1,000	/
Total Organic Carbon	6,300	/	44,600	/	/	29,700	/	5,300	52,000	/	/	/	/	/	/
Xylenes	<5	<5	<5	<5	3J	<5	<5	<5	<5	<5	<5	<5	<5	2BJ	<5

<5 = Below method detection limit shown.
"/ " = Sample not taken or analysis not performed.
"J" = Estimated value. Measured value is less than quantitative detection limit.
"B" = Compound was detected in associated laboratory blank.

Table 4-6
ORGANIC CHEMICAL ANALYSES
SURFACE WATER SAMPLES--DRAINAGE, MARSH, POND
(μg/ℓ)

	SW9	SW11		SW16		SW20	SW24	SW25	SW27	PS1	SW33
Analysis	**11/89**	**7/88**	**11/89**	**7/88**	**11/89**	**11/89**	**11/89**	**11/89**	**11/89**	**11/89**	**11/90**
Acetone	<10	<10	11 B	<10	40 BJ	860 B	54 B	110 B	13 B	10	3BJ
Carbon Disulfide	1J	12	27	<5	11 J	60 J	130	39	16	28	<5
Chloroethane	14	<10	34	<10	<50	<100	<50	<50	<10	<10	<10
1,1-Dichloroethane	<5	14	2J	<5	<50	<100	<25	<25	<5	<5	<5
1,4-Dioxane	1,100	26,000	1,600	11,000	4,700	44,000	6,700	6,500	490	<50	<50
Methylene Chloride	9 B	<10	10 B	<10	37 B	90 BJ	30 B	18 BJ	13 B	<10	4BJ
Trichloroethylene	<5	<5	<5	<5	5 J	<100	<25	<25	/	<5	<5
Triethylene Glycol (mg/l)	2.4	<5	2.6	<5	1.1	53	0.51	5.0	<0.25	<0.25	/
TOC (mg/l)	38.2	103	28.8	17.6	51.2	/	/	88.8	36.9	10.1	/

<5 = Below method detection limit shown.
"/" = Sample not taken or analysis not performed.
"J" = Estimated value. Measured value is less than quantitative detection limit.
"B" = Compound was detected in associated laboratory blank.

Table 4-7
ORGANIC CHEMICAL ANALYSES
SURFACE WATER SAMPLES
BEAVERDAM BRANCH AND NEUSE RIVER
(μg/l)

	Beaverdam Branch								Neuse River		
	Upstream				Downstream				Upstream Kinston Plant	Upstream of Beaverdam Branch	Downstream of Beaverdram Branch
	SW22			SW28	SW23			SW29	SW30	SW31	SW32
Analysis	**7/88**	**11/89**	**8/90**	**8/90**	**7/88**	**11/89**	**8/90**	**8/90**	**8/90**	**8/90**	**8/90**
Acetone	<10	<10	15B	16B	<10	<10	15B	22B	4BJ	8BJ	4BJ
Carbon Disulfide	<5	14	55	1J	<5	10	6	2J	<5	<5	<5
1,1-Dichloroethylene	<5	<5	<5	2J	<5	<5	<5	<5	<5	<5	<5
1,4-Dioxane	<50	<50	<50	<50	<50	58	<50	<50	<50	<50	<50
Methylene Chloride	16	5B	6B	6B	<10	5B	20B	21B	6B	29B	4BJ
1,1,1-Trichloroethane	<5	<5	<5	3J	<5	<5	<5	<5	<5	<5	<5
Triethylene Glycol	<5,000	4,100	3,600	<1,000	<5,000	4,900	<1,000	<1,000	/	/	/
Total Organic Carbon	<1,000	6,900	/	/	16,700	7,700	/	/	/	/	/

<5 = Below method detection limit shown.
"/ " = Sample not taken or analysis not performed.
"J" = Estimated value. Measured value is less than quantitative detection limit.
"B" = Compound was detected in associated laboratory blank.

Table 4-8
ORGANIC CHEMICAL ANALYSES
SEDIMENT SAMPLES
(µg/kg)

	SED9	SED11	SED16	SED20	SED22	SED23	SED24	SED25	SED27
Analysis	**11/89**	**11/89**	**11/89**	**11/89**	**11/89**	**11/89**	**11/89**	**11/89**	**11/89**
Acetone	<10	<10	<10	170 B	<10	64 B	20 B	45 B	<10
Carbon Disulfide	1 J	13	<5	32 J	<5	24	<6	22	2 J
1,4-Dioxane	1,000	210	1,800	18,000	280	1,500	1,000	2,400	<50
Methylene Chloride	98 B	95 B	13 B	89 B	140 B	30 B	57 B	67 B	150 B
Triethylene Glycol	<250	<250	<250	760	<250	<250	<250	390	<250

<5 = Below method detection limit shown.
"/" = Sample not taken or analysis not performed.
"J" = Estimated value. Measured value is less than quantitative detection limit.
"B" = Compound was detected in associated laboratory blank.

Chapter 5
CONCLUSIONS

The general purposes of the groundwater assessment at the Kentec facility were to evaluate 1) contamination of surficial groundwater and surface water on and near the facility, 2) the potential for contamination of deeper groundwaters, and 3) the potential effects of surface water contamination on biota in the water. The third phase of the assessment was conducted in conjunction with an audit of wastewater-handling practices at the Kentec facility; a primary objective of the audit was to complete the identification of potential sources of contamination on the facility. The results of the audit were used to guide the third phase of the assessment and to design immediate corrective actions at a number of locations on the facility.

POTENTIAL SOURCES OF CONTAMINATION

Seven potential sources of contamination, past and present, were identified on the Kentec facility during the course of the assessment. Sampling indicated that two of these (the former rinsewater drainfields, and a powdered metal burial area) are not currently sources of significant groundwater contamination; the rinsewater drainfields were probably significant sources of contamination during their operation. Four of the remaining five potential sources (the former discharge area for rinsewater, the rinsewater settling tanks, the wet well, and underground piping associated with the wet well) were considered to be current sources of contamination. Du Pont took corrective actions (replacement, retrofitting, or removal of the structures and removal of soils) to stop releases from these areas in the winter of 1990-1991. The seventh potential source (cracks in concrete diking in some containment areas) was not obviously associated with groundwater contamination. Du Pont took the precautionary step of sealing the cracks and the containment surfaces in the winter of 1990-1991.

SURFICIAL GROUNDWATER

Surficial groundwater beneath the Kentec facility was found to be contaminated, primarily by the three organic compounds 1,4-dioxane, DCE, and DCA. The maximum concentrations of contaminants detected on the site are compared to the relevant state and federal standards in Table 5-1; the concentrations of 1,4-dioxane and DCE exceed the state standard at some locations along the boundary of the facility. TEG, which is present in Kentec's wastewater in relatively high concentrations, was detected in the environment only sporadically and at relatively low concentrations. Surficial groundwater is reportedly not used for potable supply in the vicinity of the Kentec site.

The majority of surficial groundwater contamination appears to have originated in an area near the northeastern corner of the main Kentec building. The distribution of this contamination is complex, in part because groundwater flows radially away from the area. Groundwater contaminated with 1,4-dioxane flows westward from the northeastern corner and discharges to the drainageway which passes west of the Kentec buildings. Lower concentrations of 1,4-dioxane are found in surficial groundwaters north of the area. Groundwater contaminated with 1,4-dioxane, DCA, and DCE flows south and east from the area, to the boundaries of the Kentec property; the information currently available is insufficient to define the extent of contamination beyond the property boundaries.

There is a second, separate area of high 1,4-dioxane concentrations in surficial groundwater at the southeast end of the main Kentec building; this contamination migrates south and west, discharging into the drainageway to the south.

Iron and manganese appear to be naturally abundant in the soils of the area. However, highest iron concentrations in groundwater appear to correlate with the highest 1,4-dioxane concentrations.

DEEPER GROUNDWATERS

Some of the surficial groundwater beneath the Kentec site flows downward toward the upper part of the Peedee aquifer. The rate of flow is slow relative to the rate of horizontal flow in the surficial aquifer, because a relatively impermeable layer intervenes between the two aquifers. The Peedee aquifer is used locally and regionally for water supply.

No significant contamination was detected in monitoring wells and residential wells tapping the Peedee. However, low concentrations of 1,4-dioxane were detected in an inactive production well on the Kentec facility; it is believed that the well was improperly sealed during installation, allowing contaminants to migrate along the well casing. The network of monitoring wells on the site is currently insufficient to determine whether the aquifer is contaminated downgradient of the production well. Du Pont abandoned the well in the winter of 1990-1991, using procedures designed to prevent flow along the annulus of the well.

SURFACE WATER AND SEDIMENT

1,4-Dioxane was detected in surface water and sediment samples downstream of the Kentec facility. The other major contaminants (DCE and DCA) do not appear to be migrating to the drainage system in detectable amounts. The primary source of contamination in surface waters adjacent to the facility appears to be discharge of contaminated surficial groundwater; analyses of sediment samples suggest that the sediment is a not a major source of contamination.

1,4-Dioxane is migrating through the surface drainages on and near the site to Beaverdam Branch. However, the concentrations of 1,4-dioxane in the branch are very low: 1,4-dioxane was observed only once in a downstream sample from Beaverdam Branch, at a concentration near the detection limit.

The elevated counts of coliform bacteria found in surface waters on the site do not appear to be associated with operations at the Kentec facility.

BIOMONITORING

The elevated concentrations of 1,4-dioxane observed in surface water samples did not appear to have adverse effects upon the biological community in the vicinity of the site. There appeared to be little difference in biological activity between locations where the concentration of 1,4-dioxane was elevated and locations where it was low. Bioassay test results confirmed that there was no acutely toxic effect of the organic compounds found in the surface water during the study. Although the biomonitoring study indicated a diversity of benthic populations at the site, the primary organisms were pollution-tolerant types.

WDCR527/049.51

Table 5-1
MAXIMUM ORGANIC CONCENTRATIONS IN WATER AND APPLICABLE STATE AND FEDERAL STANDARDS OR GUIDELINES
(μg/1)

	Observed Concentration				Standard or Guideline			
						Safe Drinking Water Act		
Compound	Deep Groundwater Onsite	Surficial Groundwater Onsite	Surficial Groundwater Property Boundary	Surface Water	NC[a] Groundwater Standard	Maximum Contaminant Level (MCL)	Maximum Contaminant Level Goal (MCLG)	EPA Health Advisory 10-Kg Child 1 day dose
1,1 DCA	-	900*	290	14*	/	/	/	/
1,1 DCE	-	82	75	-	7	7	7	2,000
1,4-Dioxane	110	33,000*	550	44,000	7	/	/	4,000
Vinyl Chloride	-	6	-	-	0.015	2	0	3,000
TCE	-	-	-	5	2.8	5	0	/
Carbon Disulfide	-	20	-	130	/	/	/	/
Chloroethane	-	150	190	34	/	/	/	/
TEG	1,900	810	-	53,000	/	/	/	/

\- Undetected, Below Method Detection Limit
* Concentration observed during Phase 2, all other concentrations observed during Phase 3
/ No standard developed for this compound
a North Carolina Administrative Code T15A:02L.0100, .0200, .0300

WDCR344/072.51

Chapter 6
RECOMMENDATIONS

The recommendations offered in this report are intended to bring to conclusion the investigative phases of the groundwater assessment and begin to address the need for remediation at the site. There are three general issues addressed by the recommendations: 1) characterization of the extent of contamination in the surficial aquifer beyond the boundaries of the Kentec property, 2) study of the Peedee aquifer, particularly in the vicinity of and downgradient of PW1, to demonstrate the presence or absence of contamination, and 3) development of a remediation plan for surficial groundwater onsite.

Specific recommendations are given below:

- Install a series of shallow groundwater monitoring wells offsite to define the extent of contaminant migration in the surficial aquifer beyond the boundaries of the Kentec property. East & South

- Sample new and existing monitoring wells and drainageways for VOCs and 1,4-dioxane.

- Install and sample three 100-foot monitoring wells: one near PW1, one at MW11, and one at MW10. Install a 50-foot monitoring well at MW11 to complete the monitoring array for the 50-foot zone in the Peedee Formation.

- Evaluate the data collected in these efforts to determine if it is necessary to remediate surficial groundwater offsite or deeper groundwater.

- Perform a feasibility study of remediation alternatives, as appropriate to North Carolina groundwater regulations, to stop further offsite migration of contaminated shallow groundwater.

WDCR337/092.51

REFERENCES

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CH2M HILL, 1988. Phase 2 Groundwater Assessment--Kentec

Narkunas, James, 1980. Groundwater Evaluation in the Central Coastal Plain of North Carolina. North Carolina Department of Natural Resources and Community Development.

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North Carolina Department of Natural Resources and Community Development (NCDNR&CD), 1985. Lithologic log of well Q25D11X, Graingers Research Station, Du Pont Kinston Plant, logged by Timmy Hill, October 1, 1985.

Winner, M.D., Jr., Coble, R.W., 1989. Hydrogeologic Framework of the North Carolina Coastal Plain Aquifer System. United States Geological Survey Open-File Report 87-690. United States Geological Survey.

WDCR337/086.51

Appendix A
DRILLING AND MONITORING WELL INSTALLATION

Appendix A

DRILLING AND MONITORING WELL INSTALLATION

This section describes the procedures, materials, and equipment used for drilling, subsurface soil sampling, and monitoring well installation at the Du Pont Kentec facility from October 2 through October 12, 1989; from January 22, 1989, through February 1, 1990; and from July 30 through August 2, 1990. Drilling and well installation were performed by Westinghouse Environmental and Geotechnical Services, Inc., of Raleigh, North Carolina, and Hardin Huber Inc., of Greensboro, North Carolina, under the supervision of D. Dronfield, S. Brown, T. Bryda, and J. Ford of CH2M HILL. The well elevations were surveyed to ±0.01 foot (NCGS Datum) by Barrow Surveying of Kinston, North Carolina.

Eight shallow wells and four deep wells were installed during Phase 3 drilling. The shallow and deep zones are separated by a 15- to 20-foot-thick layer of dark gray clayey, sandy silt. The locations of these wells are shown in Figure A-1.

The drilling and well installation were done using two drilling rigs--a CME-55 rig equipped with 6-1/4-inch hollow stem augers and a Speedstar 30K air and mud rotary rig. The smaller CME-55 rig was used for installation of the 8 shallow monitoring wells and of deep well MW14B. The large Speedstar 30K rig was used for the installation of deep wells MW4B and MW7B.

The 8 shallow boreholes were drilled to a depth approximately 2 feet below the top of the clayey silt. This depth ranged from 9 to 12.5 feet below land surface. Soil samples were taken during drilling using a 2-foot split spoon at 5-foot intervals. Two-inch diameter PVC casing and screen were installed in each borehole to a depth chosen by the CH2M HILL hydrogeologists. In many instances, the well screens were installed from above the water table into the upper part of the clayey sandy silt. This was done because the saturated thickness of the sand layer was typically only a few feet, and the supervising hydrogeologists were concerned that the wells provide water at all times of the year. A sand pack of No. 2 sand was placed in the annulus between the PVC casing and screen and the borehole wall. This sand pack was added to a depth approximately 1 foot above the screen. A 1- to 2-foot thick layer of bentonite pellets was added to the annular space above the sand pack to prevent near surface contamination of the well by grout and surface water. The borehole was filled with cement grout from the top of the bentonite to the land surface. A protective steel casing and locking cap and three guard posts were installed at each well except MW13 and MW16 to prevent tampering and damage to the wells. Wells MW13 and MW16 were completed with flush-mounted manhole covers. Schematic diagrams of both the shallow and deep monitoring wells are shown in Figure A-2. Deep wells are designated with the letter B and shallow wells paired with deep wells are designated with the letter A.

The four deep wells at Kentec were completed with a 6-inch casing installed into the clayey silt to prevent downward migration of contaminants during drilling. The annulus between the 6-inch casing and the borehole was grouted and pressure tested to ensure a watertight seal. Powdered bentonite was added to the grout used in the deep wells to prevent excessive shrinkage of the grout. After washing out the interior of the 6-inch casing, drilling continued below the bottom of the 6-inch casing to a final depth determined on the basis of the sediments present. At three deep wells (MW4B, MW7B and MW14B), Shelby tubes were taken in the clayey silt to determine the hydraulic conductivity of this unit. Two-inch PVC casing and screen were installed inside the 6-inch casing to final depths ranging from 46 to 56 feet below land surface. A sand pack was placed in the borehole annulus to a depth approximately 3 feet above the screen, followed by a 4-foot thick layer of bentonite pellets. Cement grout was added from the top of bentonite to the land surface. Guard posts, a protective steel casing and locking cap, and a cement pad were installed at each well.

All equipment was decontaminated by steam cleaning between wells to prevent cross contamination. In addition, all equipment used in the drilling of the deep wells was steam cleaned between different phases of the drilling. The borehole itself was washed out after installation of the 6-inch casing. All equipment was also steam cleaned before drilling began and after drilling ended at the Kentec plant to prevent cross contamination to and from other sites.

Each well was developed by block surging and pumping to remove drilling mud and natural fines from around the well screen. Shallow wells MW9, MW10, and MW11 were pumped using a vacuum pump. The deep wells and the remaining shallow wells were pumped using air lifting. Development continued until the turbidity of the water was substantially reduced or showed little potential for further progress due to substantial amounts of fines in the screened zone.

ACTIVITIES AT SPECIFIC DRILLING LOCATIONS

Some details of drilling activities at specific wells are given below to describe unique circumstances encountered during drilling. More details are reported in the field logbook and in Table A-1.

Drilling at deep monitoring well MW4B began on October 3, 1989, with the installation of the 6-inch casing to a depth of 15.2 feet, approximately 5 feet below the top of the clayey silt. Because of a cave-in problem in the sands above the clayey silt, a great deal of grout was needed to grout in the 6-inch casing. The 6-inch casing was washed out and then pressure tested by pressurizing the borehole to 20 psi and measuring a pressure loss of less than 1 psi over 5 minutes. After the pressure test, a Shelby tube was taken from 17 to 19 feet below land surface. A 10-foot segment of screen was installed to a final depth of 56 feet in well MW4B without incident. The turbidity of the discharge water was low at the end of development.

In deep well MW7B, the 6-inch casing was installed to 9.75 feet, approximately 2.75 feet below the top of the clayey silt. A Shelby tube was taken in the clay layer from 11 to 13 feet below land surface. Drilling continued normally, and a 10-foot segment of screen was installed to a final depth of 46 feet without incident. The discharge water was clear at the end of development.

Shallow well MW9 was drilled to 14 feet using 6-1/4-inch hollow stem augers and the CME-55 rig. Because of a problem with running sands, the 5-foot segment of screen could not be installed to this depth. Instead the screen was installed to 10 feet below land surface, the approximate depth of the top of the clayey silt. The installation of MW9 proceeded normally. Details are given in Table A-1. The turbidity was high at the end of development but progress was too slow for continued development.

The installation of shallow wells MW10 and MW11 was similar to the installation of MW9. Running sands were encountered in both wells, forcing the installation of the screen above the final drilling depth. Very strong organic odors were observed during drilling but the monitoring equipment showed no readings above background. The discharge water during development was foamy and had a strong organic odor. The turbidity of the discharge water from wells MW10 and MW11 was low to moderate at the end of development due to suspended silts and clays.

The installation of shallow well MW12 was similar to the installation of wells MW9, MW10, and MW11. Running sands were a minor problem. No odor was detected during drilling. The turbidity of the discharge water was low at the end of development.

Shallow well MW13 had to be drilled twice because of excessive runup inside the augers in the first borehole. The problem was solved by drilling with a metal plug at the bottom of the augers. MW13 was completed with a manhole cover instead of pads and posts because it was on residential property. The turbidity of the discharge water was moderate at the end of development. The well yield was low during development.

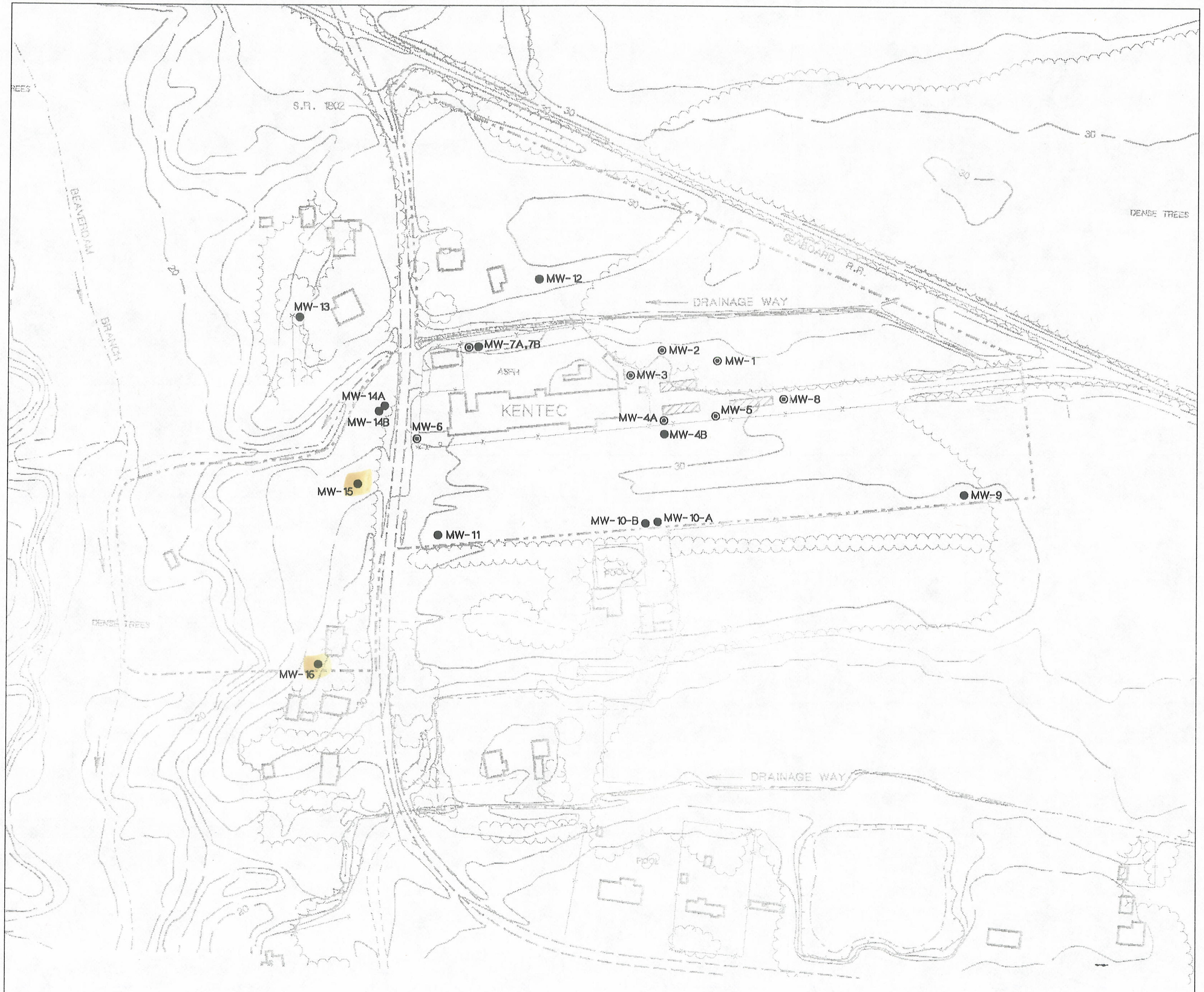
Shallow well MW14A was drilled and installed to a depth of 8 feet without incident. The discharge water was clear at the end of development. The well was developed by block surging and air lifting.

The drilling of deep well MW14B began on January 24, 1990, with the installation of a 6-inch casing to a depth of 9 feet. The casing was grouted into place by pouring cement grout from the surface. After passing a pressure test, drilling proceeded below the 6-inch casing. Resistant layers were encountered at depths of 11-12.5 feet and 42-42.5 feet, as judged by drilling action. These layers were believed to be semiconsolidated to consolidated but attempts to collect samples were unsuccessful. The layer at 11 feet below land surface formed a ledge in the borehole. A Shelby tube was taken at a depth of 15-17 feet. The borehole was drilled to a final depth of 52 feet. No problems were encountered during well installation. The discharge water was clear at the end of development.

Organic vapors were detected in the borehole by the monitoring equipment during the drilling of shallow well MW15. There was no detection in the breathing zone. Drilling proceeded after the borehole was allowed to vent for several minutes. Some problems with sediment running up the augers also occurred during drilling. The discharge water was clear at the end of development.

Organic odors were detected by the hydrogeologist during the drilling of MW16. No organic vapors were detected by the monitoring equipment. Drilling and well installation continued without further incident. The discharge water was clear at the end of development.

WDCR478/009.51



LEGEND

◎ EXISTING MONITORING WELL

● PHASE 3 MONITORING WELL

NOTE: BASE MAP COMPILED FROM AERIAL PHOTOGRAPHY FLOWN ON 2/10/89.

0 100 200 300

SCALE: 1"=200'

Figure A-1

PHASE 3 MONITORING WELL SYSTEM

Du Pont Kentec Facility

CH2M HILL

2398fc11.dgn 28-Mar-1991

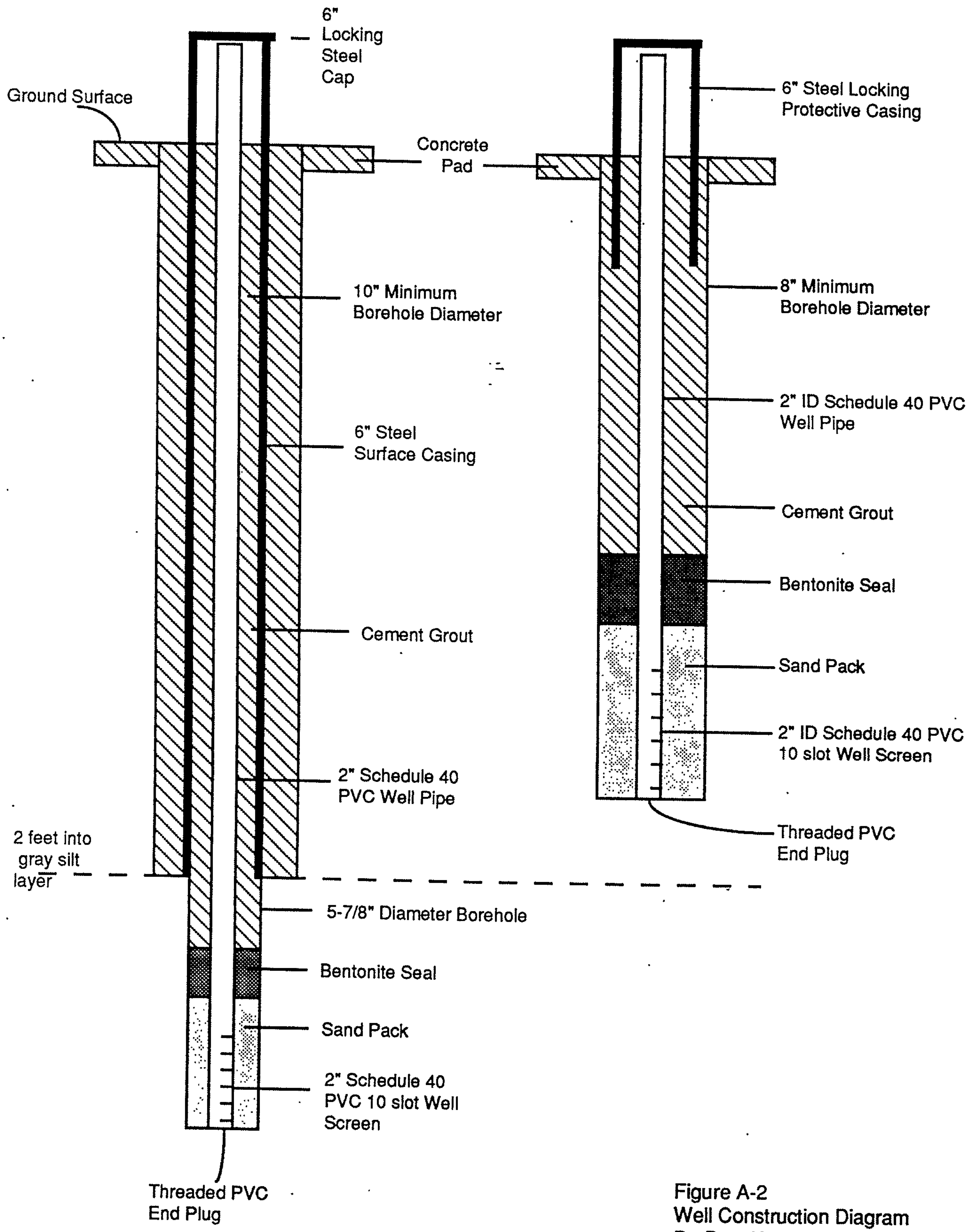


Figure A-2
Well Construction Diagram
Du Pont Kentec Plant

Table A-1
DuPONT-KENTEC PHASE 3 MONITORING WELL CONFIGURATIONS

Well	Ground Elevation	Depth to Top of Bentonite	Depth to Top of Sand	Depth to Top of Screen	Depth to Bottom of Screen	Length of Screened Interval	Depth to Bottom of 6-Inch Casing	Total Borehole Depth
MW4B	30.4	39'	43'	46'	56'	10'	15'2"	56'
MW7B	27.8	29'6"	33'6"	36'	46'	10'	9'9"	46'
MW9	29.7	2'6"	4'	5'	10'	5'	--	10'
MW10A	30.6	3'	5'3"	6'	12'6"	6'6"	--	12'6"
MW10B	30	36.5'	42.5'	45'	55'	10'	14'	57'
MW11	30.1	3'1"	4'6"	5'6"	9'	3'6"	--	9'
MW12	27.5	2'10"	5'	6'3"	9'6"	3'3"	--	9'6"
MW13	27.1	3'	4'6"	5'8"	8'10"	3'2"	--	8'10"
MW14A	25.4	2'1"	2'9"	3'6"	8'	4'6"	--	8'1"
MW14B	25.3	31'	34'10"	40'6"	50'6"	10'	9'	52'
MW15	25.2	3'	4'	4'10"	8'6"	3'8"	--	8'6"
MW16	29.5	3'8"	5'	6'4"	9'10"	3'6"	--	12'9"

WDCR478/008.51

PHASE 3
GEOLOGIC LOGS

PROJECT: DU PONT KENTEC FACILITY, GRIFTON, NORTH CAROLINA
DRILLER: WESTINGHOUSE ENVIRONMENTAL LOGGER: J. FORD
DRILLING METHOD/EQUIPMENT: MUD ROTARY / SPEEDSTAR
GROUND ELEVATION (FT MSL): 30.4 START DATE: 10/3/89 FINISH DATE: 10/5/89

BORING : MW-4B
PAGE 1 OF 2; 0 ft - 50 ft
CH2M HILL
PROJECT #:SAT 22398.CO

ELEVATION (FT MSL)	DEPTH (FEET)	SAMPLE COLLECTION DATA: INTERVAL (FEET)	SAMPLE NUMBER	RECOVERY (IN)	STANDARD PENETRATION TEST 6"-6"-6"-6" (N)	WRITTEN LOG	SYMBOLIC LOG	WELL CONSTRUCTION 2 Inch PVC
25.4	5					NOTE: REFER TO THE MW-4 LOG IN THE PHASE 2 REPORT FOR SHALLOW LITHOLOGIES		
20.4	10							
15.4	15					6-INCH STEEL CASING TO 15' 2"		
10.4	20							GROUT
		22-24	S-1	24	N/A	0-24": VERY FINE CLAYEY SILT, DARK GREENISH GRAY (5G 4/1), CLEAN, MOIST, NON-PLASTIC		
5.4	25							
		27-29	S-2	24	N/A	0-24": SAME AS S-1		
0.4	30							
		32-34	S-3	24	N/A	0-24": SAME AS S-1		
-4.6	35							
		37-39	S-4	24	N/A	0-24": SAME AS S-1 WITH MORE BANDED SILT AND SAND LAYERS		
-9.6	40							BENT.
		42-44	S-5	24	N/A	0-24": SAME AS S-1		SAND
-14.6	45							
		47-49	S-6	24	N/A	0-21": VERY SANDY CLAY WITH SOME SILT,GRAYISH OLIVE GREEN (5GY3/2), MEDIUM TO COARSE SAND,WET , 21-24": FINE TO MEDIUM UNCONSOLIDATED SAND, DARK YELLOWISH GREEN (10GY3/2)		

PROJECT: DU PONT KENTEC FACILITY ; GRIFTON, NORTH CAROLINA
DRILLER: WESTINGHOUSE ENVIRONMENTAL   LOGGER: J. FORD
DRILLING METHOD/EQUIPMENT: MUD ROTARY / SPEEDSTAR
GROUND ELEVATION (FT MSL): 30.4   START DATE: 10/3/89   FINISH DATE: 10/5/89

BORING : MW-4B
PAGE 2 OF 2; 50 ft - 100 ft
CH2M HILL
PROJECT #:SAT 22398.CO

ELEVATION (FT MSL)	DEPTH (FEET)	SAMPLE COLLECTION DATA				WRITTEN LOG	SYMBOLIC LOG	WELL CONSTUCTION 2 Inch PVC
		INTERVAL (FEET)	SAMPLE NUMBER	RECOVERY (IN)	STANDARD PENETRATION TEST 6"-6"-6"-6" (N)			
-24.6	55	52-54	S-7	24	N/A	0-24": FINE TO MEDIUM UNCONSOLIDATED SAND, DARK YELLOWISH GREEN (10GY 3/2)		SAND
						BORING TERMINATED AT 56.0 FEET WELL SUMMARY GROUT: 0 - 39.0 FT BENTONITE: 39.0 - 43.0 FT SAND: 43.0 - 56.0 FT SCREEN: 46.0 - 56.0 FT		

PROJECT: DU PONT KENTEC FACILITY; GRIFTON, NORTH CAROLINA
DRILLER: WESTINGHOUSE ENVIRONMENTAL LOGGER: J. FORD
DRILLING METHOD/EQUIPMENT: MUD ROTARY / SPEEDSTAR
GROUND ELEVATION (FT MSL): 27.8 START DATE: 10/3/89 FINISH DATE: 10/9/89

BORING : MW-7B
PAGE 1 OF 2; 0 ft - 50 ft
CH2M HILL
PROJECT #:SAT 22398.C0.02

ELEVATION (FT MSL)	DEPTH (FEET)	SAMPLE COLLECTION DATA: INTERVAL (FEET)	SAMPLE NUMBER	RECOVERY (IN)	STANDARD PENETRATION TEST 6"-6"-6"-6" (N)	WRITTEN LOG	SYMBOLIC LOG	WELL CONSTUCTION 2 Inch PVC
22.8	5					NOTE: REFER TO THE MW-7 LOG IN THE PHASE 2 REPORT FOR SHALLOW LITHOLOGIES		
						6-INCH STEEL CASING TO 9' 9"		
17.8	10							
12.8	15							
		16-18	S-1	24	N/A	0-24":CLAYEY SILT WITH FINE SAND, GREENISH BLACK (5G 2/1), MOIST , SEMI-PLASTIC		
7.8	20							GROUT
		21-23	S-2	24	N/A	0-24":SAME AS S-1		
2.8	25							
		26-28	S-3	24	N/A	0-24":SAME AS S-1		
-2.2	30							BENT.
		31-33	S-4	24	N/A	0-24":SAME AS S-1		
-7.2	35							
		36-38	S-5	24	N/A	0-24":SAME AS S-1		
-12.2	40							
		41-43	S-6	24	N/A	0-24": VERY CLAYEY SAND WITH SOME SILT, GRAYISH OLIVE GREEN (5GY 3/2), WET,COARSE GRAINED		SAND
-17.2	45							
		46-48	S-7	22	N/A	0-24":FINE TO MEDIUM UNCONSOLIDATED SANDS, DARK YELLOWISH GREEN (10GY 3/2)		
						BORING TERMINATED AT 48.0 FEET WELL SUMMARY: GROUT: 0 - 29.5 FT; BENTONITE: 29.5 - 33.5 FT; SAND: 33.5 - 46.0 FT; SCREEN: 36.0 - 46.0 FT		

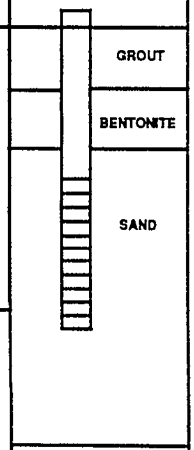
PROJECT: KENTEC FACILITY ; GRIFTON, NORTH CAROLINA
DRILLER: WESTINGHOUSE ENVIRONMENTAL LOGGER: STEVEN BROWN
DRILLING METHOD/EQUIPMENT: CME-55 WITH 6 1/4" HSA
GROUND ELEVATION (FT MSL): 29.7 START DATE: 10/2/89 FINISH DATE: 10/2/89

BORING : MW-9
PAGE 1 OF 1
CH2M HILL
PROJECT #:SAT 22398.C0

ELEVATION (FT MSL)	DEPTH (FEET)	SAMPLE COLLECTION DATA INTERVAL (FEET)	SAMPLE NUMBER	RECOVERY (IN)	STANDARD PENETRATION TEST 6"-6"-6"-6" (N)	WRITTEN LOG	SYMBOLIC LOG
24.7	5	3.5 - 5	S1	17	7-12-16	0-5": FINE SAND WITH TR. SILT, MEDIUM YELLOWISH ORANGE (10 YR 7/6), MOIST, SLIGHTLY STIFF; 5-17": FINE TO MED. SAND, DARK YELLOWISH ORANGE (10 YR 6/6) , WITH SOME IRON STAINING, WET, LOOSE	
19.7	10	9-10.5	S2	25	5-9-18	0-7": FINE TO V. COARSE SAND WITH SOME FN. PEBBLES,DARK YELLOWISH ORANGE (10 YR 6/6), WET, LOOSE FROM 0-5", STIFF, MOIST FROM 5-7"; 7-25": SILTY CLAY WITH TR. VF. SAND, DARK GRAY (N3), STIFF, MOIST	
14.7	15	14-15.5	S3	18	27-27-40	0-5": SILTY SANDY CLAY, DARK GRAY (N3), STIFF, MOIST; 5-8": SAME AS 0-5" BUT TR. SAND; 8-11": SILTY MED. TO C. SAND, DARK GRAY (N3), MOIST, LOOSE; 11-18": SANDY SILTY CLAY, DARK GRAY (N3), STIFF, MOIST	

BOREHOLE TERMINATED AT 14 FEET

WELL CONSTUCTION
2 Inch PVC



WELL SUMMARY

GROUT: 0 TO 2' 6"
BENTONITE: 2' 6" TO 4'
SAND: 4' TO 12'
SCREEN: 5' TO 10'

PROJECT: KENTEC FACILITY ; GRIFTON, NORTH CAROLINA
DRILLER: WESTINGHOUSE ENVIRONMENTAL   LOGGER: STEVEN BROWN
DRILLING METHOD/EQUIPMENT: CME-55 WITH 6 1/4" HSA
GROUND ELEVATION (FT MSL): 30.6   START DATE: 10/4/89   FINISH DATE: 10/5/89

BORING : MW-10
PAGE 1 OF 1
CH2M HILL
PROJECT #:SAT 22398.C0

ELEVATION (FT MSL)	DEPTH (FEET)	SAMPLE COLLECTION DATA: INTERVAL (FEET)	SAMPLE NUMBER	RECOVERY (IN)	STANDARD PENETRATION TEST 6"-6"-6" (N)	WRITTEN LOG	SYMBOLIC LOG	WELL CONSTUCTION 2 Inch PVC
								GROUT
25.6	5	4 - 5.5	S1	22	7-9-10	0-22": MED. TO C. BEACH SAND WITH SOME SILT, DARK YELLOWISH ORANGE (10 YR 6/6), WET, MODERATELY LOOSE		BENTONITE
20.6	10	8.5-10	S2	18	5-5-5	0-10": MED. SAND TO F. PEBBLES, MODERATE YELLOWISH BROWN (10 YR 5/4), WET, LOOSE; 10-18": SILTY SANDY CLAY, GRAYISH OLIVE (10 Y 4/2), WET, STIFF		SAND
15.6	15	13.5-15	S3	20	20-40-45	0-3": SILTY CLAYEY F. TO C. SAND, DARK YELLOWISH ORANGE (10 YR 6/6), MOIST, STIFF; 3-20": CLAYEY SILTY F. TO C. SAND, DARK GRAY (N3), MOIST, V. STIFF		

BORING TERMINATED AT 14 FEET

NOTE: STRONG ODOR DETECTED DURING DRILLING BUT NO MONITORING DETECTIONS

WELL SUMMARY

GROUT: 0 TO 3'
BENTONITE:3' T0 5' 3"
SAND: 5'3" TO 12' 6"
SCREEN: 6' TO 12' 6"

CH2M HILL

PROJECT NUMBER: SAT22398.D0 | BORING NO.: MW10B | SHEET: 1 OF 3

SOIL BORING LOG

PROJECT: DUPONT KENTEC
LOCATION: LENOIR CO., NC
ELEVATION: ~30'
DRILLING CONTRACTOR: HARDIN-HUBER INC.
DRILLING METHOD AND EQUIPMENT: 8" HSA & 6" ROTARY W/A FAILING F-7
WATER LEVEL AND DATE: ~8', 7/30/90
START: 7/30/90
FINISH: 8/1/90
LOGGER: A. BRYDA

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
							AIR MONITORING (AM): OVA AND EXPLOSIMETER. WILL NOTE ANY ABOVE BACKGROUND READINGS
							DRILLING NEXT TO MW10 SEE MW10 BORING LOG FOR SOIL DESCRIPTION
5							
							WATER LEVEL ~8'
10	10-12	S1	1.7	2-2-2-3 (4)	0-3" SILTY SAND, (SC), SAND IS F-M, GRAYISH ORANGE (10YR7/4), WET, VERY LOOSE 3-12" SILT W/ SAND, (ML), SAND IS F., VERY PALE ORANGE TO DARK YELLOW ORANGE (10YR6/6), WET, VERY LOOSE 12-20" SILT W/ SAND, (ML), SAND IS C. W/ SOME CLAY, MOIST, VERY LOOSE		SILT LAYER AT ~11' AM: >100 PPM, 0. SET 6" ID CASING +1 TO 13' SUCCESSFUL PRESSURE TEST OF CASING ON 7/31/90
15	15-17	S2	1.8	15-13--10-13 (23)	0-6" SILTY SAND, (SC), SAND IS M-VC, OLIVE GRAY (5Y3/2), WET, MEDIUM TO DENSE, SOME SHELLS 6-20" SILT W/ SAND, (ML), SAND IS M, OLIVE GRAY (5Y3/2), WET, V. STIFF		
20							

CH2M HILL

PROJECT NUMBER:SAT22398.D0 | BORING NO.: MW10B | SHEET: 2 OF 3

SOIL BORING LOG

PROJECT: DUPONT KENTEC LOCATION:LENOIR CO., NC
ELEVATION:~30' DRILLING CONTRACTOR: HARDIN-HUBER INC.
DRILLING METHOD AND EQUIPMENT: 8" HSA & 6" ROTARY W/A FAILING F-7
WATER LEVEL AND DATE: ~8', 7/30/90 START: 7/30/90 FINISH: 8/1/90 LOGGER: A. BRYDA

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
20	20-22	S3	2.0	7-8- -10-11 (18)	SILT, (ML), OLIVE GRAY (5Y3/2), WET, V. STIFF		
25	25-27	S4	1.4	7-12- 20-30 (32)	SIMILAR TO S3 W/ SEVERAL THIN CLAY SEAMS AND SILTY SAND SEAMS, MICACEOUS		
30	30-32	S5	2.0	8-10- -12-18 (22)	SIMILAR TO S3, SILT, (ML), OLIVE GRAY (5Y3/2), WET, V. STIFF, SOME CLAY AND F. SAND SEAMS		
35	35-37	S6	2.0	8-10- -12-18 (22)	SIMIALR TO S5 ABOVE, SILT, MOIST W/ SEVERAL THIN SILTY F. SAND SEAMS		
40							

CH2M HILL

PROJECT NUMBER:SAT22398.D0	BORING NO.: MW10B	SHEET: 3 OF 3

SOIL BORING LOG

PROJECT: DUPONT KENTEC LOCATION:LENOIR CO., NC
ELEVATION:~30'. DRILLING CONTRACTOR: HARDIN-HUBER INC.
DRILLING METHOD AND EQUIPMENT: 8" HSA & 6" ROTARY W/A FAILING F-7
WATER LEVEL AND DATE: ~8', 7/30/90 START: 7/30/90 FINISH: 8/1/90 LOGGER: A. BRYDA

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	40-42	S7	2.0	10-12--7-26 (19)	SIMILAR TO ABOVE, SILT W/ SEVERAL THIN SILTY F. SAND SEAMS		
45	45-47	S8	2.0	8-14--21-40 (35)	SILTY CLAYEY SAND, (SC-SM), SAND IS M-C., OLIVE GRAY (5Y3/2), WET, DENSE, SOME SHELLS PRESENT		
50	50-52	S9	1.3	21-36--50-23 (86)	SILTY SAND, (SM), SAND IS M-C., OLIVE GRAY (5Y3/2), WET, DENSE		BLOW COUNTS INDICATE "DENSE" SEDIMENTS, BUT THE SAND IS "LOOSE" WELL CONSTRUCTION INFO 57' TOTAL DEPTH
55	55-57	S10	1.7	24-60--70-100/ (130)	SAME AS S9, SOME SHELLS		+1-13' 6" STEEL CASING 45-55' 2-INCH SCH 40 PVC, 10 SLOT SCREEN 55-57' NATURAL SAND PACK 42.6-55' #2 MORIE SAND PACK 36.5-42.6' BENTONITE PELLETS SEAL 0-36.5' PORTLAND TYPE I CEMENT GROUT
60							

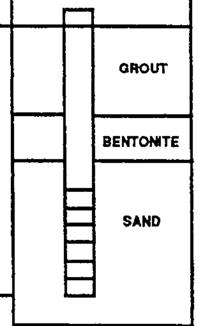
PROJECT: KENTEC FACILITY ; GRIFTON, NORTH CAROLINA
DRILLER: WESTINGHOUSE ENVIRONMENTAL LOGGER: STEVEN BROWN
DRILLING METHOD/EQUIPMENT: CME-55 WITH 6 1/4" HSA
GROUND ELEVATION (FT MSL): 30.1 START DATE: 10/5/89 FINISH DATE: 10/5/89

BORING : MW-11

CH2M HILL
PROJECT #:SAT 22398.C0

ELEVATION (FT MSL)	DEPTH (FEET)	SAMPLE COLLECTION DATA: INTERVAL (FEET)	SAMPLE NUMBER	RECOVERY (IN)	STANDARD PENETRATION TEST 6"-6"-6" (N)	WRITTEN LOG	SYMBOLIC LOG
25.1	5	3.5-5'	S1	18	5-8-9	0-18": MED. TO C. BEACH SAND WITH VF. TO F. PEBBLES, PALE YELLOWISH BROWN (10 YR 6/2), LOOSE, WET	
20.1	10	8.5-10	S2	19	6-10-14	0-3": CLAYEY F. SAND, MODERATE YELLOWISH BROWN (10 YR 5/4), STIFF, MOIST; 3-19": SANDY CLAY, DARK GRAY (N3), SAND IS F. TO MED.,STIFF, MOIST	

WELL CONSTUCTION
2 Inch PVC



BOREHOLE TERMINATED AT 10 FEET

NOTE: STRONG ODOR DETECTED DURING DRILLING BUT NO MONITORING DETECTIONS

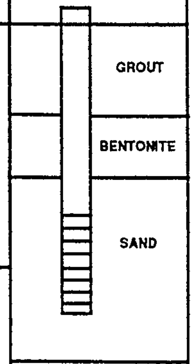
WELL SUMMARY

GROUT: 0 TO 3'1"
BENTONITE: 3'1" TO 4'6"
SAND: 4'6" TO 9'
SCREEN: 5'6" TO 9'

PROJECT: KENTEC FACILITY ; GRIFTON, NORTH CAROLINA
DRILLER: WESTINGHOUSE ENVIRONMENTAL
LOGGER: STEVEN BROWN
DRILLING METHOD/EQUIPMENT: CME-55 WITH 6 1/4" HSA
GROUND ELEVATION (FT MSL): 27.5
START DATE: 10/5/89
FINISH DATE: 10/5/89

BORING : MW-12
PAGE 1 OF 1
CH2M HILL
PROJECT #:SAT 22398.C0

ELEVATION (FT MSL)	DEPTH (FEET)	SAMPLE COLLECTION DATA: INTERVAL (FEET)	SAMPLE NUMBER	RECOVERY (IN)	STANDARD PENETRATION TEST 6"-6"-6"-6" (N)	WRITTEN LOG	SYMBOLIC LOG	WELL CONSTUCTION 2 Inch PVC
22.5	5	4-5.5	S1	18	13-9-10	0-6": SILTY CLAY, PALE YELLOWISH BROWN (10 YR 6/2), STIFF, MOIST; 6-18": F. TO MED. CLEAN BEACH SAND, GRAYISH ORANGE (10 YR 7/4), WET, LOOSE		
17.5	10	9-10.5	S2	22	10-19-21	0-2": CLAYEY F. TO MED. SAND, PALE YELLOWISH BROWN (10 YR 6/2), STIFF, MOIST; 2-22": SANDY CLAY, DARK GRAY (N3), SAND IS F. TO MED., STIFF, MOIST		
						BORING TERMINATED AT 11 FEET		



WELL SUMMARY

GROUT: 0 TO 2'10"
BENTONITE: 2'10" TO 5'
SAND: 5' TO 9'6"
SCREEN: 6'3" TO 9'6"

PROJECT: KENTEC FACILITY ; GRIFTON, NORTH CAROLINA
DRILLER: WESTINGHOUSE ENVIRONMENTAL LOGGER: STEVEN BROWN
DRILLING METHOD/EQUIPMENT: CME-55 WITH 6 1/4" HSA
GROUND ELEVATION (FT MSL): 27.1 START DATE: 10/6/89 FINISH DATE: 10/6/89

BORING : MW-13

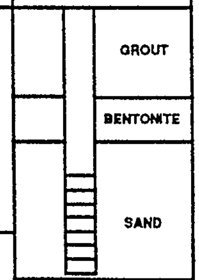
CH2M HILL
PROJECT #:SAT 22398.C0

ELEVATION (FT MSL)	DEPTH (FEET)	SAMPLE COLLECTION DATA: INTERVAL (FEET)	SAMPLE NUMBER	RECOVERY (IN)	STANDARD PENETRATION TEST 6"-6"-6" (N)	WRITTEN LOG
22.1	5	3.5-5	S1	6	11-9-7	0-6": SILTY F. TO VC. SAND WITH VF. TO F. PEBBLES, PALE YELLOWISH BROWN (10 YR 6/2) TO LIGHT BROWN (10 YR 5/6), WET, LOOSE WHERE COARSE, STIFF WHERE SILTY
17.1	10	8.5-10	S2	20	30-32-45	0-20": VERY SANDY CLAY, DARK GRAY (N3), MOIST, STIFF

BOREHOLE TERMINATED AT 9 FEET

SYMBOLIC LOG

WELL CONSTUCTION
2 INCH PVC
FLUSH MOUNT



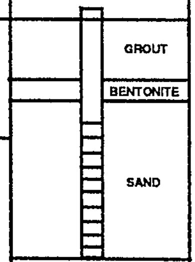
WELL SUMMARY

GROUT: 0 TO 3'
BENTONITE: 3' TO 4'6"
SAND: 4'6" TO 8'10"
SCREEN: 5'8" TO 8'10"

PROJECT: KENTEC FACILITY ; GRIFTON, NORTH CAROLINA
DRILLER: WESTINGHOUSE ENVIRONMENTAL   LOGGER: STEVEN BROWN
DRILLING METHOD/EQUIPMENT: CME-55 WITH 6 1/4" HSA
GROUND ELEVATION (FT MSL): 25.4   START DATE: 1/24/90   FINISH DATE: 1/24/90

BORING : MW-14A
PAGE 1 OF 1
CH2M HILL
PROJECT #:SAT 22398.C0

ELEVATION (FT MSL)	DEPTH (FEET)	SAMPLE COLLECTION DATA: INTERVAL (FEET)	SAMPLE NUMBER	RECOVERY (IN)	STANDARD PENETRATION TEST 6"-6"-6"-6" (N)	WRITTEN LOG	SYMBOLIC LOG	WELL CONSTUCTION 2 INCH PVC
20.4	5					NOTE: MW-14A LITHOLOGIES GIVEN IN MW-14B LOG. MW-14B IS 6 FEET AWAY SO MW-14A WAS NOT LOGGED		
15.4	10							



WELL SUMMARY

GROUT: 0 TO 2'1"
BENTONITE: 2'1" TO 2'9"
SAND: 2'9" TO 8'1"
SCREEN: 3'6" TO 8'0"
TOTAL BOREHOLE DEPTH: 8'1"

PROJECT: KENTEC FACILITY ; GRIFTON, NORTH CAROLINA
DRILLER: WESTINGHOUSE ENVIRONMENTAL LOGGER: STEVEN BROWN
DRILLING METHOD/EQUIPMENT: CME-55 WITH 6 1/4" HSA
GROUND ELEVATION (FT MSL): 25.3 START DATE: 1/24/90 FINISH DATE: 1/26/90

BORING : MW-14B

CH2M HILL
PROJECT #:SAT 22398.C0

ELEVATION (FT MSL)	DEPTH (FEET)	SAMPLE COLLECTION DATA: INTERVAL (FEET)	SAMPLE NUMBER	RECOVERY (IN)	STANDARD PENETRATION TEST 6"-6"-6"-6" (N)	WRITTEN LOG	SYMBOLIC LOG	WELL CONSTUCTION 2 INCH PVC
20.3	5	3.5-5	S1	22	3-2-3	0-2": FINE TO COARSE SAND, MODERATE YELLOWISH BROWN (10 YR 5/4), LOOSE, MOIST; 2-4": SANDY SILT, MODERATE YELLOWISH BROWN (10 YR 5/4), STIFF, MOIST; 4-22": SANDY SILT WITH SOME CLAY, DARK GREY (N3), STIFF, MOIS T		
15.3	10	8.5-10	S2	21	4-5-11	0-10": SAME AS S1, 4-22" INTERVAL, SAND IS VERY FINE TO FINE; 10-21": CLAYEY SILT WITH SOME VERY FINE SAND, DARK GREY (N3), STIFF, MOIST **NOTE: 6-INCH CASING TO 9 FT BLS**		
-10.3	15	13.5-15	S3	18	11-10-17	0-10": SAME AS S2, 0-10" INTERVAL; 10-18": SAME AS S2, 10-21" INTERVAL		GROUT
-5.3	20	18.5-20	S4	20	11-14-17	0-20": SAME AS S2, 10-21" INTERVAL		
0.3	25	23.5-25	S5	22	19-24-50(5")	0-22": SAME AS S2, 0-10" INTERVAL BUT SOME FINE (1-2 MM) STRINGERS OF SAND AND CLAY EVIDENT, SAMPLE IS GLAUCONITIC		
-4.7	30	28.5-30	S6	13	18-32-50(5 1/2")	0-13": SAME AS S5		CAVE-IN
-9.7	35	33.5-35	S7	21	13-19-27	0-21": SAME AS S5		BENTONITE
-14.7	40	38.5-40	S8	18	16-24-34	0-10": SILTY FINE TO COARSE SAND WITH SHELL FRAGMENTS, DARK GREY (N3), GLAUCONITIC, STIFF, MOIST; 10-14": SILTY FINE TO VERY COARSE SAND WITH SOME 2-4 MM PEBBLES (5%), FIRM, MOIST; 14-18": LIKE 0-10" INTERVAL BUT MODERATELY LOOSE		SAND
-19.7	45	43.5-45	S9	12	50(6") - 50(3")	0-8": MEDIUM TO VERY COARSE SAND WITH SOME SMALL LIMESTONE AND SHELL FRAGMENTS AND VERY FINE PEBBLES, DARK GREY (N3), GLAUCONITIC, LOOSE, WET; 8-12": MEDIUM TO VERY COARSE CLAYEY SAND, DARK GREY (N3), CLAY IS GREENISH GREY, GLAUCONITIC, SOFT TO FIRM		
		48.5-50	S10	0	50 (1")	NO RECOVERY. DRILLER REPORTS THAT DRILLING ACTION AND CUTTINGS ARE SIMILAR TO WHAT WAS OBSERVED DURING DRILLING OF S9 INTERVAL		

PROJECT: KENTEC FACILITY ; GRIFTON, NORTH CAROLINA
DRILLER: WESTINGHOUSE ENVIRONMENTAL LOGGER: STEVEN BROWN
DRILLING METHOD/EQUIPMENT: CME-55 WITH 6 1/4" HSA
GROUND ELEVATION (FT MSL): 25.3 START DATE: 1/24/90 FINISH DATE: 1/26/90

BORING : MW-14B

CH2M HILL
PROJECT #:SAT 22398.C0

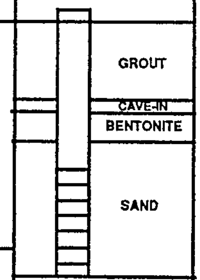
ELEVATION (FT MSL)	DEPTH (FEET)	SAMPLE COLLECTION DATA: INTERVAL (FEET)	SAMPLE NUMBER	RECOVERY (IN)	STANDARD PENETRATION TEST 6"-6"-6"-6" (N)	WRITTEN LOG	SYMBOLIC LOG	WELL CONSTUCTION 2 INCH PVC
		52-53	S11	11	29-50 (4")	0-11": SILTY FINE TO VERY COARSE SAND,WITH SHELL AND LIMESTONE FRAGMENTS AND VERY FINE PEBBLES OF QUARTZ AND INDURATED MUDSTONE, DARK GREY (N3), SOFT TO LOOSE, WET		SAND / CAVE-IN
-29.7	55							

WELL SUMMARY

GROUT: 0 TO 25'
CAVE-IN: 25' TO 31'
BENTONITE: 31' TO 34'10"
SAND: 34'10" TO 50'6"
SCREEN: 40'6" TO 50'6"
CAVE-IN: 50'6" TO 52'
TOTAL BOREHOLE DEPTH: 52'

PROJECT: KENTEC FACILITY ; GRIFTON, NORTH CAROLINA
DRILLER: WESTINGHOUSE ENVIRONMENTAL LOGGER: STEVEN BROWN
DRILLING METHOD/EQUIPMENT: CME-55 WITH 6 1/4" HSA
GROUND ELEVATION (FT MSL): 26.2 START DATE: 1/24/90 FINISH DATE: 1/25/90

BORING : MW-15
PAGE 1 OF 1
CH2M HILL
PROJECT #:SAT 22398.C0

ELEVATION (FT MSL)	DEPTH (FEET)	SAMPLE COLLECTION DATA: INTERVAL (FEET)	SAMPLE NUMBER	RECOVERY (IN)	STANDARD PENETRATION TEST 6"-6"-6"-6" (N)	WRITTEN LOG	SYMBOLIC LOG	WELL CONSTUCTION 2 INCH PVC
		3.5-5	S1	21	12-13-10	0-5": FINE SILTY SAND, DARK YELLOWISH BROWN (10 YR 4/2), FIRM, MOIST; 5-13": SILTY VERY FINE TO FINE SAND, STIFF, MOIST; 13-21": COARSE TO VERY COARSE BEACH SAND, CLEAN, LOOSE, WET, CONTAINS SOME SHELL FRAGMENTS		
21.2	5							
		8.5-10	S2	12	6-8-12	0-12": CLAYEY SILT WITH SOME SAND, DARK GREY (N3), SAND IS VERY FINE, STIFF, MOIST		
16.2	10							

WELL SUMMARY

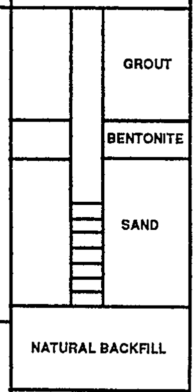
GROUT: 0 TO 2'6"
CAVE-IN: 2'6" TO 3'
BENTONITE: 3'0" TO 4'0"
SAND: 4'0" TO 8'6"
SCREEN: 4'10" TO 8'6"
TOTAL BOREHOLE DEPTH: 8'6"

PROJECT: KENTEC FACILITY ; GRIFTON, NORTH CAROLINA
DRILLER: WESTINGHOUSE ENVIRONMENTAL LOGGER: STEVEN BROWN
DRILLING METHOD/EQUIPMENT: CME-55 WITH 6 1/4" HSA
GROUND ELEVATION (FT MSL): 29.5 START DATE: 1/23/90 FINISH DATE: 1/23/90

BORING : MW-16
PAGE 1 OF 1
CH2M HILL
PROJECT #:SAT 22398.C0

ELEVATION (FT MSL)	DEPTH (FEET)	SAMPLE COLLECTION DATA: INTERVAL (FEET)	SAMPLE NUMBER	RECOVERY (IN)	STANDARD PENETRATION TEST 6"-6"-6" (N)	WRITTEN LOG	SYMBOLIC LOG
		3.5-5	S1	18	3-3-3	0-18": MEDIUM SAND, DARK YELLOWISH ORANGE (10 YR 6/6), WELL SORTED, LOOSE, WET	
24.5	5						
		8-9.5	S2	17	3-2-2	0-7": SAME AS S1; 7-10": MEDIUM TO VERY COARSE SAND, LIGHT BROWN (5 YR 5/6), WITH 3-4 MM PEBBLES AT BASE, LOOSE, WET; 10-17": SANDY SILT, DARK YELLOWISH ORANGE (10 YR 6/6), SAND IS FINE TO MEDIUM, FIRM, MOIST	
19.5	10						
		13-14.5	S3	9	7-13-19	0-9": VERY SANDY SILT, DARK GREY (N3), STIFF, MOIST	
14.5	15						

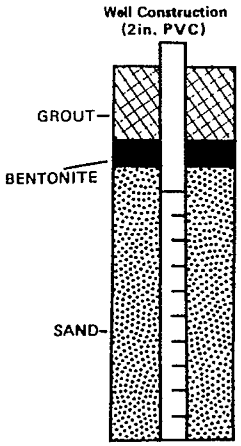
WELL CONSTUCTION
2 INCH PVC
FLUSH MOUNT

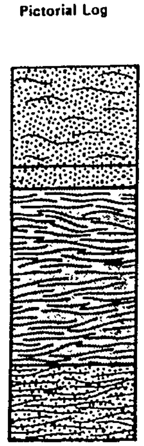


WELL SUMMARY

GROUT: 0 TO 3'8"
BENTONITE: 3'8' TO 5'0"
SAND: 5'0" T0 10'0"
SCREEN: 6'4" TO 9'10"
NATURAL BACKFILL: 10' TO 12'9"
TOTAL DEPTH: 12'9"

PHASE 1 AND PHASE 2
GEOLOGIC LOGS





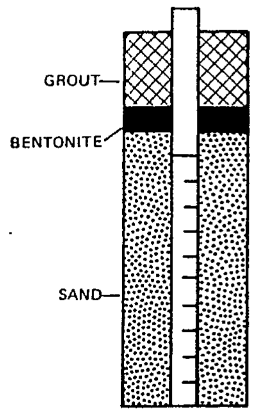
Depth(ft.): 5, 10, 15, 20

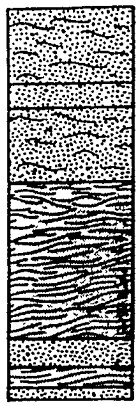
Elevation (ft.): 29.0, 24.0, 19.0, 14.0, 9.0

Sample Number	Interval (ft.)	Recovery (in.)	Blow Counts 6"–6"–6"–6"	Written Log
S1	0- 1.5	11	3–3- 4	Fine silty sand, dusky brown (5YR 2/2)– gray orange (10YR 7/4), moist.
S2	3 5–5	18	7–9–11	M – c. sand, gray-orange (10YR 7/4), to fine sil y sand, green gray (5GY 4/1), wet.
S3	8.5–10	24	12–16–22	Clayey silt with trace sand, green-black (5G 2/1), dense, sl. plastic, moist.
S4	13.5–15	20	5–9–12	Sandy silt with trace clay, green black (5G 2/1), dense, v. sl. plastic, some glauconite, v. moist.

WELL CONSTRUCTION AND GEOLOGIC LOG
MONITORING WELL 1
Du PONT – KENTEC

CH2M HILL





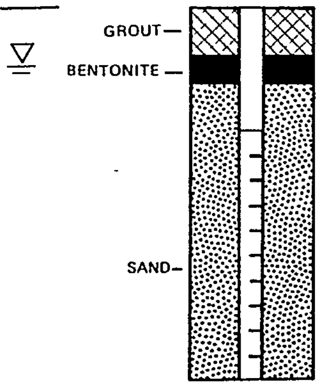
Depth(ft.)	Sample Number	Interval (ft.)	Recovery (in.)	Blow Counts 6"–6"–6"–6"	Written Log	Elevation (ft.)
						30.0
	S1	0–1.5	14	2–1–2	Fine sand with some silt, dusky yel. br. (10YR 2/2) gray orange (10YR 7/4) sl moist.	
	S2	3.5–5	15	2–5–8	Fine –m sand, trace silt, yel. orange (10YR 6/6), wet	
5					Fine –m silty sand, trace clay, green gray (5G 2/1), sl. plastic, dense, v. moist.	25.0
10	S3	8.5–10	24	2–6–7	Clayey silt, trace sand, green-black (5G 2/1), sl. plastic, dense, v. moist.	20.0
	S4	13.5–15	10	17–29–14	Fine –m. sand with some gravel, grey-green (5GY 4/1), wet.	
15					Clayey sandy silt, green-black (5G 2/1), dense, sl. plastic, v. moist.	15.0
	S5	14–15.5	24	6–14–15	M–c. sand, gray (N4), wet.	
20						10.0

WELL CONSTRUCTION AND GEOLOGIC LOG
MONITORING WELL 2
Du PONT – KENTEC

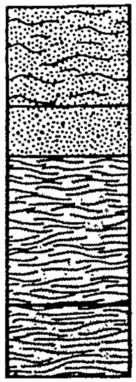
CH2M HILL

Depth (ft.)	Sample Number	Interval (ft.)	Recovery (in.)	Blow Counts 6"–6"–6"–6"	Written Log	Elevation (ft.)
						29.5
					Fine silty sand, yellow orange (10YR 6/6) - gray orange (10YR 7/4) moist wet.	
5	S1	3.5 5	17	5 8 9	Fine- c. sand, with some silt, color as above, wet.	24.5
	S2	8.5–10	18	3–6–10	Clayey sandy silt, gray (N3), dense, sl. plastic, v. moist.	
10						19.5
	S3	13.5–15	18	7–12–12	As above, with more sand, with some glauconite, moist.	
15						14.5
20						9.5

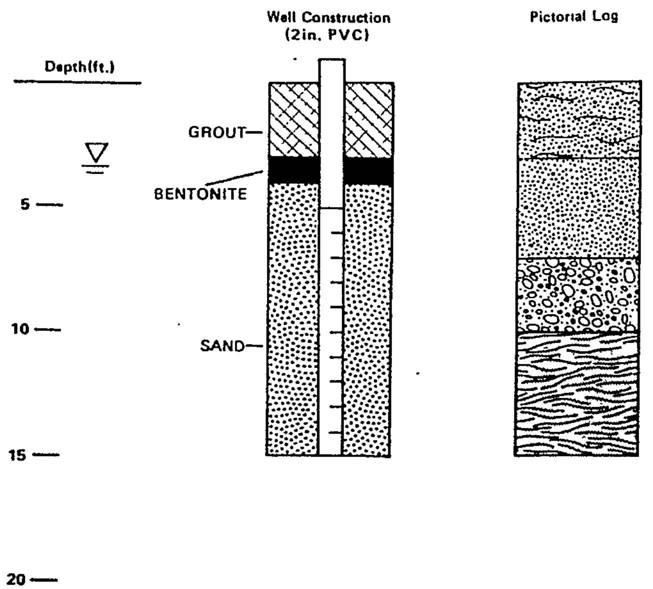
Well Construction (2in. PVC)



Pictorial Log



WELL CONSTRUCTION AND GEOLOGIC LOG
MONITORING WELL 3
Du PONT – KENTEC



Sample Number	Interval (ft.)	Recovery (in.)	Blow Counts 6"–6"–6"–6"
S1	0–1.5	18	3–2–2
S2	3.5–5	17	4–5–6
S3	8.5–10	24	3–4–5
S4	13.5–15	24	8–10–14

Written Log

Fine silty sand, yell. br. (10YR 4/2)–yell. orange (10YR 6/6), moist.

Fine–c. sand, trace silt, yell. orange (10YR 6/6), gray orange (10YR 7/4), wet.

M–c. sand with some gravel, gray (N4–N5)–black ((N1), wet.

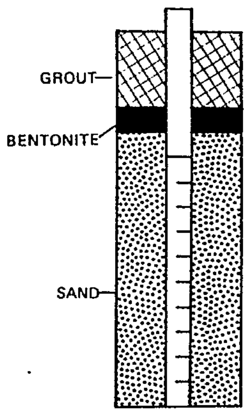
Clayey silt with some sand, green black (5G 2/1)–gray (N4), dense, moist-wet.

Elevation (ft.): 30.6, 25.6, 20.6, 15.6, 10.6

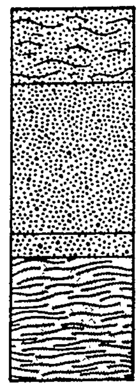
WELL CONSTRUCTION AND GEOLOGIC LOG
MONITORING WELL 4
Du PONT – KENTEC

CH2M HILL

Well Construction (2in. PVC)



Pictorial Log

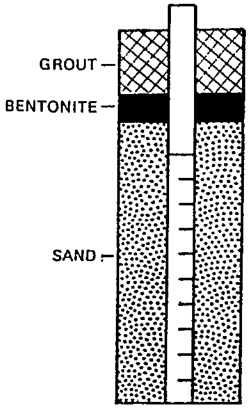


Depth(ft.)	Sample Number	Interval (ft.)	Recovery (in.)	Blow Counts 6"–6"–6"–6"	Written Log	Elevation (ft.)
						30.6
	S1	0–1.5	24	3–2–2	Fine silty sand, dusky yell. br. (10YR 4/2)–yell. orange (10YR 6/6), moist.	
	S2	3.5–5	18	2–2–4		
5						25.6
					M–c. sand, gray orange (10YR 7/4), wet.	
	S3	8.5–10	24	2–3–4		
					As above but black (N1), wet.	
10						20.6
					Clayey sandy silt, green black (5G 2/1), wet.	
	S4	13.5–15	18	6–8–11		
15						15.6
20						10.6

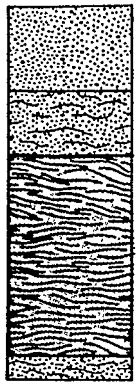
WELL CONSTRUCTION AND GEOLOGIC LOG
MONITORING WELL 5
Du PONT – KENTEC

CH2M HILL

Well Construction (2 in. PVC)



Pictorial Log



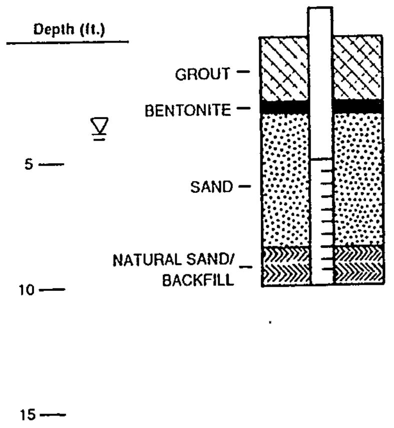
Depth (ft.)	Sample Number	Interval (ft.)	Recovery (in.)	Blow Counts 6"–6"–6"–6"	Written Log	Elevation (ft.)
						28.5
					Fine–c. sand, gray orange (10YR 7/4) wet.	
5 ∇	S1	3.5–5	15	7–9–11	Fine–m. silty sand, gray green (5G 6/1), sl. cohesive, wet.	23.5
10	S2	8.5–10	20	7–10–14	Clayey sandy silt, green-black (5G 2/1), sl. plastic, dense, v. moist	18.5
15	S3	13.5–15	18	7–13–18	Silty sand, green black (5G 2/1), wet	13.5
20						8.5

WELL CONSTRUCTION AND GEOLOGIC LOG
MONITORING WELL 6
Du PONT – KENTEC

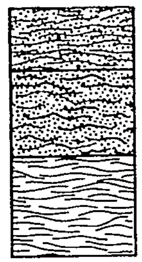
CH2M HILL

SAT 22398.B0

Well Construction (2 " PVC)



Pictorial Log



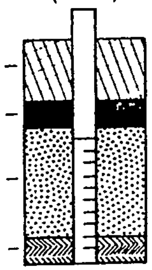
Sample Number	Interval (ft.)	Recovery (in.)	Blow Count 6"-6"-6"	Written Log	Elevation (ft.) 27.9
				Top soil: clayey silty sand, light brown.	25.7
S1	3.5-5	17	6-11-11	Silty fine to medium sand with trace clay, brown (5 YR 3/2) to greenish gray (5 GY 6/1).	21.7
S2	8.5-10	24	11-9-14	Clayey silt, greenish black (5 GY 2/1), moist, sl. plastic.	

WELL CONSTRUCTION AND GEOLOGIC LOG
MONITORING WELL 7
Du PONT - KENTEC

CH2M HILL

Depth (ft.): 5 (water level symbol), 10, 15

Well Construction (2 " PVC)



Pictorial Log

Sample Number	Interval (ft.)	Recovery (in.)	Blow Count 6"-6"-6"	Written Log	Elevation (ft.)
					29
S1	3.5-5	11	3-4-9	Silty c. sand, dark yellowish orange (10 YR 5/6), wet.	
					23
S2	8 5-10	20	3-5-6	Silty clay with some fine sand, several thin c. sand seams, black (N1), moist, plastic.	

WELL CONSTRUCTION AND GEOLOGIC LOG
MONITORING WELL 8
Du PONT - KENTEC

CH2M HILL

Appendix B
SAMPLING

Appendix B
SAMPLING

INTRODUCTION

Groundwater, surface water, soils, and aquatic biota were sampled at the Du Pont Kentec site. Groundwater samples were collected from 20 monitoring wells and 4 residential wells and one inactive production well. Surface water, sediments, and aquatic biota were sampled at several locations in drainage ditches near the plant. Soil samples were collected from the drainfield area and other surface locations. Groundwater and surface water samples were collected from selected locations from November 13, 1989 through February 14, 1990; from July 30 to August 1, 1990; on October 11, 1990; and November 11 through 14, 1990. Samples collected are summarized in Table B-1. The locations of all sampling points are shown in Figures B-1 and B-2. The equipment and procedures used during sampling are described in this appendix.

The CH2M HILL laboratories in Montgomery, Alabama; Redding, California; and Gainesville, Florida; analyzed the samples for the selected constituents shown in Table B-2. The specific analyses done for each sample are shown in Table B-3. The laboratory provided containers and preservatives consistent with standard laboratory procedures. Chain-of-custody forms were maintained to keep track of the shipment and handling of the samples.

GENERAL PROCEDURES

Groundwater Sampling

The sampling procedure at the shallow wells began with purging the well with a positive displacement bladder pump until in-line measurements of Eh, pH, temperature, and conductivity were stable for three well volumes. This was done to ensure that the samples collected were representative of the groundwater in the formation near the well. A summary of field parameters measured during sampling is given in Tables B-4 and B-5.

The deep wells were purged using an air lift pump. This allowed for faster purging of the well. Purging continued until parameters stabilized for three well volumes. The positive displacement bladder pump was then used to sample the well, after the in-line parameters restabilized to the values recorded at the end of purging.

After purging was completed, the samples were collected in the sample bottles provided by the laboratory. All samples of dissolved metals were filtered with a 0.45 micron filter to eliminate suspended solids. The samples collected at each site were packed in ice, sealed, and shipped to the laboratory in Montgomery within 48 hours of sampling. The Montgomery laboratory shipped some sample bottles to the Gainesville and Redding laboratories for analysis of selected constituents. All samples were analyzed within standard holding time limits.

After each well the sampling equipment was decontaminated using (1) a detergent wash, (2) a 10 percent methanol solution, (3) tap water, and (4) deionized water. One gallon of each of these four fluids was pumped successively through the sampling pump between wells. After each sample, filter paper was changed and the metals filter was cleaned by spraying the inside of the filter with deionized water.

Duplicate samples were taken at well MW-5 as a quality control of the laboratory results. As a check of the decontamination procedures, an equipment blank was taken after MW-7A. Trip blanks were sent with each shipment of samples to detect potential contamination of the samples during shipping and handling.

Drainfield Soil Sampling

Soils in the area of the Kentec plant drainfield were sampled at five locations on November 13, 1989. The samples were taken using a 3-inch diameter hand bucket auger. Each location was sampled at two depths--one at 1 foot below land surface and a second at approximately 5 feet below land surface. The shallow soil samples are designated by an "A" and the deep soil samples are designated by a "B". The locations of these soil samples are shown in Figure B-3.

During sampling of deep soil samples DS3-B and DS4-B, hard objects that may have been part of the drainfield system were struck at a depth of 2.5 feet. These samples were taken successfully by offsetting the sampling location by 2 or 3 feet. Strong odors were detected in the deep samples DS1-B and DS2-B during sampling.

To prevent cross-contamination, the hand auger was decontaminated between sampling locations by spraying the auger with a 10 percent methanol solution, wiping with a paper towel, and then spraying with deionized water. A duplicate sample was taken at location DS2-A for quality control purposes.

Surface Water, Sediment, and Soil Sampling

Surface water and sediment samples were collected at several points along the streams and drainages at the site. At each stream or drainage ditch location, a sediment sample from a depth of approximately 6 inches was taken using a 3-inch diameter bucket auger. The sediment sample was disturbed as little as possible to prevent volatiles from escaping. To prevent cross-contamination, the hand auger was decontaminated between sampling locations by spraying the auger with a 10 percent methanol solution, wiping with a paper towel, and then spraying with deionized water.

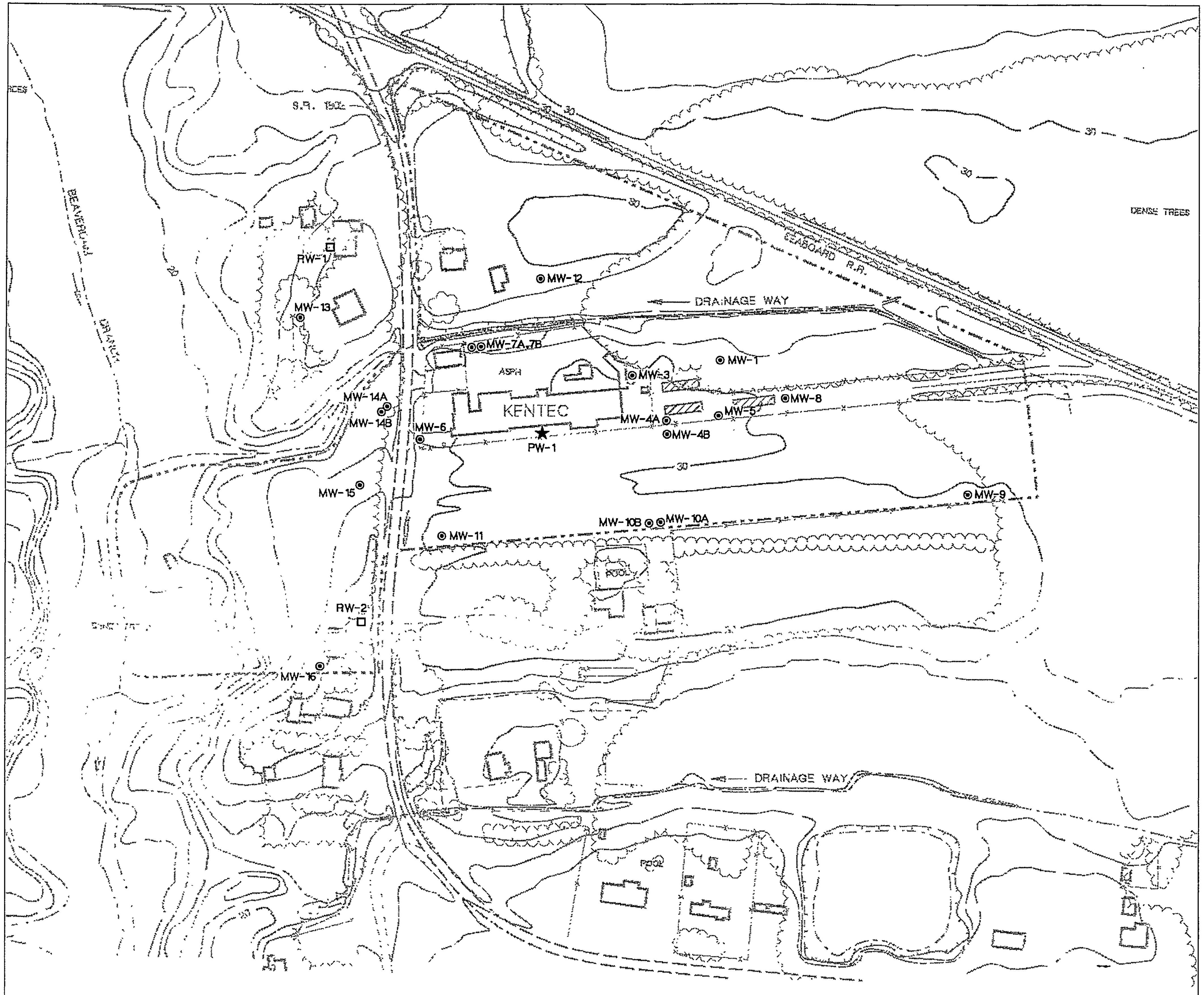
A surface water sample was also taken at each drainage or stream location by dipping the sample bottles directly into the water. Each sample container was filled without the loss of the preservative shipped in the sample container. Duplicate sediment and surface water samples were taken at SW-25 for quality control purposes.

A surface water sample, PS-1, was taken from a pond east of the Kentec plant along State Road 1802.

Two background soil samples, SS-1 and SS-2, were taken in the vicinity of the plant as a basis for comparison to the sediment samples taken along surface water drainages. These samples were also taken to test for the possibility that potential airborne contamination from the plant might settle out near the plant or be carried to the ground by precipitation. Samples were taken from a depth of 6 inches using sampling and decontamination procedures described above.

Biomonitoring of the biota in the surface water drainages at the site was also performed as part of the Phase 3 sampling. This work is described in detail in Appendix E.

WDCR478/010.51



LEGEND

◉ MONITORING WELL

□ RESIDENTIAL WELL

★ PRODUCTION WELL

NOTE: BASE MAP COMPILED FROM AERIAL PHOTOGRAPHY FLOWN ON 2/10/89.

0 100 200 300

SCALE: 1"=200'

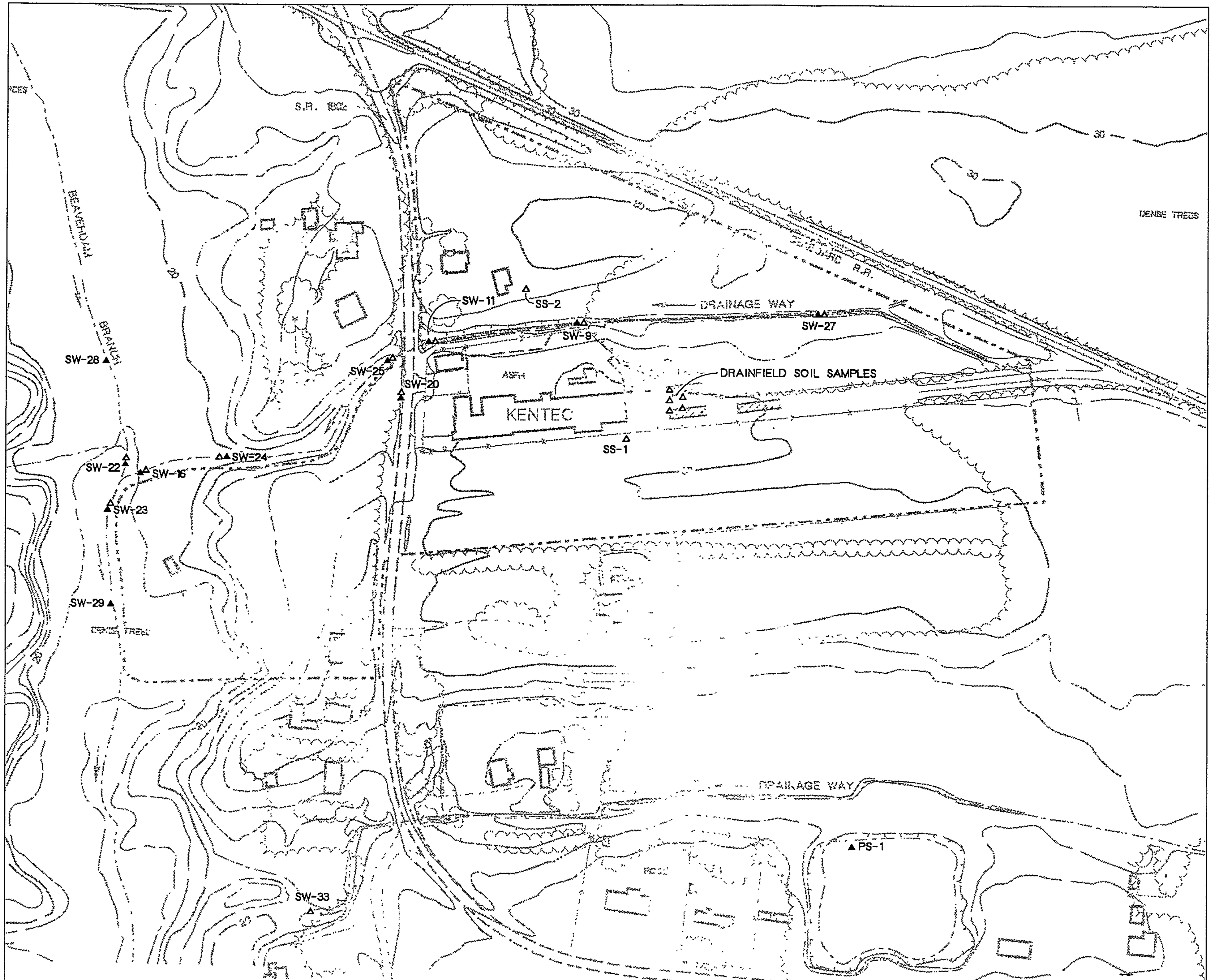
Figure B-1

GROUNDWATER SAMPLING LOCATIONS

Du Pont Kentec Facility

CH2M HILL

2398fc12.dgn 28-Mar-1991



NOTE: SW30,SW31, AND SW32 COLLECTED FROM NEUSE RIVER, 1 MILE SOUTHEAST OF KENTEC

LEGEND

▲ SURFACE WATER SAMPLE

△ SEDIMENT OR SOIL SAMPLE

NOTE: BASE MAP COMPILED FROM AERIAL PHOTOGRAPHY FLOWN ON 2/10/89.

0 100 200 300

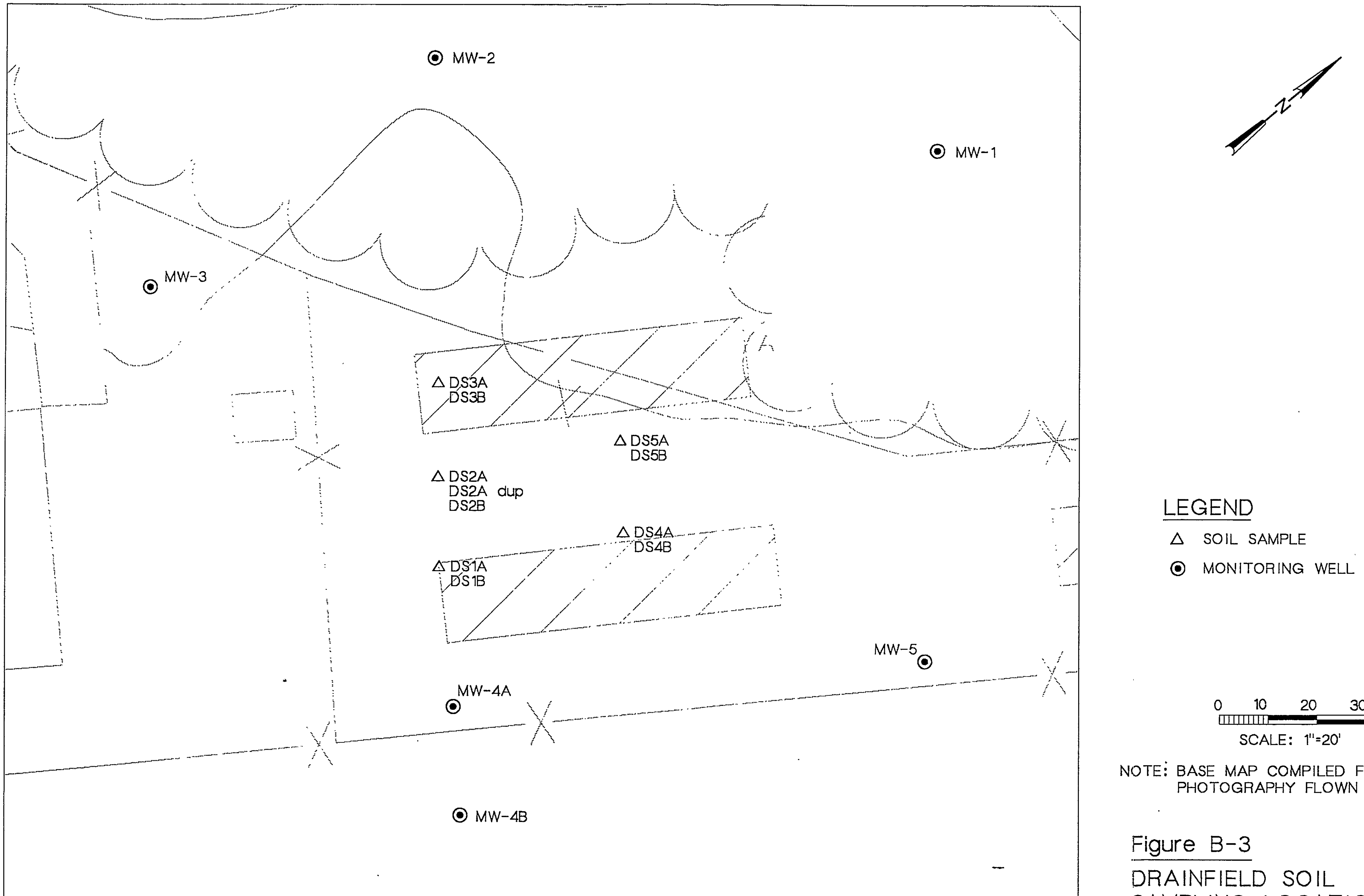
SCALE: 1"=200'

Figure B-2

SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS
Du Pont Kentec Facility

CH2M HILL

2398fc13.dgn 28-Mar-1991



NOTE: BASE MAP COMPILED FROM AERIAL PHOTOGRAPHY FLOWN ON 2/10/89.

Figure B-3
DRAINFIELD SOIL SAMPLING LOCATIONS
Du Pont Kentec Facility

Table B-1
SUMMARY OF SAMPLES COLLECTED

Biomonitoring, Sediment, and Surface Water Sampling	November 13-14, 1989
Groundwater Sampling of all Monitoring Wells except MW2 and MW10B	February 5-14, 1990
Groundwater Sampling (MWs 9, 10A, 11, 16, 4B, 7B, 10B, 14B, and PW1) Surface Water Sampling in Beaver Dam Branch (SWs 22, 23, 28, and 29)	July 30 - August 31, 1990
Sample PW1	October 11, 1990
Groundwater Samples at PW1, RW2, RW3, RW4 Surface Water Sampling in Neuse River (SWs 30-32) and Braxton Pond (SW33)	November 11-14, 1990

WDCR478/077.51

Table B-2
CONSTITUENTS ANALYZED AND DETECTION LIMITS

Volatile Organic Compounds	Method Detection Limit Water (µg/l)
Acetone	10
Benzene	5
Bromodichloromethane	5
Bromoform	5
Bromomethane	10
2-Butanone	10
Carbon Disulfide	5
Carbon Tetrachloride	5
Chlorobenzene	5
Chloroethane	10
2-Chloroethylvinylether	10
Chloroform	5
Chloromethane	10
cis-1,3-Dichloropropene	5
Dibromochloromethane	5
1,1-Dichloroethane	5
1,1-Dichloroethylene	5
1,2-Dichloroethane	5
1,2-Dichloroethylene (total)	5
1,2-Dichloropropane	5
1,2-Dichlorobenzene	5
1,3-Dichlorobenzene	5
1,4-Dichlorobenzene	5
1,4-Dioxane	50
Ethylbenzene	5
2-Hexanone	10
4-Methyl-2-Pentanone	10
Methylene Chloride	5
Styrene	5
1,1,2,2-Tetrachloroethane	5
Tetrachloroethylene	5
Toluene	5
trans-1,3-Dichloropropene	5
1,1,1-Trichloroethane	5
1,1,2-Trichloroethane	5
Trichloroethene	5
Trichlorofluoromethane	5
Vinyl Acetate	10
Vinyl Chloride	10
Xylenes (total)	5

Table B-2
(Continued)

	Method Detection Limit Water (µg/l)
Acid Extractable Organics	
Benzoic Acid	50
4-Chloro-3-methylphenol	10
2-Chlorophenol	10
2,4-Dichlorophenol	10
4,6-Dinitro-2-methylphenol	50
2,4-Dinitrophenol	50
2,4-Dimethylphenol	10
Dowtherm A	10
2-Methylphenol	10
4-Methylphenol	10
2-Nitrophenol	10
4-Nitrophenol	50
Phenol	10
Pentachlorophenol	50
2,4,5-Trichlorophenol	50
2,4,6-Trichlorophenol	10
Other Organics	
Triethylene Glycol	250
Inorganics	
Iron	100
Manganese	15
Ammonia	60
Nitrate/Nitrite-N	50
Ortho Phosphate-P	50
Total Phosphate-P	30
Total Kjeldahl Nitrogen	100
Total Organic Carbon	1,000

Table B-3
KENTEC CHEMICAL ANALYTICAL PROTOCOL

	VOCs	TOC	Fe, Mn	Triethylene Glycol	Ammonia-N	Nitrate/ Nitrite-N	Total Kjeldahl Nitrogen	Ortho Phosphate-P	Total Phosphate-P	pH, Solids	Fecal & Total Coliform
Monitoring Wells											
MW-1, MW-3 through MW-16	X	X[a]	X[a]	X							
Residential Wells											
RW-1, RW-2 RW-3, RW-4	X X	X[a]	X[a]	X							
Production Well											
PW-1	X			X							
Background Soils											
SS-1, SS-2	X			X							
Drainfield Soils											
DS-1A through DS-5B	X		X	X							
Surface Water											
SW-9, SW-11, SW-16, SW-22, SW-23, SW-25, SW-27	X	X[a]	X[a]	X	X[a]	X[a]	X[a]	X[a]	X[a]		X[a]
SW-20, SW-24	X		X	X							
SW-28, SW-29	X			X							
SW-30, SW-31, SW-32, SW-33	X										
Sediments											
SED-9, SED-11, SED-16, SED-22, SED-23, SED-25, SED-27	X		X	X			X		X	X	
SED-20, SED-24	X		X	X							

[a]Analysis performed only during the first time samples were collected in Phase 3. Additional rounds of sampling did not include this analysis.

Table B-4
PHASE 3 FIELD PARAMETERS FROM GROUNDWATER SAMPLING

Well Number	Date	pH	Eh (mV)	Conductivity (umhos/cm)	Alkalinity (mg/l $CaCO_3$)	Temperature (°C)
Monitoring Wells						
MW-1	Feb. 7, 1990	7.0	-52	333	218	16
MW-3	Feb. 7, 1990	7.2	-110	370	228	14.7
MW-4A	Feb. 6, 1990	8.2	-219	1,700	/	15
MW-4B	Feb. 6, 1990 July 30, 1990	7.5 7.1	-10 49	249 275	159 /	17.5 20.5
MW-5	Feb. 7, 1990	5.8	-31	218	24	15
MW-6	Feb. 7, 1990	6.1	-125	700	/	15
MW-7A	Feb. 7, 1990	6.5	-54	675	/	15.5
MW-7B	Feb. 7, 1990 July 30, 1990	7.9 7.2	-111 56	262 289	/ /	18 22
MW-8	Feb. 7, 1990	6.6	-25	147	48	14
MW-9	Feb. 7, 1990 July 31, 1990	7.3 7.4	55 102	215 165	119 /	16 28
MW-10A	Feb. 6, 1990 July 31, 1990	7.6 8.1	-207 -219	438 510	2[a] /	14.3 27
MW10B	Aug. 30, 1990	8.8	-33	230	/	21
MW-11	Feb. 6, 1990 July 30, 1990	6.4 8.1	-25 -249	465 700	282[a] /	13.5 25
MW-12	Feb. 6, 1990	7.3	-31	290	109	12.5
MW-13	Feb. 6, 1990	7.4	20	272	/	8
MW-14A	Feb. 5, 1990	6.3	-18	160	89	12.3
MW-14B	Feb. 5, 1990 July 30, 1990	7.8 7.3	-42 12	245 280	216 /	17.0 18.5
MW-15	Feb. 5, 1990	6.5	-55	205	181	12.5
MW-16	Feb. 5, 1990 July 31, 1990	6.4 6.4	97 81	85 120	12 /	14 23
Residential Wells						
RW-1 (Corbett)	Feb. 7, 1990	7.5	-119	260	/	.17
RW-2 (Wade)	Feb. 14, 1990	7.7	/	250	/	17.5
Production Well						
PW-1	Aug. 31, 1990 Oct. 11, 1990 Nov. 14, 1990	7.3 7.4 7.2	/ / /	265 260 266	/ / /	21 19 18.7

[a]Alkalinity measured in the laboratory.
"/" = Sample not taken or analysis not performed.
Eh value is an uncorrected field measurement.

Table B-5
FIELD PARAMETERS FROM SURFACE WATER SAMPLING

Location	Date	pH	Conductivity (umhos/cm)	Dissolved Oxygen (mg/l)	Temperature (°C)
SW-9	Nov 14, 1989	6.5	355	5.6	20.8
SW-11	Nov 14, 1989	6.5	345	3.4	22.1
SW-16	Nov 14, 1989	6.1	291	0.4	15.1
SW-20	Nov 14, 1989	/	/	/	/
SW-22	Nov 14, 1989	6.6	133	3.3	15.8
SW-22	Aug 1, 1990	6.4	192	2.4	23
SW-23	Nov 14, 1989	6.5	130	3.6	15.7
SW-23	Aug 1, 1990	5.9	202	2.8	24
SW-24	Nov 14, 1989	/	/	/	/
SW-25	Nov 14, 1989	6.5	355	2.3	22.8
SW-27	Nov 14, 1989	6.6	315	1.5	17.5
SW-28	Aug 1, 1990	6.5	200	2.4	23
SW-29	Aug 1, 1990	6.3	185	2.5	23

/ = Sample not taken or analysis not performed.

Appendix C
IN SITU HYDRAULIC CONDUCTIVITY TESTING

Appendix C
IN SITU HYDRAULIC CONDUCTIVITY TESTING

From December 6, 1989 through February 1, 1990, in situ hydraulic conductivity was measured in 5 shallow wells and 3 deep wells at the Du Pont Kentec plant. Data from these tests provide an estimate of the ability of the formation in the vicinity of the well to transmit water in a horizontal direction.

Three different methods were used to measure in situ hydraulic conductivity. In theory, each method involves the instantaneous introduction or withdrawal of water to or from the borehole. In each case, the water level is recorded continuously from the time the instantaneous change is made until the water level has recovered to near its natural static level. The rate at which the water level recovery occurs is used to estimate the hydraulic conductivity in the immediate vicinity of the well. The 2 methods used to measure hydraulic conductivity were:

1. The slug test/falling head method in which 1 gallon of deionized water was poured down the well as rapidly as possible, followed by a falling water-level recovery. This method was used in wells where the water level was from 0 to 3 feet above the top of the screen.

2. The gas displacement/rising head method in which the water level is lowered 3 feet using compressed gas and allowed to stabilize, followed by a release of pressure and a rising water-level recovery. This method was used in wells with a water level greater than 3 feet above the top of the screen.

The water level recovery was recorded using 5-psi Druck pressure transducers and a Campbell 21X micrologger. During the in situ hydraulic conductivity tests, the transducers were in a fixed position in the well before water-level recovery began. Two or more tests were conducted at each well to be sure that at least one representative data set was collected. Tests were performed on the shallow wells MW10, MW13, and MW16 and on the deep wells MW4B, MW7B, and MW14B. The results of these tests are summarized in Table C-1 and presented graphically at the end of this appendix.

The recovery data were analyzed by the method developed by Hvorslev (1951). The method involves fitting a regression line to a semilog plot of normalized hydraulic heads versus time. The normalized hydraulic heads are defined as (H-h)/(H-Ho), where H is the initial head prior to the instantaneous water-level rise or fall, Ho is the head after the instantaneous water-level rise or fall but before recovery begins, and h is the head at specified time during the recovery.

For the 5 shallow wells under unconfined conditions, hydraulic conductivity is given by:

$$K = \frac{R^2}{2L(t_2-t_1)} \ln \frac{L}{R} \ln \frac{s_1}{s_2}, \qquad \text{for } \frac{L}{R} > 8$$

where:

- K = hydraulic conductivity
- R = radius of borehole
- L = screen length
- t_1 = time when recovery equals h_1
- t_2 = time when recovery equals h_2
- s_1 = residual change in water level at time t_1, $(H-h_1)$
- s_2 = residual change in water level at time t_2, $(H-h_2)$

For the deep wells, which were assumed to be screened in the upper fifth of a confined aquifer, hydraulic conductivity is given by:

$$K = \frac{\pi r^2}{C_s R\ (t_2 - t_1)} \ln \frac{S_1}{S_2}$$

where:

π = pi

C_s = a shape factor

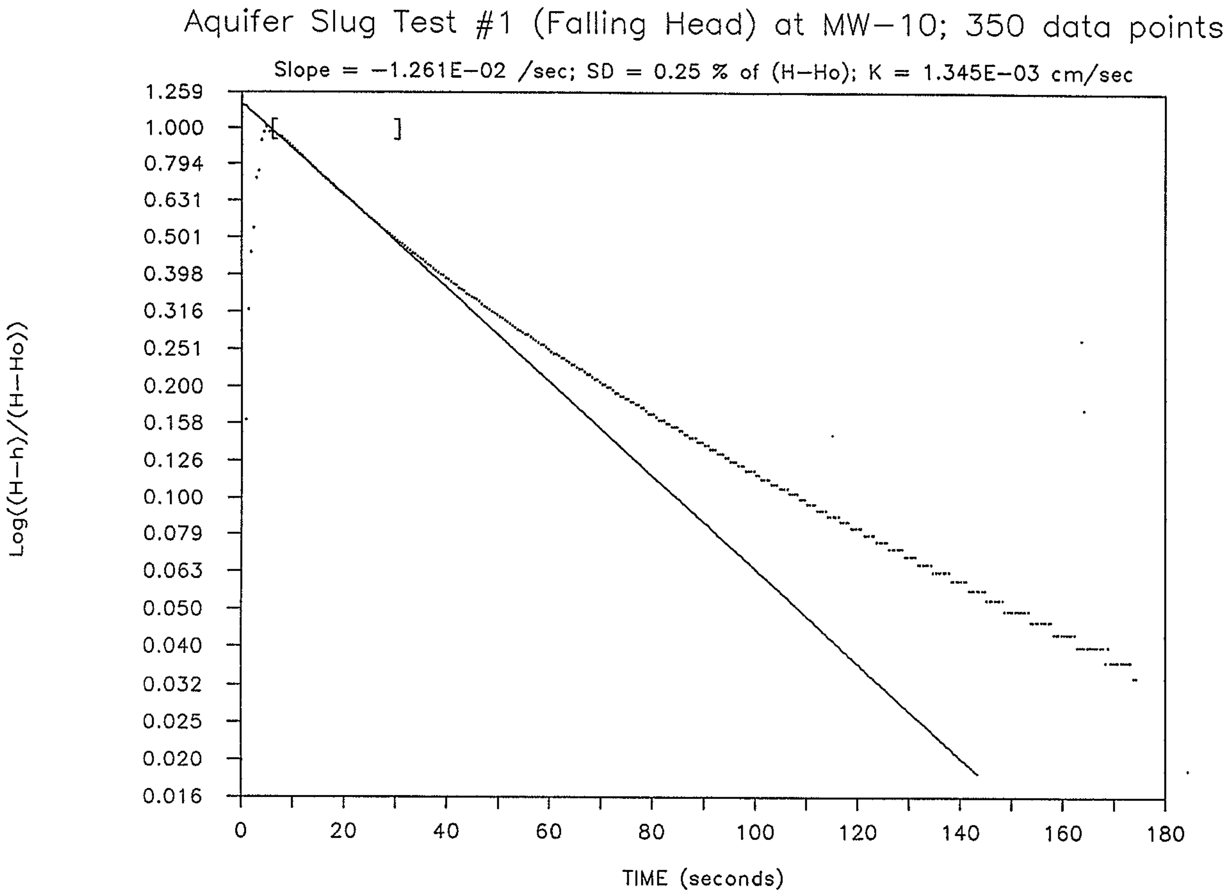
R = radius of borehole

r = radius of screen

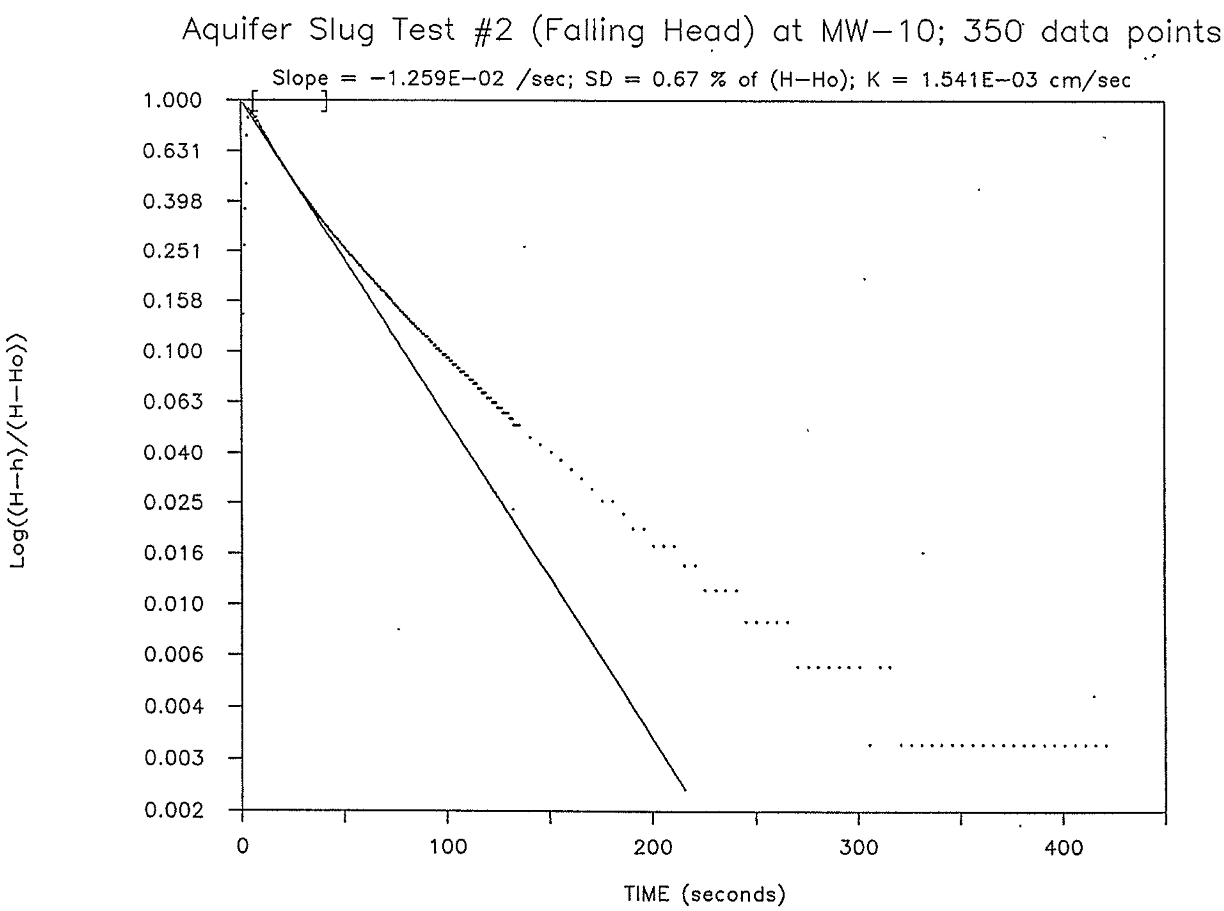
Several assumptions must be satisfied for these two equations to be valid. First, the head in the formation must be constant. Second, flow to the well must follow Darcy's Law. Third, the effects of the sand pack around the well are assumed to be negligible. Fourth, the screen and sand pack must not inhibit flow to the well.

WDCR478/006.51

Table C-1 IN-SITU HYDRAULIC CONDUCTIVITY TEST				
Monitoring Wells	**Type of Test**	**Hydraulic Conductivity (cm/sec)**		
		Test 1	**Test 2**	**Arithmetic Mean**
Phase 2 Tests				
MW3	Bail test/rising head	8×10^{-4}	9×10^{-4}	8×10^{-4}
MW4	Bail test/rising head	1×10^{-3}	1×10^{-3}	1×10^{-3}
MW5	Bail test/rising head	3×10^{-3}	3×10^{-3}	3×10^{-3}
MW7	Bail test/rising head	7×10^{-3}	6×10^{-3}	6×10^{-3}
MW8	Bail test/rising head	4×10^{-2}	3×10^{-2}	4×10^{-2}
Phase 3 Tests				
Shallow				
MW10	Slug test/falling head	1×10^{-3}	2×10^{-3}	1×10^{-3}
MW13	Slug test/falling head	4×10^{-5}	5×10^{-5}	5×10^{-5}
MW16	Slug test/falling head	1×10^{-3}	1×10^{-3}	1×10^{-3}
Deep				
MW4B	Gas displacement/rising head	1×10^{-2}	1×10^{-2}	1×10^{-2}
MW7B	Gas displacement/rising head	3×10^{-2}	3×10^{-2}	3×10^{-2}
MW14B	Gas displacement/rising head	1×10^{-3}	1×10^{-3}	1×10^{-3}

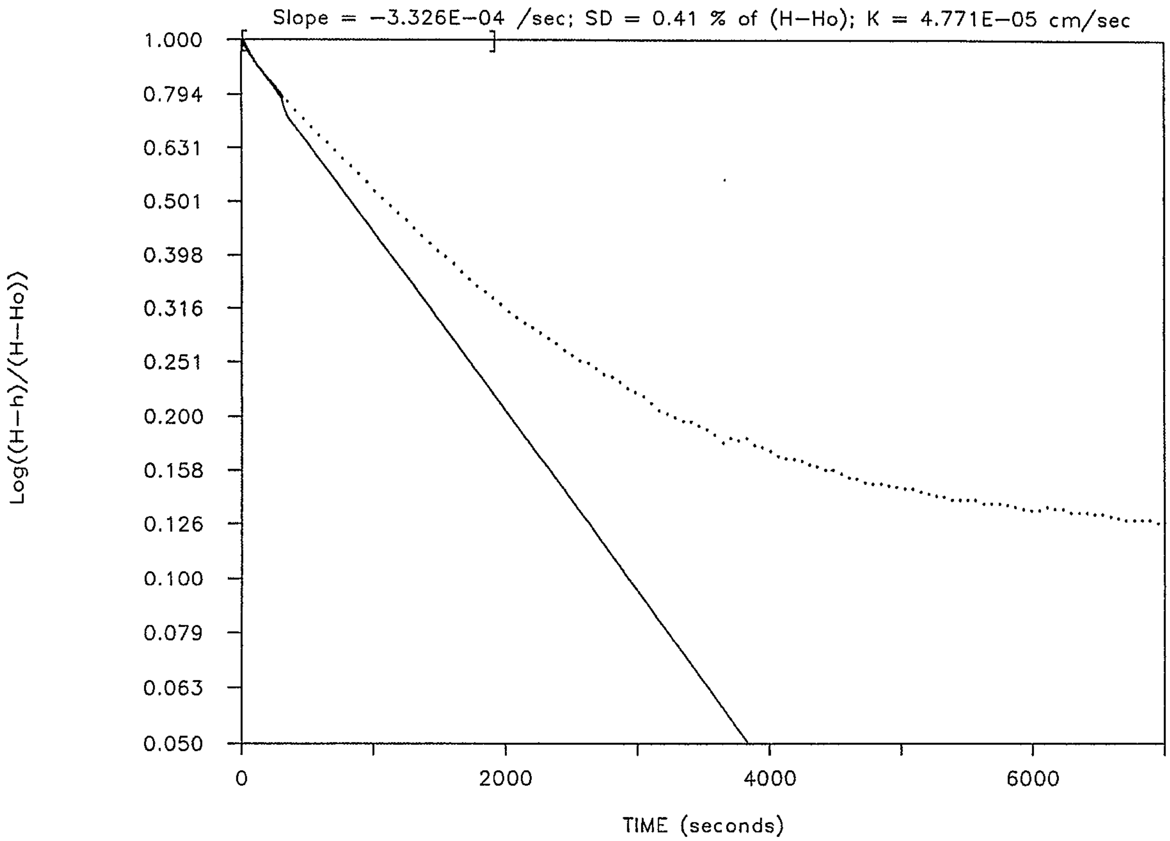


Aquifer Slug Test #1 (Falling Head) at MW-10; 350 data points
Slope = -1.261E-02 /sec; SD = 0.25 % of (H-Ho); K = 1.345E-03 cm/sec
Log((H-h)/(H-Ho))
1.259
1.000
0.794
0.631
0.501
0.398
0.316
0.251
0.200
0.158
0.126
0.100
0.079
0.063
0.050
0.040
0.032
0.025
0.020
0.016
0
20
40
60
80
100
120
140
160
180
TIME (seconds)

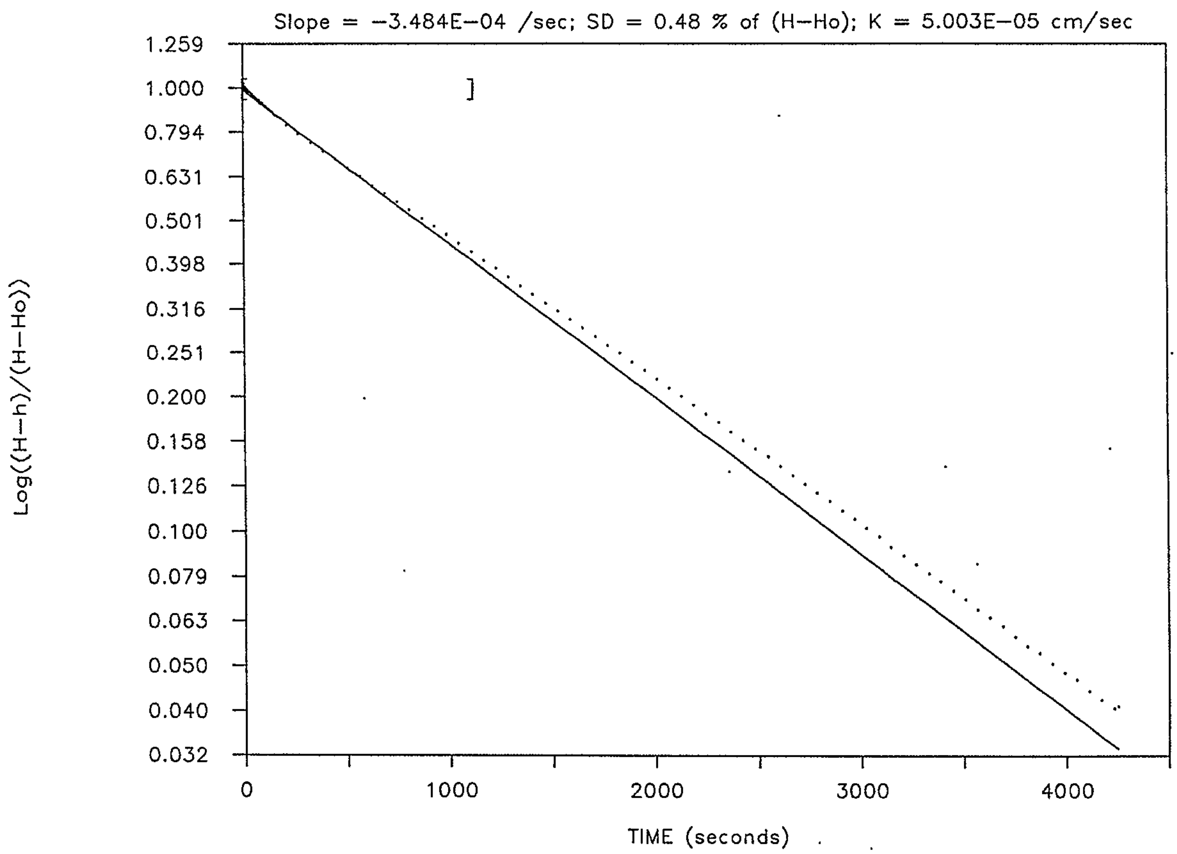


Aquifer Slug Test #2 (Falling Head) at MW-10; 350 data points
Slope = -1.259E-02 /sec; SD = 0.67 % of (H-Ho); K = 1.541E-03 cm/sec
Log((H-h)/(H-Ho))
1.000
0.631
0.398
0.251
0.158
0.100
0.063
0.040
0.025
0.016
0.010
0.006
0.004
0.003
0.002
0
100
200
300
400
TIME (seconds)

Aquifer Slug Test #1 (Falling Head) at MW-13; 287 data points

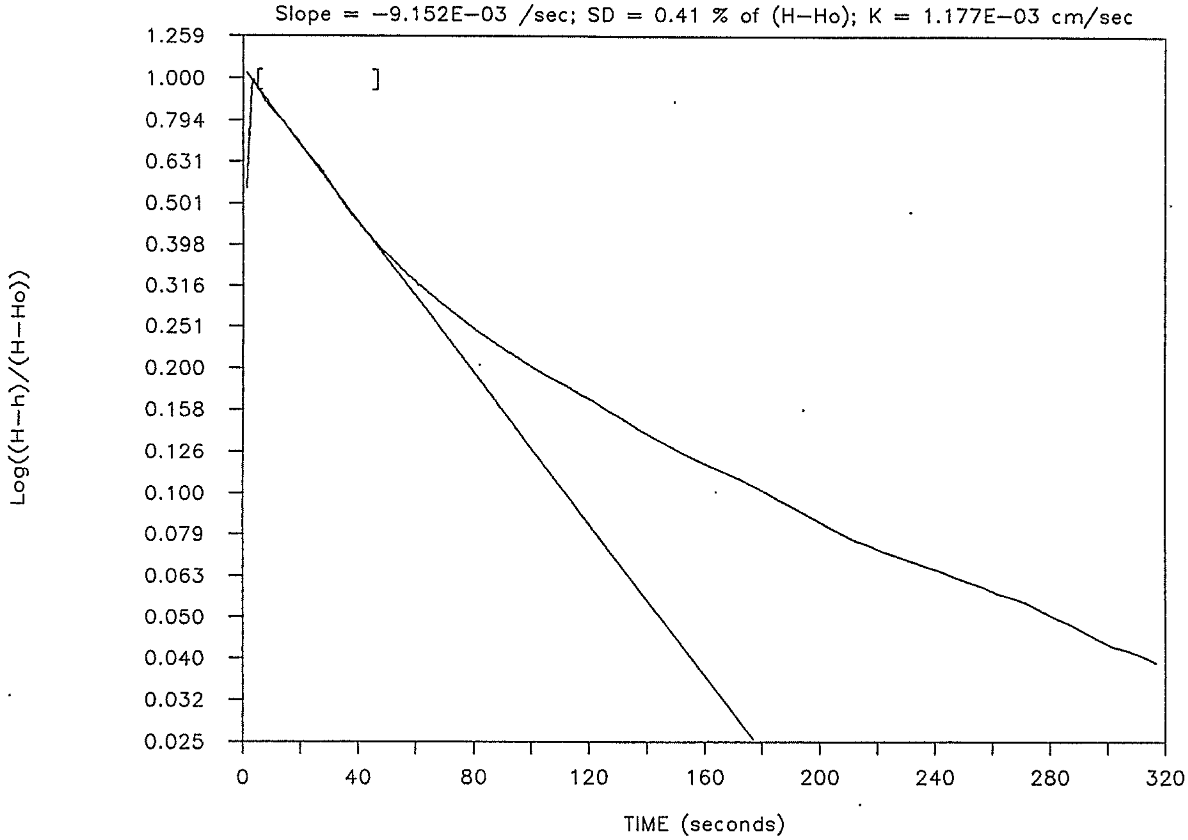


Aquifer Slug Test #2 (Falling Head) at MW-13; 139 data points



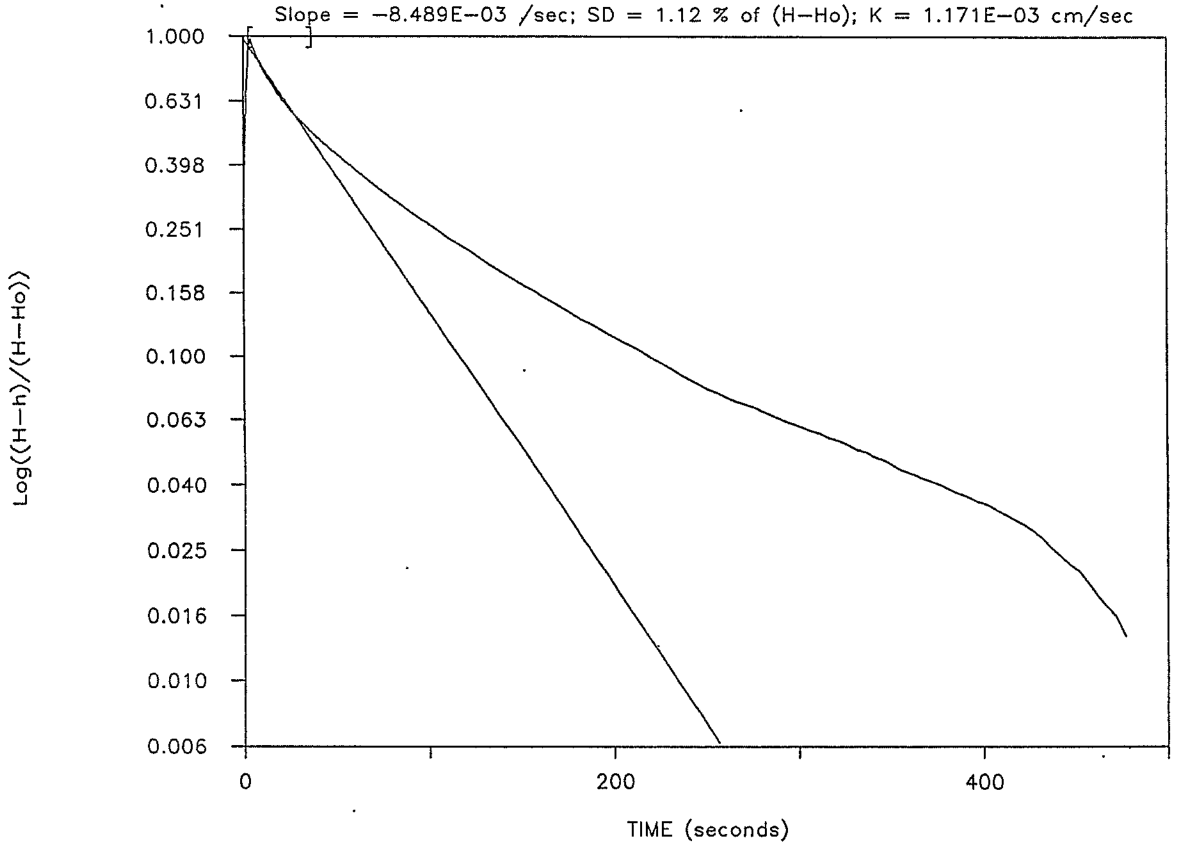
Aquifer Slug Test #1 (Falling Head) at MW-16; 242 data points

Slope = −9.152E−03 /sec; SD = 0.41 % of (H−Ho); K = 1.177E−03 cm/sec

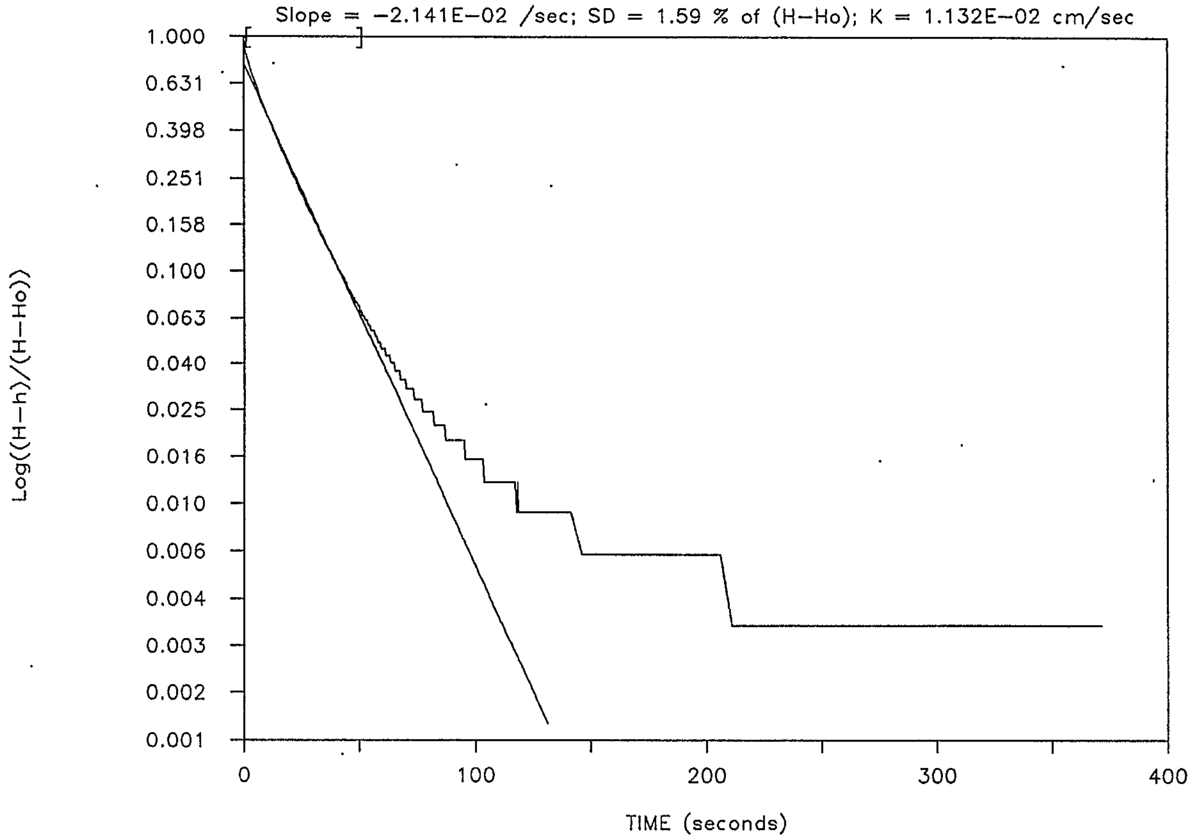


Aquifer Slug Test #2 (Falling Head) at MW-16; 281 data points

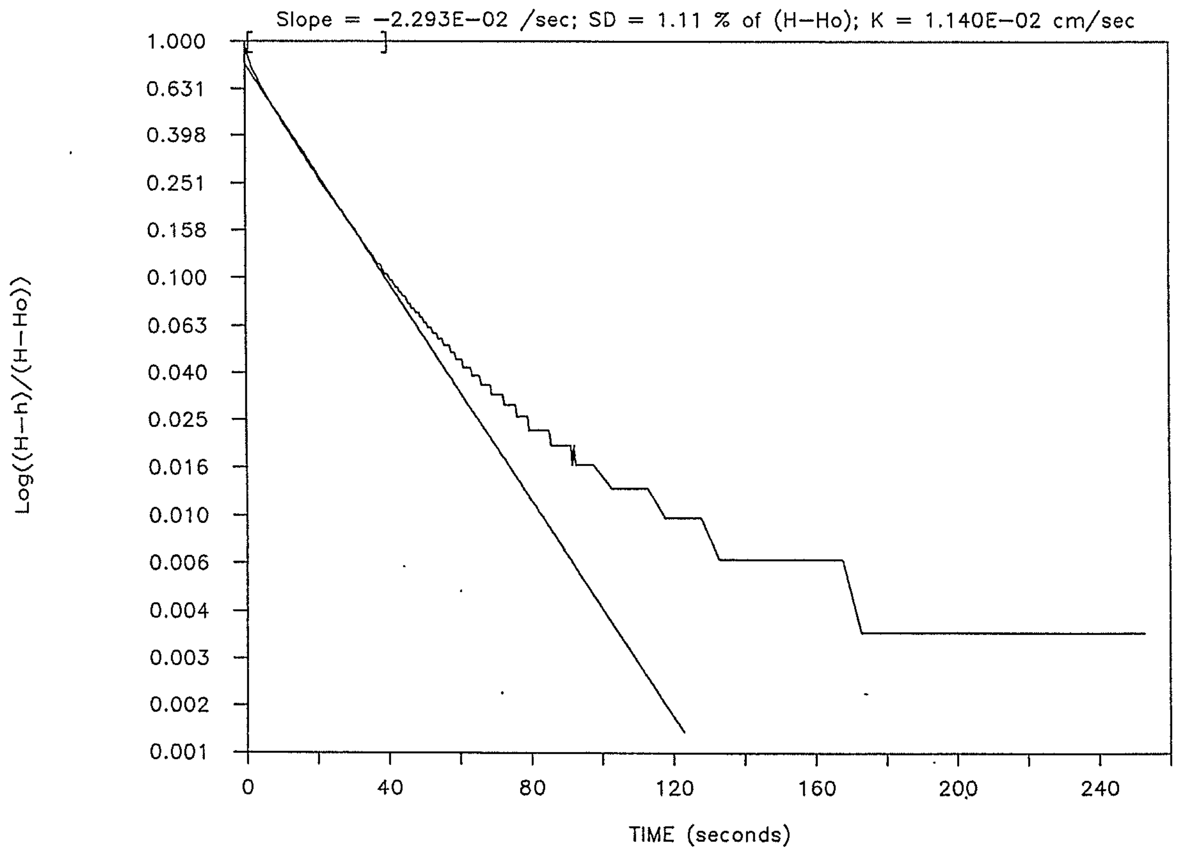
Slope = −8.489E−03 /sec; SD = 1.12 % of (H−Ho); K = 1.171E−03 cm/sec

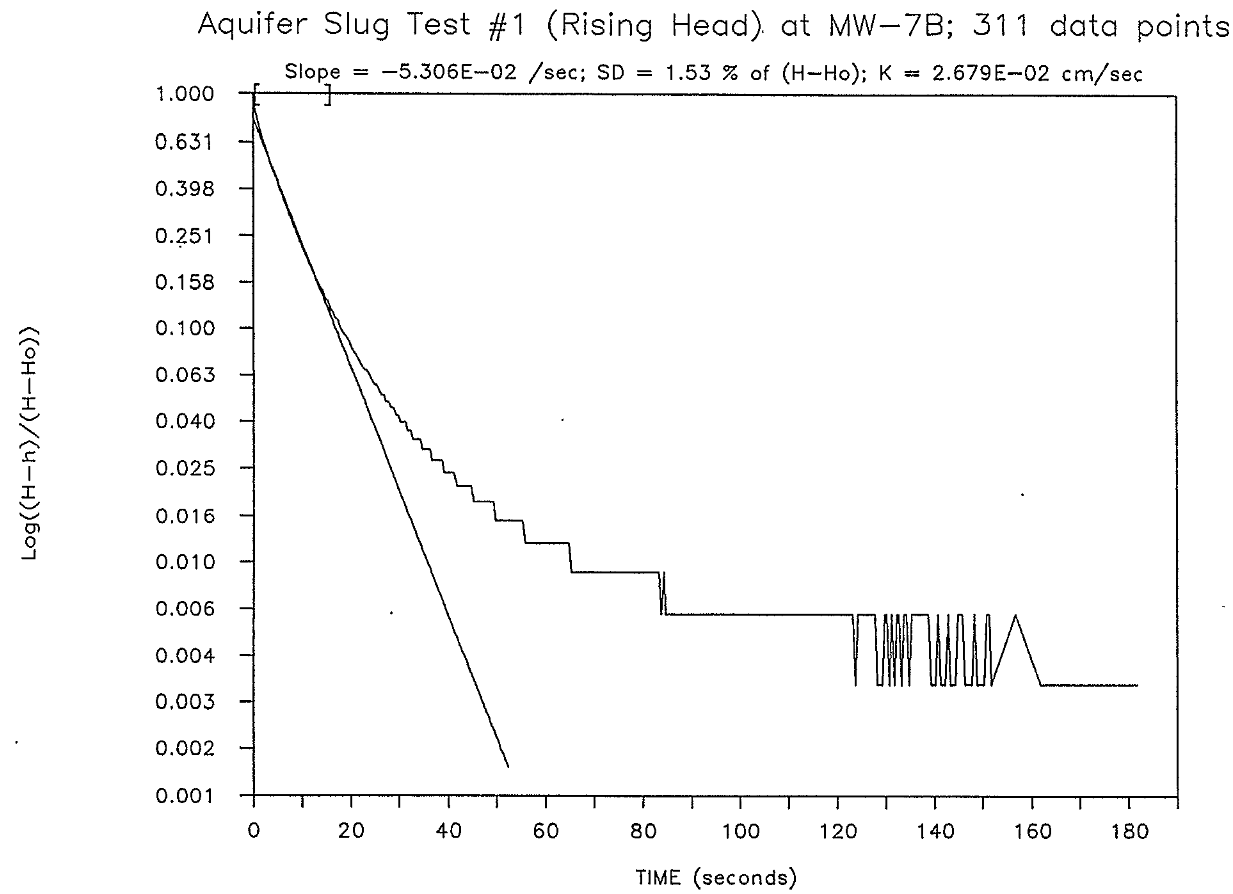


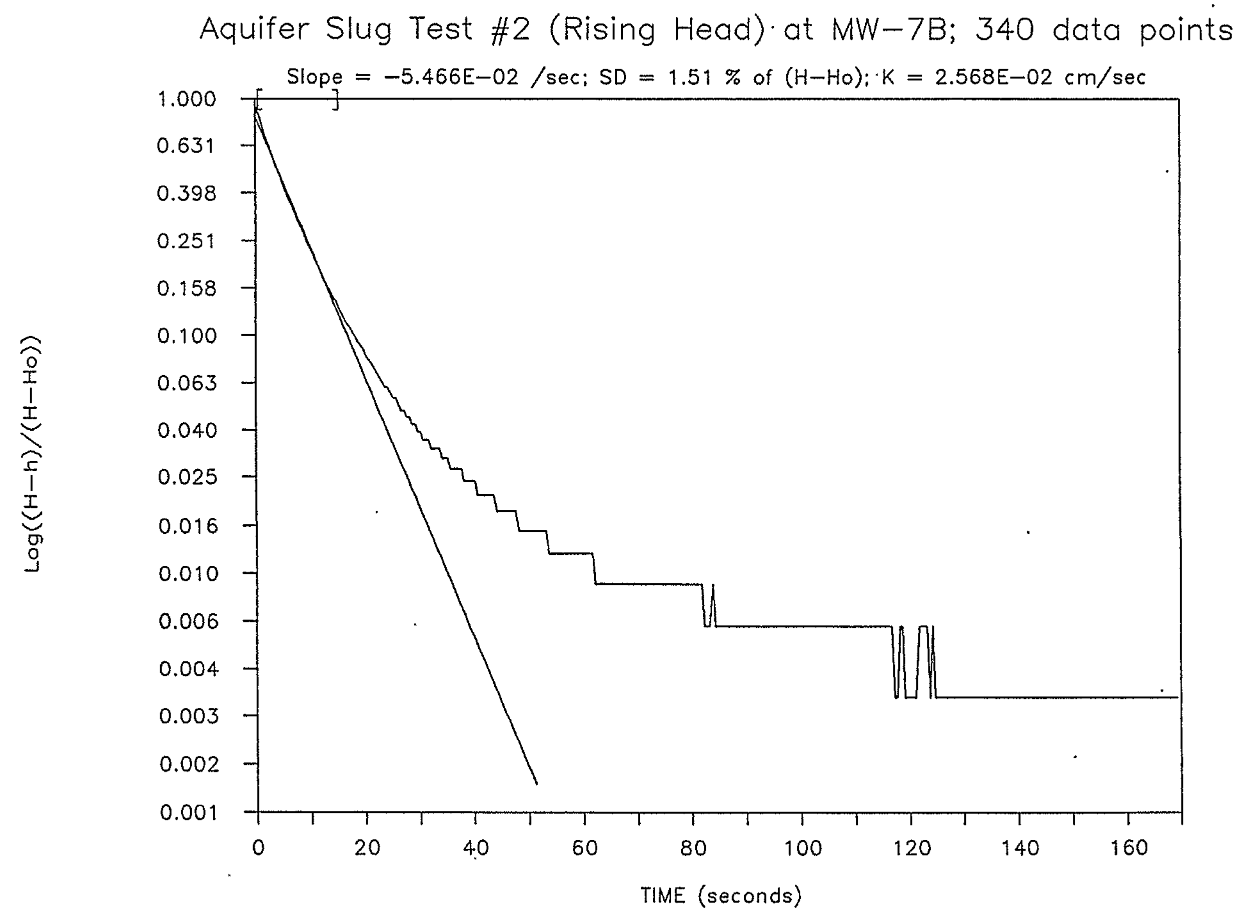
Aquifer Slug Test #1 (Rising Head) at MW-4B; 303 data points

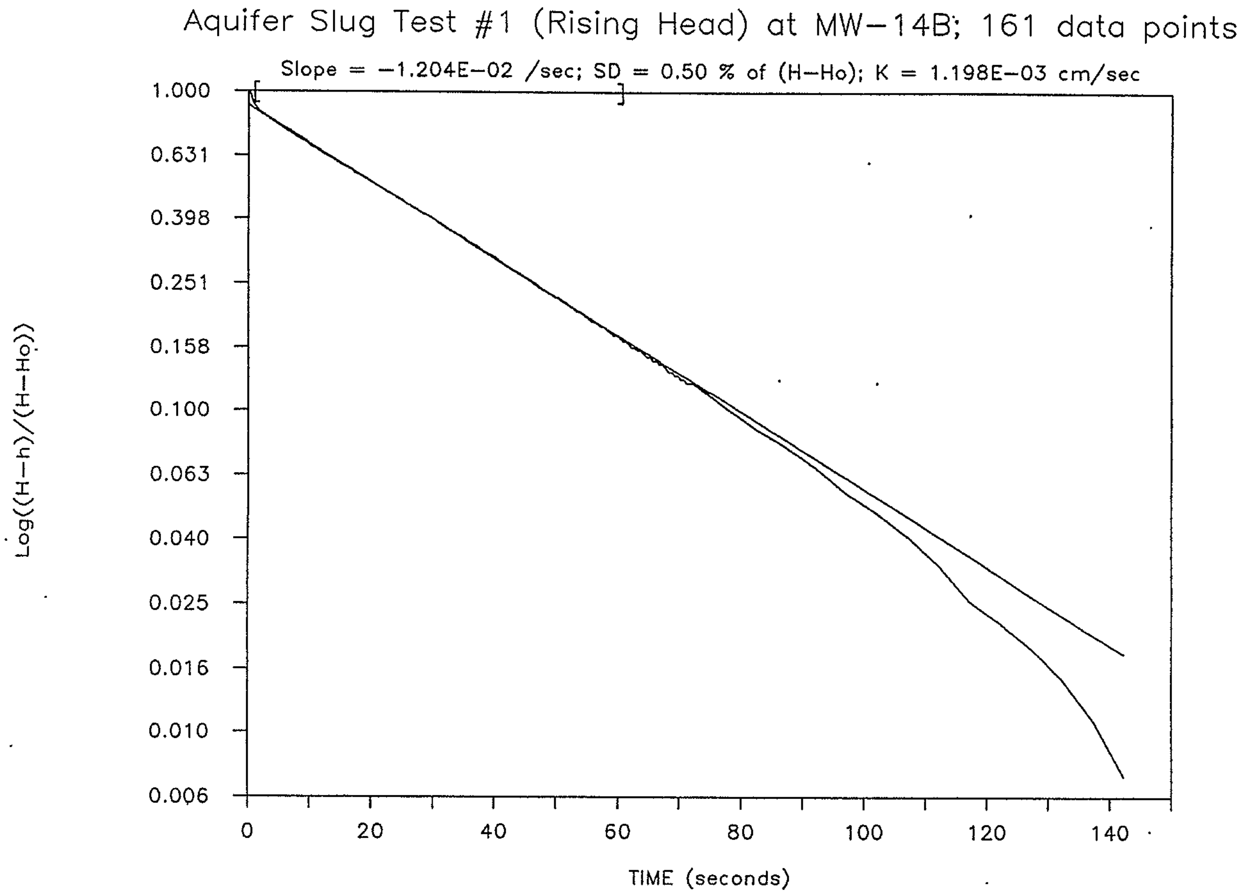


Aquifer Slug Test #2 (Rising Head) at MW-4B; 219 data points

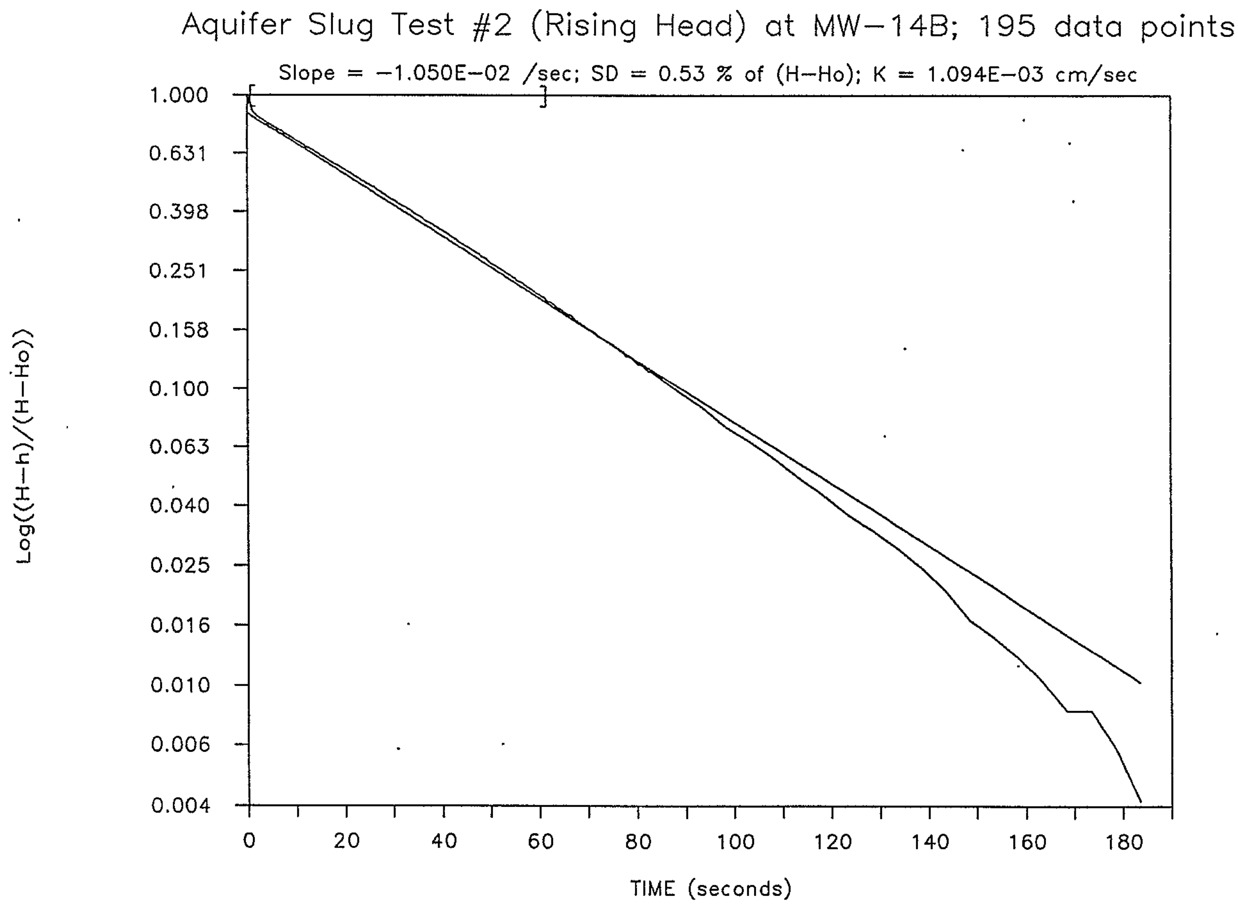



Aquifer Slug Test #1 (Rising Head) at MW-7B; 311 data points
Slope = −5.306E−02 /sec; SD = 1.53 % of (H−Ho); K = 2.679E−02 cm/sec
Log((H−h)/(H−Ho))
1.000
0.631
0.398
0.251
0.158
0.100
0.063
0.040
0.025
0.016
0.010
0.006
0.004
0.003
0.002
0.001
0
20
40
60
80
100
120
140
160
180
TIME (seconds)


Aquifer Slug Test #2 (Rising Head) at MW-7B; 340 data points
Slope = −5.466E−02 /sec; SD = 1.51 % of (H−Ho); K = 2.568E−02 cm/sec
Log((H−h)/(H−Ho))
1.000
0.631
0.398
0.251
0.158
0.100
0.063
0.040
0.025
0.016
0.010
0.006
0.004
0.003
0.002
0.001
0
20
40
60
80
100
120
140
160
TIME (seconds)



Aquifer Slug Test #1 (Rising Head) at MW-14B; 161 data points
Slope = -1.204E-02 /sec; SD = 0.50 % of (H-Ho); K = 1.198E-03 cm/sec
Log((H-h)/(H-Ho))
1.000
0.631
0.398
0.251
0.158
0.100
0.063
0.040
0.025
0.016
0.010
0.006
0
20
40
60
80
100
120
140
TIME (seconds)



Aquifer Slug Test #2 (Rising Head) at MW-14B; 195 data points
Slope = -1.050E-02 /sec; SD = 0.53 % of (H-Ho); K = 1.094E-03 cm/sec
Log((H-h)/(H-Ho))
1.000
0.631
0.398
0.251
0.158
0.100
0.063
0.040
0.025
0.016
0.010
0.006
0.004
0
20
40
60
80
100
120
140
160
180
TIME (seconds)

Appendix D
SUMMARY OF
WATER QUALITY ANALYSES

PHASE 3
SAMPLING

Table D-1
ORGANIC CHEMICAL ANALYSES[a]
KENTEC GROUNDWATER SAMPLES (FEBRUARY 1990)
(ug/l)

	Acetone	Methyl Ethyl Ketone	Carbon Disulfide	Chloroethane	1,4-Dichlorobenzene	1,1-Dichloroethane	1,1-Dichloroethylene	1,4-Dioxane	Toluene	Triethylene Glycol	Vinyl Chloride	Total Organic Carbon (mg/l)
Detection Limit	10	10	5	10	5	5	5	50	5	250	10	1
Monitoring Wells												
MW1	-	-	-	120	-	4 J	11	1,200	-	810	-	70.1
MW3	-	-	-	80	-	73	13	1,100	-	-	-	26.8
MW4A	32	11	20	150	-	800	82	2,300	-	-	6 J	35.2
MW4B	5 J	-	-	-	-	-	-	-	-	-	-	6.3
MW5	-	-	-	-	-	-	-	-	-	-	-	59.1
MW5 DUP	-	-	-	-	-	-	-	-	-	-	-	68.5
MW6	11	-	20	95	-	16	15	22,000	3 J	-	-	69.1
MW7A	7 J	-	-	100	4 J	10	12	5,700	-	-	-	75.0
MW7B	6 J	-	-	-	-	-	-	-	-	-	-	44.6
MW8	-	-	4 J	12	-	3 J	-	360	-	-	-	15
MW9	5 J	-	-	-	-	-	-	49 J	-	-	-	41.0
MW10	9 J	7 J	-	43	-	290	34	430	-	-	-	72.2
MW11	13	9 J	-	190	-	230	75	550	-	-	-	94.9
MW12	-	-	-	-	-	-	-	-	-	-	-	6.2
MW13	-	-	-	-	-	-	-	-	-	-	-	29.0
MW14A	-	-	-	-	-	-	-	1,600	-	772	-	51.6
MW14B	-	-	-	-	-	-	-	-	-	1,900	-	29.7
MW15	7 J	-	-	74	-	13	27	410	-	-	-	21.7
MW16	5 J	-		-	-	-	14	160	-	-	-	2.3
Residential Wells												
RW-1	-	-	-	-	-	-	-	-	-	-	-	5.3
RW-2	6 BJ	-	-	-	-	-	-	-	-	-	-	52.0
Equipment Blank												
EQ-2 (after MW7A)	-	-	-	-	-	-	-	69	-	-	-	40.0

Notes:

[a]Compounds in this group not listed in this table were below detection limits in all samples. See Table B-1 for a list of organic compounds analyzed in this group and their detection limits.
"-" = Undetected, below method detection limit.
"B" = Compound was detected in associated laboratory blank.
"J" = Estimated value. Measured value is less than quantitative detection limit.

Table D-2
ORGANIC CHEMICAL ANALYSIS[a]
KENTEC QUALITY CONTROL DATA (FEBRUARY 1990)
(μg/l)

	Acetone	Methylene Chloride	TEG	1,4-Dioxane
KTB-1 (11/13/89)	8 BJ	3 BJ	<250	<50
KTB-2 (11/14/89)	2 BJ	7 BJ	<250	<50
KTB-3 (11/14/89)	/	/	7,900	/
TB-1A (2/6/90)	9 J	<10	<250	<50
TB-2A (2/7/90)	10	<10	<250	<50
EQ-2 (after MW7A)	<10	<10	<250	69

Notes:

[a]Compounds in this group not listed in this table were below detection limits in all samples. See Table B-1 for a list of organic compounds analyzed and their detection limits.

"B" = Compound was detected in associated laboratory blank.
"J" = Estimated value. Measured value is less than quantitative detection limit.
"/ " = Sample not taken or analysis not performed.
<10 = Below method detection limit shown.

Table D-3
INORGANIC CHEMICAL ANALYSES
KENTEC GROUNDWATER SAMPLES (FEBRUARY 1990)
(mg/l)

	Iron	Manganese
Monitoring Wells		
MW1	7.490	0.550
MW3	9.710	0.180
MW4A	3.990	0.402
MW4B	0.550	<0.015
MW5	3.755	2.910
MW5 DUP	3.770	2.880
MW6	29.0	0.585
MW7A	39.3	0.400
MW7B	<0.1	<0.015
MW8	12.7	0.470
MW9	1.375	0.193
MW10A	/	/
MW11	/	/
MW12	0.400	0.052
MW13	0.230	0.081
MW14A	7.2	0.150
MW14B	<0.1	<0.015
MW15	20.8	0.621
MW16	0.185	0.168
Residential Well		
RW-1	0.400	<0.015
RW-2	/	/
Equipment Blank		
EQ-2 (after MW7A)	0.470	<0.015

Notes:

<5 = Below method detection limit shown.
"/ " = Sample not taken or analysis not performed

Table D-4
ORGANIC CHEMICAL ANALYSES[a]
KENTEC SEDIMENT SAMPLES (NOVEMBER 1989)
(µg/kg)

	Dilution Factor	Acetone	Carbon Disulfide	1,4-Dioxane	Ethylbenzene	Methylene Chloride	Toluene	Triethylene Glycol	Xylene (Total)
KSED9	1	-	1 J	1,000	-	98 B	-	-	2 J
KSED11	1	-	13	210	-	95 B	-	-	-
KSED16	1	-	-	1,800	-	13 B	-	-	-
KSED20	5	170 B	32 J	18,000	-	89 B	8 J	760	-
KSED23	1	64 B	24	1,500	-	30 B	-	-	-
KSED24	1.2	20 B	-	1,000	-	57 B	-	270	-
KSED25	2.5	45 B	22	2,400	-	67 B	-	390	-
KSED25(DUP)	1.6	21.							
KSED27	1	-	2 J	-	4 J	150 B	-	-	-

Notes:

[a]Compounds in this group not listed in this table were below detection limits in all samples. See Table B-1 for a list of organic compounds analyzed in this group and their detection limits in water.
All surface water data are in µg/l (ppb) and all sediment data are in ug/kg unless otherwise indicated.
"-" = Not detected, below method detection limit.
"B" = Compound was detected in associated laboratory blank.
"J" = Estimated value. Measured value was less than quantitation detection limit.

Table D-5
ORGANIC CHEMICAL ANALYSES[a]
KENTEC SOIL SAMPLES (NOVEMBER 1989)
(μg/kg)

	Acetone	1,4-Di-chlorobenzene	Methylene Chloride	Triethylene Glycol
Drainfield Soils				
DS1-A	10 BJ	-	21 B	-
DS1-B	21 B	-	38 B	400
DS2-A	10 BJ	-	13 B	-
DS2-A(DUP)	7 BJ	-	13 B	-
DS2-B	14 B	-	32 B	-
DS3-A	14 B	-	12 B	330
DS3-B	9 BJ	-	25 B	-
DS4-A	10 BJ	-	19 B	-
DS4-B	12 B	-	14 B	-
DS5-A	11 BU	1 J	20 B	-
DS5-B	13 B	-	26 B	-
Background Soils				
SS1	-	-	24 B	330
SS2	-	-	110 B	2,200

Notes:

[a]Compounds in this group not listed in this table were below detection limits in all samples. See Table B-1 for a list of organic compounds analyzed in this group and their detection limits in water.
"-" = Not detected, below method detection limit.
"B" = Compound was detected in associated laboratory blank.
"J" = Estimated value. Measured value was less than quantitation detection limit.

Table D-6
ORGANIC CHEMICAL ANALYSES[a]
KENTEC SURFACE WATER SAMPLES (NOVEMBER 1989)
(μg/l)

	Dilution Factor	Acetone	Carbon Disulfide	Chloroethane	1,1-Di-chloroethane	1,4-Dioxane	Methylene Chloride	Toluene	Tri-chloroethylene	Triethylene Glycol	Xylene (Total)
KSW9	1	-	1 J	14	-	1,100	9 B	-	-	2,400	2 J
KSW11	1	11 B	27	34	2 J	1,600	10 B	-	-	2,600	-
KSW16	5	40 BJ	11 J	-	-	4,700	37 B	18 J	5 J	1,100	-
KSW20	25	860 B	60 J	-	-	44,000	90 BJ	-	-	53,000	-
KSW22	1	-	14	-	-	-	5 B	-	-	4,100	-
KSW23	1	-	10	-	-	58	5 B	-	-	4,900	-
KSW24	5	54 B	130	-	-	6,700	30 B	9 J	-	510	-
KSW25	5	54 B	22 J	-	-	6,200	42 B	5 J	-	1,900	-
KSW25(DUP)	5	110 B	39	-	-	6,500	18 BJ	2 J	-	5,000	-
KSW27	1	13 B	16	-	-	490	13 B	3 J	-	-	-
PS1	1	10	28	-	-	-	-	-	-	-	-

Notes:

[a]Compounds in this group not listed in this table were below detection Limits in all samples. See Table B-1 for a list of organic compounds analyzed in this group and their detection limits in water. All surface water data are in μg/l (ppb) and all sediment data are in ug/kg unless otherwise indicated.
"-" = Not detected, below method detection limit
"B" = Compound was detected in associated laboratory blank.
"J" = Estimated value. Measured value was less than quantitation limit.

Table D-7
INORGANIC CHEMICAL ANALYSES
KENTEC SEDIMENT SAMPLES (NOVEMBER 1989)
(mg/kg)

	Iron	Manganese	Total Phosphate-P	Total Kjeldahl Nitrogen	pH Solid
KSED9	1,692	12.9	74	310	7.4
KSED11	6,336	33.0	301	600	6.7
KSED16	4,493	41.7	407	1,260	6.5
KSED20	946	5.2	/	/	/
KSED22	2,118	15.4	102	520	6.7
KSED23	5,471	37.1	474	1,200	6.6
KSED24	1,008	13.5	/	/	/
KSED25	2,465	9.2	81	575	6.6
KSED25(DUP)	1,050	4.4	112	420	6.9
KSED27	4,394	7.1	159	435	7.4

Notes:

All surface water data in mg/l and all sediment data in mg/kg unless otherwise indicated.
"/" = Sample not taken or analyses not performed.

Table D-8
INORGANIC CHEMICAL ANALYSES
KENTEC DRAINFIELD SOIL SAMPLES
(NOVEMBER 1989)
(mg/kg)

	Iron	Manganese
DS1-A	2,546	52.8
DS1-B	639	2.1
DS2-A	2,503	15.1
DS2-A(DUP)	2,605	16.9
DS2-B	1,132	3.5
DS3-A	1,924	16.8
DS3-B	3,646	15.5
DS4-A	3,800	13.6
DS4-B	1,983	7.6
DS5-A	2,357	36.8
DS5-B	1,342	7.7

Notes:

"/" = Sample not taken or analysis not performed.

Table D-9
INORGANIC AND OTHER CHEMICAL ANALYSES
KENTEC SURFACE WATER SAMPLES (NOVEMBER 1989)
(mg/l)

	Iron	Manganese	Ammonia-N	Nitrate/ Nitrite-N	Ortho Phosphate-P	Total Phosphate-P	Total Kjeldahl Nitrogen	Total Organic Carbon	Total[a] Coliform	Fecal[a] Coliform
KSW9	5.444	0.193	0.94	<0.05	0.06	0.32	2.45	38.2	1,600	2
KSW11	6.060	0.222	2.40	0.07	0.08	0.95	4.46	28.8	1,600	4
KSW16	17.0	0.491	<0.15	<0.05	0.16	0.75	1.88	51.2	≥2,400	1,600
KSW20	106.0	1.606	/	/	/	/	/	/	/	/
KSW22	0.882	0.031	<0.15	<0.84	0.06	0.13	0.25	6.9	≥2,400	350
KSW23	0.892	0.027	<0.15	0.85	0.07	0.11	0.29	7.7	≥2,400	90
KSW24	13.1	0.462	/	/	/	/	/	/	/	/
KSW25	8.405	0.329	1.70	<0.05	<0.05	0.26	3.17	87.1	≥2,400	1,600
KSW25(DUP)	14.2	0.336	1.62	<0.05	<0.05	0.32	3.19	88.8	900	8
KSW27	5.190	0.398	0.92	0.05	<0.05	0.23	2.17	36.9	300	110
PS-1	0.560	<0.015	/	/	/	/	/	10.1	/	/

Notes:

[a] Units are number of coliform per 100 ml.
All surface water data in mg/l and all sediment data in mg/kg unless otherwise indicated.
"/" = Sample not taken or analysis not performed.

PHASES 1 AND 2
SAMPLING

Appendix E
BIOMONITORING TECHNICAL MEMORANDUM

PHASES 1 AND 2
SAMPLING

Table 5
ORGANIC CHEMICAL ANALYSES
GROUNDWATER
PHASES 1 AND 2

Analysis Well No./ Date/	MW1		MW2		MW3		MW4		MW5		MW6		MW7		MW8	
	5/87	6/88	5/87	6/88	5/87	6/88	5/87	6/88	5/87	6/88	5/87	6/88	5/87	6/88	5/87	6/88
TOC (ppm)	110	24.9	75	-	65	55.6	83	313	26	19	600/609	100	-	31.9	-	10.7
COD (ppm)	194	61	154	-	169	139	206	660	52	35	1,570/1,790	464	-	96	-	27
TEG (ppm)	<10	<5	<10	-	<10	<5	<10	<5	<10	<5	<10/<10	<5	-	<5	-	<5
Acetic Acid (ppm)	<2	-	<2	-	<2	-	<2	-	3	-	7/3	-	-	-	-	-
Buteric Acid (ppm)	<2	-	<2	-	<2	-	<2	-	<2	-	<2/3	-	-	-	-	-
BNAs (ppb)[a]																
4 Methylphenol	-	<10	-	-	-	<10	-	90	-	<10	-	<10	-	<10	-	<10
VOCs (ppb)[a]																
1,4 Dioxane	1,700*	2,000*	1,600*	-	1,000*	5,900*	1,900*	5,400*	300*	230*	16,000*	33,000*	-	11,000*	-	810*
Acetone	35	<10	1,400	-	900	<50	3,000	60	140	<10	1,300	22	-	<10	-	<10
Chloroethane	<5	<10	<5	-	11	<50	1.5	<50	<5	<10	43	<10	-	<10	-	<10
Toluene	<5	<5	<5	-	<5	<25	1.1	<25	<5	<5	4.3	10	-	<5	-	<5
1,1 Dichoroethene	<5	<5	<5	-	<5	<25	<5	<25	<5	<5	1.7	<5	-	<5	-	<5
1,1 Dichoroethane	<5	5	<5	-	1.6	280	<5	900	<5	<5	11	<5	-	9	-	<5
2-Butanone	<10	<10	<10	-	<10	58	<10	140	<10	<10	130	<10	-	<10	-	<10
Benzene	<5	<5	<5	-	<5	<25	<5	<25	<5	<5	2.1*	<5	-	<5	-	<5
4 Methyl-2 Pentanone	<10	<10	<10	-	<10	<50	<10	<50	<10	<10	2.1	<10	-	<10	-	<10
Trichlorotrifluoromethane	<5	<5	<5	-	<5	<25	<5	<25	<5	<5	<5	<5	-	5	-	<5
1,4 Dichlorobenzene	-	<5	-	-	-	<25	-	<25	-	<5	-	<5	-	7*	-	<5
Carbon Disulfide	<5	<5	<5	-	<5	<25	<5	<25	<5	<5	<5	6	-	<5	-	<5

[a]Compounds in this group that are not shown in this table were below detection limits
<--Below detection limit shown
Dash (-) indicates constituent not analyzed
<2/<2--indicates sample result and a duplicate sample result
BNA--Base/neutral and acid extractable compounds
*Concentration exceeds state or federal standard (see Table 8)

WDR377/015/1

Table 6
INORGANIC CHEMICAL ANALYSES
GROUNDWATER
PHASES 1 AND 2
(Results in ppm)

Analysis Well No./ Date/	MW1 5/87	MW1 6/88	MW2 5/87	MW2 6/88	MW3 5/87	MW3 6/88	MW4 5/87	MW4 6/88	MW5 5/87	MW5 6/88	MW6 5/87	MW6 6/88	MW7 5/87	MW7 6/88	MW8 5/87	MW8 6/88
Antimony	<0.3	-	<0.2	-	<0.2	-	<0.2	-	1.0	-	<0.2/<0.2	-	-	-	-	-
Chromium	<0.025	-	<0.025	-	<0.025	-	<0.025	-	<0.025	-	.025/<0.025	-	-	-	-	-
Cobalt	<0.025	-	<0.025	-	<0.025	-	<0.025	-	<0.025	-	.025/<0.025	-	-	-	-	-
Iron	25*	16.2*	30*	-	63.8*	35.9*	37.5*	20.0*	8.1*	4.17*	57.5/58.8*	48.9*	-	47.3*	-	11.3*
Manganese	0.69*	0.59*	0.9*	-	1.38*	1.11*	8.55*	2.61*	2.55*	6.58*	1.32/1.32*	1.26*	-	0.52*	-	0.47*
Titanium	<0.3	-	<0.3	-	<0.3	-	<0.3	-	<0.3	-	<0.3/<0.3	-	-	-	-	-
Ammonia	2.4	-	1.3	-	0.1	-	31.1	-	18.1	-	<0.05/<0.05	-	-	-	-	-
Chloride	19	-	15	-	9	-	10	-	9	-	26/18	-	-	-	-	-
Nitrate	<0.2	-	<0.2	-	<0.2	-	<0.2	-	<0.2	-	<0.2/<0.2	-	-	-	-	-
Total Phosphorus	0.13	-	0.2	-	0.1	-	0.03	-	0.15	-	0.51/0.77	-	-	-	-	-
Total Dissolved Solids	-	357	-	-	-	579*	-	1,522*	-	341	-	996	-	334	-	177

<--Below detection limit shown
Dash (-) indicates constituent not analyzed
<0.2/<0.2--indicates sample result and a duplicate sample result
*Concentration exceeds a state or federal standard (see Table 8).

Table 7
INORGANIC AND ORGANIC CHEMICAL ANALYSES
SURFACE WATER
(Results in ppm)

Analysis	May 1987			June/July 1988[b]			
	SW9[a]	SW20	SW21	SW11	SW16	SW22	SW23
Iron	17.5	3.75	2	12.1	3.35	0.58	0.82
Manganese	0.40	0.20	0.10	0.42	0.21	0.03	0.06
TEG	<10	<10	<10	<5	<5	<5	<5
TOC	62	57	34	103	17.6	<1	16.7
COD	116	371	71	350	69	26	52
Total Dissolved Solids	-	-	-	342	151	128	113
BNA[a]	-	-	-	BMDL	BMDL	BMDL	BMDL
VOC[a]							
1,4 Dioxane	-	-	-	26	11	<0.05	<0.05
Carbon Disulfide	-	-	-	0.012	<0.005	<0.005	<0.005
1,1 Dichloroethane	-	-	-	0.014	<0.005	<0.005	<0.005
Methylene Chloride	-	-	-	<0.01	<0.01	<0.016	<0.01
Toluene	-	-	-	0.004	<0.005	<0.005	<0.005

[a]Compounds in this group that are not shown in this table were below detection limits
[b]VOC samples were collected on July 7, 1988, all other samples were collected June 15, 1888
<--Below detection limit shown
Dash (-) indicates constituent not analyzed
BMDL--Below method detection limit
BNA--Base/neutral and acid extractable compounds

Table 6 (Revised 7-30-87)
CHEMICAL ANALYTICAL RESULTS--GROUNDWATER AND SURFACE WATER SAMPLES,
MAY 14-15, 1987
(Results in ppm)

	Groundwater							Surface Water		
						Duplicates				
Analysis	MW1	MW2	MW3	MW4	MW5	MW6	MW6B	SW9	SW20	SW21
TEG	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Acetic Acid	<2	<2	<2	<2	3	7	3	10	21	9
Buteric Acid	<2	<2	<2	<2	<2	<2	3	2	4	2
TOC	110	75	65	83	26	600	609	62	57	34
COD	194	154	169	206	52	1,570	1,790	116	371	71
Titanium	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Antimony	<0.3	<0.2	<0.2	<0.2	1.0	<0.2	<0.2	<0.2	<0.2	<0.2
Iron	25	30	63.8	37.5	8.1	57.5	58.8	17.5	3.75	2
Chromium	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Cobalt	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Manganese	0.69	0.9	1.38	8.55	2.55	1.32	1.32	0.23	0.24	0.09
Ammonia	2.4	1.3	0.1	31.1	18.1	<0.05	<0.05	0.4	0.2	0.1
Nitrate	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2.38	<0.2
Total Phosphorus	0.13	0.2	0.1	0.03	0.15	0.51	0.77	0.1	1.07	<0.2
Chloride	19	15	9	10	9	26	18	33	6	29
Fecal Coliform (C/100 ml)	0	0	0	0	0	0	0	≥2,400	≥2,400	≥2,400
VOC[a]							--	--	--	--
1,4 Dioxane	1.7	1.6	1.00	1.9	0.3	16				
Acetone	0.035	1.4	0.90	3.8	0.14	1.3				
Chloroethane	BMDL	BMDL	0.011	0.0015	BMDL	0.043				
Toluene	BMDL	BMDL	BMDL	0.0011	BMDL	0.0043				
1,1 Dichloroethene	BMDL	BMDL	BMDL	BMDL	BMDL	0.0017				
1,1 Dichloroethane	BMDL	BMDL	.0016	BMDL	BMDL	0.011				
2-Butanone	BMDL	BMDL	BMDL	BMDL	BMDL	0.13				
Benzene	BMDL	BMDL	BMDL	BMDL	BMDL	0.0021				
4 Methyl-2 pentanone	BMDL	BMDL	BMDL	BMDL	BMDL	0.0021				

[a]Compounds in this group that are not shown in this table were below detection limits.
BMDL--All compounds in this group were below method detection limits. Values for detection limits are given in Table 7 at the end of this report.
<--Below detection limit shown.
Dash (--) indicates constituent not analyzed.
Groundwater metals samples were filtered in the field.

WDR252/021

Appendix E
BIOMONITORING TECHNICAL MEMORANDUM

Technical Memorandum

BIOMONITORING RESULTS FOR THE KENTEC GROUNDWATER ASSESSMENT, PHASE 3

Prepared for

DUPONT - KENTEC

Prepared by

CH2M HILL

January 1990
SAT22398.C0.06

CONTENTS

Section 1
INTRODUCTION

The Du Pont Kentec Facility located near Kinston, North Carolina, is a pack cleaning facility which utilizes triethylene glycol (TEG) and 1,4-dioxane in its industrial processes. As part of Phase 3 of the groundwater assessment at the Kentec facility, a biomonitoring study of the surface water in the vicinity of the site was conducted to evaluate potential impacts of the Kentec rinsewater discharger.

Three tasks were identified as pertinent to this biomonitoring study: (1) comparison of algal community structure at upstream and potentially impacted downstream stations, (2) comparison of benthic macroinvertebrate populations at these stations, and (3) acute toxicity tests on surface water from all stations.

This technical memorandum provides a description of the methods and results of the completed tasks.

WDCR529/017.51

Section 2
METHODS

SITE DESCRIPTION

The study area (see Figure 2-1) consists of a drainage ditch extending from about 500 feet north (upstream) of the Kentec facility to Beaverdam Branch approximately 1300 feet downstream. The last 500 feet of this drainage passes unchannelized through a swamp before its confluence with Beaverdam Branch. Water flow was extremely slow at the time of sampling, comprised entirely of groundwater seepage at the upper end of the drainage ditch.

Sampling stations were selected to help isolate potential sources of surface water contamination. A total of seven sampling stations, including two upstream and five downstream of the Kentec plant site were established. These stations are described as follows and their locations are illustrated on Figure 2-1:

Station 1. upstream of all influences to act as a control station

Station 2. between the farm field and leach field to show any contributions from these areas

Station 3. just downstream of the point where the Kentec site drains into the stream

Station 4. at the culvert on the downstream side of the road prior to entering the swamp

Station 5. at a point where the flow exits the swamp, but before it enters Beaverdam Branch

Station 6. Beaverdam Branch upstream of the swamp inflow

Station 7. Beaverdam Branch downstream of swamp inflow

WATER QUALITY

At each sample station in situ water quality measurements were taken for pH, dissolved oxygen, conductivity, and temperature. Field analyses for temperature and DO were made with a YSI Model 57 DO meter with saturated air calibration. Field pH was measured with a Corning Model 105 meter, calibrated by use of buffer solutions at pH 4 and pH 7. Conductivity was analyzed with a YSI Model SCT meter calibrated with a standard KC1 solution.

BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates were collected at each of the seven stations using a long handled dip net with 3/8 inch mesh. Five sweeps were made at each station across the entire stream width and including up to two inches of stream sediment. Sweep samples were taken within 10 feet of either side of the station center point. In addition, two grabs of sediment were collected by hand and sifted through a standard No. 30 sieve to account for smaller invertebrates which may have passed through the dip net mesh. All animals were picked from the net or sieve and preserved in 10 percent formalin and stained with Rose Bengal. All macroinvertebrate samples were shipped to the subconsultant Water and Air Research in Gainesville, Florida for identification of taxa to the lowest practical level.

ALGAE

Algal samples were collected for qualitative analysis. At each of the seven sampling stations, algae were removed from substrates such as leaves and twigs by scraping and from the sediment surface with a pipet. Samples were split into preserved and unpreserved containers and stored at approximately 4°C prior to laboratory analysis. Lugol's iodine solution with glacial acetic acid was used to kill, fix, and stain the algal samples. Algae were identified at CH2M HILL's laboratory in Gainesville, Florida, to the lowest practical level.

BIOASSAY

Water samples were collected at each of the seven stations for subsequent acute toxicity tests. Samples were collected into deionized water rinsed polyethylene sample bottles, labeled, iced, and packed into a cooler and shipped overnight to the CH2M HILL laboratory in Gainesville, Florida. Each sample was evaluated for toxicity by conducting 48-hour acute screening tests with the cladoceran *Ceriodaphnia dubia* and the fathead minnow, *Pimephales promelas*.

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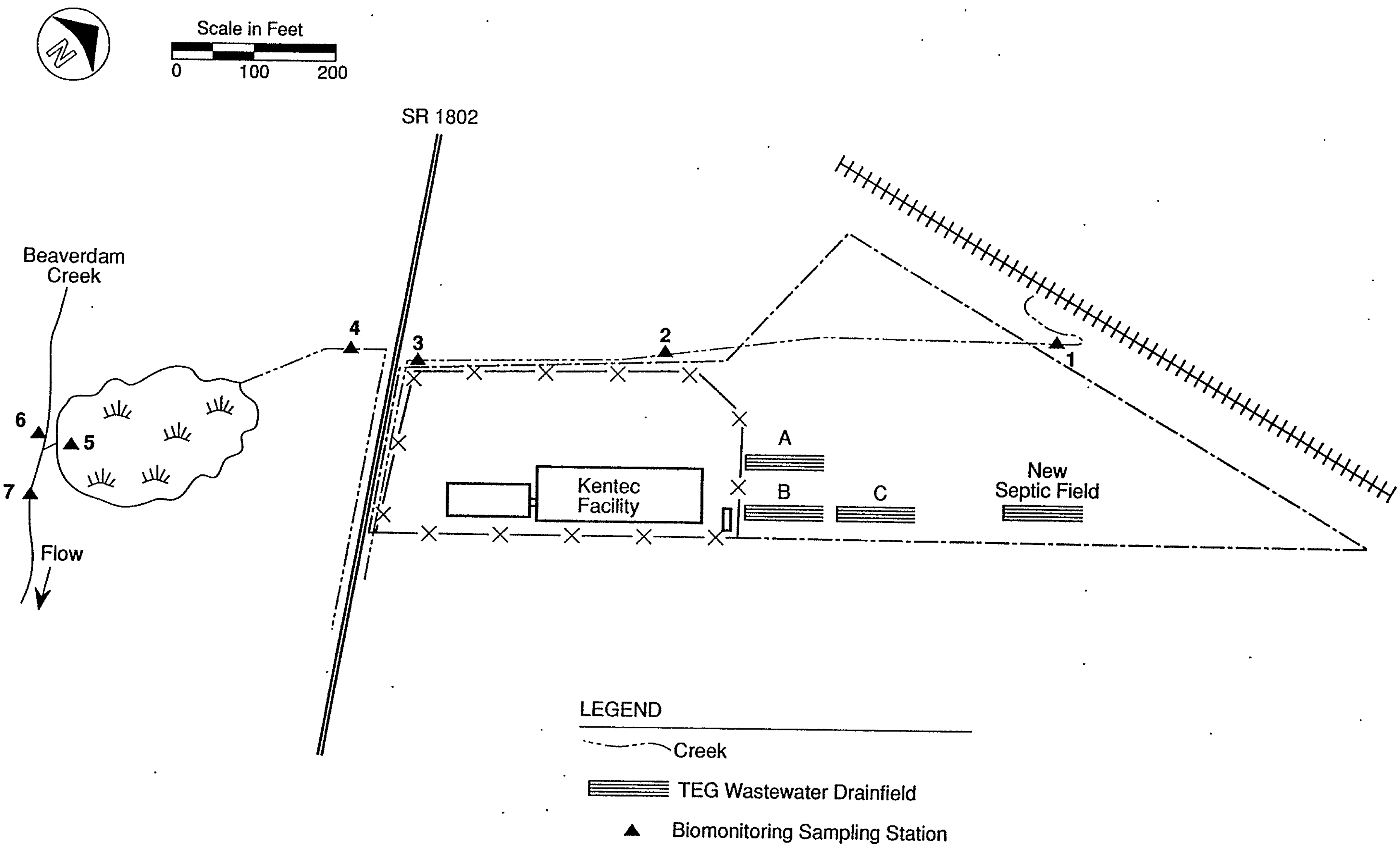

FIGURE 2-1.
Dupont-Kentec Biomonitoring Sampling Stations.

CH2M HILL

Section 3
RESULTS

WATER QUALITY

Measurements of dissolved oxygen, temperature, pH, and conductivity were made twice, once each day during the site investigation. All readings were taken within a 1 hour period. Stream characteristics and water quality are given in Tables 3-1 and 3-2, respectively.

Dissolved oxygen showed an obvious diurnal fluctuation between the two sampling events. The greatest change was 4.7 mg/l drop in dissolved oxygen at Station 1. Average dissolved oxygen ranged from 3.8 to 5.4 mg/l at all but Station 5 where the average was 0.5 mg/l. Temperature ranged from an average of 15.8°C in Beaverdam Branch (Station 6) to 21.6° at Station 3. Typical pH was lowest in the swamp (Station 5) with 6.15 units and highest at Station 3 with 6.61 units. Mean conductivity ranged between 308 and 358 μmhos/cm at Stations 1 through 5 in the drainage ditch and averaged 135 μmhos/cm in Beaverdam Branch. total nitrogen (TN) values ranged from 1.09 mg/l to a high of 4.53 mg/l at Station 3. Total phosphorus (TP) concentrations ranged from 0.11 to 0.95 mg/l, the highest again at Station 3.

BENTHIC MACROINVERTEBRATES

The data resulting from taxonomic identification of benthic macroinvertebrates was used to calculate species richness (number of taxa at the lowest identifiable level), relative abundance, and the Shannon-Weaver diversity index (Table 3-3).

Species richness increased from 10 at the upstream drainage ditch control station (Station 1) to 17 at Station 4 downstream. A sharp decrease in diversity occurs at Station 5 with nine taxa percent. In Beaverdam Branch, species richness ranged from 20 upstream (Station 6) of the drainage ditch confluence to 16 downstream at Station 7.

The Shannon-Weaver diversity index indicates low to high diversities at the seven stations. Lowest diversity indices were measured at Stations 1 and 5 with values of 1.42 and 0.94, respectively. Diversity indices for the remaining five stations ranged from 2.98 to 3.97.

Relative abundance compares the number of animals in species A with the total number of species collected at each site. The two most abundant organisms at the upstream control station (Station 1) were the chironomid *Goeldichironomus holoprasinus* (73.6 percent) and the dragonfly *Plathemis lyodia* (14.4 percent, respectively. The most abundant taxa at Station 3 were *G. holoprasinus* (40.2 percent) and the bivalve *Pisidium* sp. (28.3 percent). Station 4, the most diverse station along the drainage ditch, was dominated by rat tailed maggots (*Eristalis* sp. 12.5 percent), the chironomid *G. holoprasinus* (17.9 percent), and tubificid worms (*Tubificidae* sp. 10.7 percent). Station 5 was located in the swamp and was dominated by tubificid worms (*Tubificidae*, sp., 86.7 percent). Stations 6 and 7 were both dominated by the bivalve *Pisidium* sp. (19.4 and 34.4 percent, respectively). The alderfly *Sialis* sp. was also common at Station 7 (17.1 percent).

ALGAE

Algal samples were observed and collected at Stations 1 through 4, as well as an additional site between Stations 2 and 3, which had the most obvious signs of algal growth in the entire drainage ditch. In general, algal growth was limited to small patches on the surface of the sediment at these stations, and none was observed at Stations 5, 6, and 7. A listing of taxa identified at these stations is provided in Table 3-4. *Euglena* sp. and *Phacus* sp. were identified in all samples. Pennales diatoms were observed at all sampling locations except Station 4. Stations 1, 2, and 3 were dominated by euglenoids and diatoms, while Station 2A was dominated by a desmid species (*Closterium* sp.). Station 4 was dominated by another flagellate, *Cryptomonas*, sp.

BIOASSAY

Surface water samples collected at each of the seven stations were not acutely toxic to the chadoceran or fathead minnow test species after 48 hours of exposure based on a pass/fail criteria of 50 percent survival in 100 percent effluent.

A report of the results provided by CH2M HILL's laboratory is included in Appendix A.

WDCR529/021.51

Table 3-1
DUPONT-KENTEC SITE STREAM CHARACTERISTICS

Station	Width (ft)	Depth (ft)	Qualitative Sediment Composition	Canopy Cover (%)	Subcanopy Cover (%)
1	5.0	0.5	Silt	25	1
2	2.0	0.5	Silt/Clay	0	1
3	2.0	0.2	Sand	0	20
4	2.0	0.5	Silt/Sand	10	20
5	2.0	0.1	Silt/Clay	100	0
6	15.0	2.0	Sand	70	0
7	20.0	2.0	Silt/Sand	90	0

Table 3-2

DUPONT-KENTEC SITE SURFACE WATER QUALITY

Parameter	Units	Date	Station 1	2	3	4	5	6	7
Dissolved Oxygen	(mg/l)	11/13/89[a]	6.2	5.2	5.9	5.2	0.6	5.1	5.0
Dissolved Oxygen	(mg/l)	11/14/89[b]	1.5	5.6	3.4	2.3	0.4	3.6	3.3
Average Dissolved Oxygen	(mg/l)		3.9	5.4	4.7	3.8	0.5	4.4	4.2
Temperature	(°C)	11/13/89[a]	19.9	19.9	21.0	19.5	18.0	15.8	17.0
Temperature	(°C)	11/14/89[a]	17.5	21.0	22.1	22.8	15.1	15.7	15.8
Average Temperature	(°C)		18.7	19.5	21.6	21.2	16.6	15.8	16.4
pH	(units)	11/13/89[a]	6.50	6.50	6.71	6.50	6.20	6.24	6.40
pH	(units)	11/14/89[a]	6.60	6.50	6.50	6.53	6.10	6.50	6.60
Average pH	(units)		6.55	6.50	6.61	6.52	6.15	6.37	6.50
Conductivity	(µmhos/cm)	11/13/89[a]	300	350	370	355	349	135	138
Conductivity	(µmhos/cm)	11/14/89[a]	315	355	345	355	291	130	133
Average Conductivity	(µmhos/cm)		308	353	358	355	320	133	136
TOC	(mg/l)	11/14/89	36.9	38.2	28.8	87.1	51.2	6.9	7.7
Ortho-P	(mg/l)	11/14/89	0.05	0.06	0.08	0.05	0.16	0.06	0.07
TP	(mg/l)	11/14/89	0.23	0.32	0.95	0.26	0.75	0.13	0.11
NH_3-N	(mg/l)	11/14/89	0.92	0.94	2.40	1.70	0.15	0.15	0.15
NO_2+NO_3	(mg/l)	11/14/89	0.05	0.05	0.07	0.05	0.05	0.84	0.85
TKN	(mg/l)	11/14/89	2.17	2.45	4.46	3.17	1.88	0.25	0.29
TN	(mg/l)	11/14/89	2.22	2.50	4.53	3.22	1.93	1.09	1.14
1,4-Dioxane	(µg/l)	11/14/89	490	1,100	1,600	6,200	4,700	0	58
Tri-Ethylene Glycol	(µg/l)	11/14/89	<250	2,400	2,600	3,450	1,100	4,100	4,900
Fecal Coliforms	c/100 ml	11/14/89	110	2	4	1,600	1,600	350	90
Total Coliforms	c/100 ml	11/14/89	300	1,600	1,600	≥2,400	≥2,400	≥2,400	≥2,400

[a]Late afternoon sampling

[b]Late morning sampling

Table 3-3

TAXONOMIC IDENTIFICATION OF BENTHIC MACROINVERTEBRATES COLLECTED AT THE DUPONT - KENTEC SITE

	STATION													
	1		2		3		4		5		6		7	
TAXONOMIC CLASSIFICATION	NUMBER OF ORGANISMS	RELATIVE ABUNDANCE (%)	NUMBER OF ORGANISMS	RELATIVE ABUNDANCE (%)	NUMBER OF ORGANISMS	RELATIVE ABUNDANCE (%)	NUMBER OF ORGANISMS	RELATIVE ABUNDANCE (%)	NUMBER OF ORGANISMS	RELATIVE ABUNDANCE (%)	NUMBER OF ORGANISMS	RELATIVE ABUNDANCE (%)	NUMBER OF ORGANISMS	RELATIVE ABUNDANCE (%)
Nematoda														
Nematoda Species A	--	--	--	--	1	1.1	--	--	--	--	1	2.8	--	--
Oligochaeta - Naididae														
Dero digitata	--	--	--	--	--	--	1	1.8	--	--	--	--	--	--
Dero lodeni	1	0.8	1	1.4	--	--	4	7.1	--	--	1	2.8	--	--
Dero nivea	--	--	--	--	--	--	2	3.6	--	--	1	2.8	1	2.9
Dero sp.	--	--	--	--	3	3.3	--	--	--	--	--	--	--	--
Naididae	--	--	--	--	--	--	--	--	--	--	1	2.8	--	--
Oligochaeta - Tubificidae														
Tubificidae immature sp. A	--	--	12	17.1	2	2.2	6	10.7	72	86.7	--	--	1	2.9
Tubificidae immature sp. B	--	--	--	--	--	--	--	--	--	--	1	2.8	--	--
Oligochaeta - Lumbriculidae														
Lumbriculidae sp. A	--	--	--	--	--	--	--	--	1	1.2	1	2.8	--	--
Crustacea - Decapoda														
Palaemonetes sp.	--	--	--	--	--	--	--	--	--	--	--	--	1	2.9
Procambrus sp.	--	--	--	--	--	--	--	--	--	--	1	2.8	1	2.9
Insecta - Ephemeroptera														
Eurylophella temporalis	--	--	--	--	--	--	--	--	--	--	--	--	1	2.9
Insecta - Odonata														
Argia sp.	--	--	--	--	--	--	--	--	--	--	1	2.8	--	--
Calopteryx dimidiata	--	--	--	--	--	--	--	--	--	--	2	5.6	2	5.7
Dromogomphus spinosa	--	--	--	--	--	--	--	--	--	--	4	11.1	1	2.9
Enallagma sp.	2	1.6	--	--	2	2.2	--	--	--	--	--	--	--	--
Libellula lactuosa	--	--	--	--	1	1.1	3	5.4	--	--	--	--	--	--
Libellula sp.	--	--	--	--	--	--	--	--	--	--	--	--	1	2.9
Macromia sp.	--	--	--	--	--	--	--	--	--	--	1	2.8	--	--
Neurocordulia alabamensis	--	--	--	--	--	--	--	--	--	--	--	--	1	2.9
Perithemis tenera	--	--	--	--	--	--	--	--	--	--	--	--	1	2.9
Plathemis lydia	18	14.4	19	27.1	--	--	--	--	--	--	--	--	--	--
Insecta - Hemiptera														
Belastoma testaceum	--	--	1	1.4	--	--	--	--	--	--	--	--	--	--
Trichocorixia sp.	--	--	--	--	--	-	--	--	--	--	--	--	1	2.9
Insecta - Coleoptera														
Copelatus sp.	--	--	--	--	--	--	--	--	--	--	2	5.6	--	--
Hydrophilus sp.	--	--	--	--	--	--	1	1.8	--	--	--	--	--	--
Hygrotus sp.	--	--	--	--	--	--	4	7.1	1	1.2	3	8.3	--	--
Laccophilus sp.	1	0.8	1	1.4	--	--	--	--	--	--	--	--	--	--

Table 3-3

TAXONOMIC IDENTIFICATION OF BENTHIC MACROINVERTEBRATES COLLECTED AT THE DUPONT - KENTEC SITE

	STATION 1		STATION 2		STATION 3		STATION 4		STATION 5		STATION 6		STATION 7	
TAXONOMIC CLASSIFICATION	NUMBER OF ORGANISMS	RELATIVE ABUNDANCE (%)	NUMBER OF ORGANISMS	RELATIVE ABUNDANCE (%)	NUMBER OF ORGANISMS	RELATIVE ABUNDANCE (%)	NUMBER OF ORGANISMS	RELATIVE ABUNDANCE (%)	NUMBER OF ORGANISMS	RELATIVE ABUNDANCE (%)	NUMBER OF ORGANISMS	RELATIVE ABUNDANCE (%)	NUMBER OF ORGANISMS	RELATIVE ABUNDANCE (%)
Rhantus sp.	1	0.8	--	--	--	--	--	--	--	--	--	--	--	--
Tropisternus collaris striolatus	2	1.6	1	1.4	--	--	--	--	--	--	--	--	--	--
Insecta - Megaloptera														
Chauliodes pectinicornis	--	--	--	--	--	--	2	3.6	--	--	--	--	--	--
Sialis sp.	--	--	--	--	--	--	--	--	--	--	1	2.8	6	17.1
Insecta - Diptera - Chironomidae														
Chironomidae	--	--	--	--	2	2.2	--	--	--	--	--	--	--	--
Chironomus sp.	5	4	--	--	3	3.3	2	3.6	--	--	3	8.3	--	--
Goeldichironomus holoprasinus	92	73.6	16	22.9	37	40.2	10	17.9	3	3.6	--	--	--	--
Psectrotanypus sp.	1	0.8	--	--	--	--	1	1.8	--	--	--	--	--	--
Stenochironomus sp.	--	--	--	--	1	1.1	--	--	--	--	--	--	--	--
Tanytarsus sp. A	--	--	--	--	10	10.9	--	--	--	--	--	--	--	--
Tanytarsus sp. B	--	--	--	--	--	--	--	--	--	--	2	5.6	--	--
Tribelos sp.	--	--	--	--	--	--	--	--	--	--	1	2.8	2	5.7
Insecta - Diptera - Other														
Bittacomorpha clavipes	--	--	--	--	1	1.1	--	--	--	--	--	--	--	--
Brachydeutera sp.	--	--	1	1.4	--	--	--	--	--	--	--	--	--	--
Chrysops sp.	--	--	1	1.4	1	1.1	--	--	--	--	--	--	--	--
Culex sp. A	--	--	5	7.1	--	--	--	--	2	2.4	--	--	--	--
Culex sp. B	--	--	3	4.3	--	--	--	--	--	--	--	--	--	--
Ephydra sp.	--	--	--	--	1	1.1	1	1.8	1	1.2	--	--	--	--
Eristalis sp.	--	--	--	--	--	--	7	12.5	1	1.2	--	--	--	--
Pericoma sp.	--	--	--	--	--	--	2	3.6	1	1.2	--	--	--	--
Pseudolimnophila sp.	--	--	--	--	1	1.1	--	--	--	--	--	--	--	--
Sepedon sp.	--	--	1	1.4	--	-	2	3.6	--	--	--	--	--	--
Stratiomys sp.	2	1.6	3	4.3	--	--	--	--	--	--	--	--	--	--
Tipula sp.	--	--	--	--	--	--	--	--	1	1.2	--	--	--	--
Mollusca - Gastropoda														
Ferrissia sp.	--	--	--	--	--	--	--	--	--	--	1	2.8	2	5.7
Physella sp.	--	--	--	--	--	--	2	3.6	--	--	--	--	1	2.9
Mollusca - Pelecypoda														
Elliptio sp.	--	--	--	--	--	--	--	--	--	--	1	2.8	--	--
Pisidium sp.	--	--	5	7.1	26	28.3	6	10.7	--	--	7	19.4	12	34.3
TOTAL NUMBER OF ORGANISMS	125		70		92		56		83		36		35	
SPECIES RICHNESS	10		14		15		17		9		20		16	
SHANNON-WEAVER DIVERSITY INDEX	1.42		2.98		3.39		3.72		0.94		3.97		3.29	
TOTAL ABUNDANCE (%)		100		100		100		100		100		100		100

Table 3-4
LIST OF ALGAL SPECIES COLLECTED AT EACH STATION

Station	Taxa	Abundance
1	*Phacus* sp.	Common
	Euglena sp.	Common
	Pennales diatoms	Rare
2	*Euglena* sp.	Dominant
	Phacus sp.	Occasional
	Pennales diatoms	Rare
2A (halfway between Stations 2 and 3)	*Closterium* sp.	Common
	Oscillatoria sp.	Common
	Filamentous Alga Sp. A	Common
	Pennales diatoms	Occasional
	Phacus sp.	Occasional
	Euglena sp.	Occasional
3	*Euglena* sp.	Common
	Phacus sp.	Common
	Oscillatoria sp.	Occasional
	Pennales diatoms	Rare
4	*Cryptomonas* sp.	Dominant
	Euglena sp.	Common
	Phacus sp.	Occasional
5	None observed	
6	None observed	
7	None observed	

Section 4
CONCLUSIONS

Based upon the Shannon-Weaver diversity indices and the general pollution tolerances of the benthic macroinvertebrates collected, water quality in the entire drainage ditch adjacent to the Kentec plant should be considered fair. The maximum diversity in the ditch was 3.72, which is generally considered medium to high and typical of natural water bodies. Stations 6 and 7 in Beaver Dam Creek both had diversities greater than 3.0, indicating relatively healthy benthic macroinvertebrate populations. However, the lack of organic pollution sensitive organisms such as caddisfly larvae, stonefly nymphs, and mayfly nymphs and the abundance of pollution-tolerant macroinvertebrates (rat-tailed maggot, horsefly larva, midge larva, tubificid worms) found at most stations indicates a degree of organic enrichment. In addition, species of algae identified in the drainage ditch such as *Oscillatoria* sp., *Closterium* sp., *Euglena* sp., and diatoms are generally considered insensitive to organic enrichment. Potential sources of organic enrichment might include decaying leaves and vegetation, runoff from adjacent agricultural property, and runoff or seepage from the Kentec facility.

Although verified by surface water analyses (Table 3-2), elevated organic chemical concentrations along the drainage ditch do not correlate with benthic macroinvertebrate community diversity observed at all sampling stations. Species richness and diversity for the ditch reference station (Station 1) is lower than all but one (Station 5) of the downstream stations. Station 5 diversity is more typical of a swamp wetland with naturally low dissolved oxygen concentration. Macroinvertebrate diversity was only slightly lower at the downstream location (Station 7) in Beaverdam Branch. Therefore, it appears that the natural water quality conditions throughout the drainage ditch and in the creek were fair at the time of this field sampling, primarily supporting tolerant macroinvertebrates and algae. Bioassay test results confirm that there was no acutely toxic effect of pollutants found in the surface water during this sampling event.

WDCR529/019.51

Appendix A
REPORT OF THE RESULTS OF 48 HOUR ACUTE TOXICITY BIOASSAYS

CONTENTS

1.0 INTRODUCTION

CH2M HILL conducted fourteen 48-hour acute toxicity bioassays from November 15 through 17, 1989, on 7 samples provided by DuPont, Inc., Kinston, North Carolina, using the cladoceran, *Ceriodaphnia dubia*, and the fathead minnow, *Pimephales promelas*.

2.0 METHODS AND MATERIALS

2.1 TEST METHODS

All tests were performed according to "Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms", EPA/600/4-85/013.

2.2 TEST ORGANISMS

The cladocerans were obtained from CH2M HILL cultures and were less than 24 hours old at test initiation. Cladocerans were fed and maintained during the testing as prescribed by the EPA (1985). The fathead minnows, 15 days old, were obtained from Florida Bioassay Supply, Gainesville, Florida. These fish were acclimated to 20°C and moderately hard reconstituted water for 48 hours prior to test initiation. The minnows were fed artemia during acclimation but were not fed during testing. All test organisms appeared vigorous and in good condition prior to testing.

2.3 DILUTION WATER

The water used for acclimation, culture, dilution, and controls during the testing for the cladocerans and fathead minnows was moderately hard reconstituted water (EPA, 1985) with a hardness of 92 mg/l as $CaCO_3$, alkalinity of 54 mg/l as $CaCO_3$.

2.4 TEST CONCENTRATIONS

The concentrations used in the screening tests were 100 percent effluent and zero percent control water. All effluent and control concentrations were conducted in duplicate with 10 organisms per vessel for a total of 20 organisms per concentration. Sodium chloride concentrations used for the reference toxicant tests were 4.0, 6.0, 8.0, 10.0, and 12.0 g/l for the fathead minnows and 1.0, 2.0, 3.0, 4.0, and 5.0 g/l for the waterfleas.

2.5 SAMPLE COLLECTION

The effluent samples tested were collected on November 14, 1989, at 1330 hours from the Kentec Plant by CH2M HILL personnel. The samples were shipped iced to CH2M HILL's Gainesville laboratory and arrived on November 15, 1989, at 1100 hours. The tests were initiated within 26 hours of sample collection.

2.6 SAMPLE PREPARATION

The samples were adjusted to test temperature upon arrival at CH2M HILL's Gainesville laboratory. No other treatment was performed.

2.7 TEST MONITORING

All tests were monitored at test initiation and every 24 hours thereafter for mortality, dissolved oxygen, and pH. Temperature was monitored continuously throughout the 48-hour test period using a Primeline® temperature monitor.

3.0 RESULTS AND DISCUSSION

Raw data sheets are given in Appendix A. The results showed no acute toxicity of the seven surface water samples to the fathead minnows, with 100 percent survival in all 100 percent surface water samples. No acute toxicity was observed in any of the seven surface water samples with *Ceriodaphnia dubia* after 48 hours. Six samples showed 100 percent survival in 100 percent surface water, and one sample exhibited 95 percent survival. Control survival for both species was 100 percent.

Station Number	Time	Sample ID	Percent Survival *C. dubia*	Percent Survival *P. promelas*
1	1330	740	100	100
2	1330	741	100	100
3	1330	742	95	100
4	1330	743	100	100
5	1330	744	100	100
6	1330	745	100	100
7	1300	746	100	100
Control	--	--	100	100

The dissolved oxygen levels were at 45 percent saturation or greater throughout the test period. Test temperatures remained between 20°±2°C.

Reference toxicant test results (shown below) using sodium chloride showed that both species were within their expected sensitivity range.

Reference Toxicant Test Results (g/l)

Species	LC50	95 Percent Confidence Limits
Daphnia pulex	2.1	1.0-3.0
Pimephales promelas	9.3	8.5-10.1

All tests proceeded without interruption or incidents which may have affected test results.

4.0 CONCLUSIONS

The seven samples tested were not acutely toxic to the cladoceran or fathead minnow test species after 48 hours of exposure based on a pass/fail criteria of 50 percent survival in 100 percent effluent.

WDCR529/020.51

REFERENCES

United States Environmental Protection Agency. "Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms." EPA/600/4-85/013. Environmental Monitoring and Support Laboratory. Cincinnati, Ohio. 1985.

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Appendix A
RAW DATA SHEETS

CH2M HILL

TOXICITY TEST SURVIVAL AND WATER QUALITY DATA

Client: Dupont - Kentec

Address:

Contact: Doug Cronfield / Reston

Test Initiation: Date 11/13/89 Time 1500 Test Termination: Date 11/17/89 Time 1530

Technicians: Martin, Meyer

Test Species/I.D. #: Ceriodaphnia dubia /590; Pimephales promelas /587; /; /

Sample Information							
Sample ID Number	Collected Date	Collected Time	Total Residual Chlorine (mg/l)	De-chlorinated (Yes or No)	Salinity (ppt)	Hardness mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$
740	11/11/89	1330	Not measured	No	—	64	96
741	↓	↓	↓	↓		60	148
742	↓	↓	↓	↓		68	160
743	↓	↓	↓	↓		80	166
744	↓	↓	↓	↓		80	174
745	↓	↓	↓	↓		56	30
746	↓	↓	↓	↓		60	30
~~[illegible]~~							

Test Species Information	ID # 590	ID # 587	ID #	ID #
Age or Size	< 24 h	15 d		
Loading Rate (gm/l)				
Test Container Size	350 ml	900 ml		
Test Volume (L)	100 ml	800 ml		
Feeding: Type Amount	1 drop YTC per day	None		
Aeration: Began Amount				
Dilution Water ID #	244	244		
Acclimation Period	< 24 h	> 48 h		
Condition of Survivors	Good	Good		

Comments:

Dilution Water Source	ID #	Hardness mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$
MH Recon	244	92	54

Water Quality Meters Used/ID #

Dissolved Oxygen 2 pH 1 Temperature 1

Conductivity 1 Refractometer — Other —

CH2M HILL

TOXICITY TEST SURVIVAL AND WATER QUALITY DATA

Client: DuPont - Kentec

Sample Description: Drainage Ditch Samples

Test Species: Ceriodaphnia dubia ID# 590

Beginning: Date 11/15/89 Time 1500

Ending: Date 11/17/89 Time 1530

Technician: 0 hr JRM 24 hr JPM 48 hr JPM 72 hr ____ 96 hr ____

Time: 0 hr 1500 24 hr 1020 48 hr 1530 72 hr ____ 96 hr ____

Conc. or Percent	Test Container Number	Acclimation* Salinity (mg/ml)	Test* Salinity (mg/ml)	Number of Live Organisms					Dissolved Oxygen (mg/L)					pH					Conductivity (umhos/cm)				
				0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96
0.0	A	NA	NA	10	10	10			8.7	8.8	8.4			7.7	7.8	7.8			269	259	275		
0.0	B			10	10	10			8.7	8.6	8.2			7.7	7.9	7.7			269	261	271		
100	740 A			10	10	10			8.4	8.8	8.7			7.2	7.9	8.1			350	345	354		
100	740 B			10	10	10			8.4	9.0	8.6			7.2	7.9	8.1			350	348	353		
100	741 A			10	10	10			8.3	8.6	8.5			7.3	8.1	8.2			377	392	401		
100	741 B			10	10	10			8.3	8.6	8.2			7.3	8.2	8.2			377	397	411		
100	742 A			10	10	10			7.8	8.6	8.3			7.3	8.2	8.3			389	396	400		
100	742 B			10	10	9			7.8	8.5	8.3			7.3	8.2	8.3			389	399	413		
100	743 A			10	10	10			7.0	7.3	6.7			7.1	7.9	8.2			397	395	410		
100	743 B			10	10	10			7.0	7.3	6.2			7.1	7.9	8.1			397	397	387		
100	744 A			10	10	10			8.1	3.0	8.3			7.8	7.9	8.2			381	371	393		
100	744 B			10	10	10			8.1	2.7	8.3			7.8	7.9	8.2			381	~~362~~ 374 FRM	382		
100	745 A			10	10	10			8.7	8.5	8.4			~~7.4~~ 7.1	7.8	7.8			158	158	168		
100	745 B			10	10	10			8.7	8.5	8.3			~~7.4~~ 7.1	7.7	7.6			158	161	167		
100	746 A			10	10	10			8.4	8.5	8.3			7.1	7.6	7.7			154	161	163		
100	746 B			10	10	10			8.4	8.6	8.3			7.1	7.6	7.7			154	162	167		

*Saltwater Studies Only

CH2M HILL

TOXICITY TEST SURVIVAL AND WATER QUALITY DATA

Client: DUPONT - KENTEC

Sample Description: DRAINAGE DITCH SAMPLES

Test Species: PIMEPHALES PROMELAS ID# 587

Beginning: Date 11/15/89 Time 1500

Ending: Date 11/17/89 Time 1518

Technician: 0 hr JAM 24 hr PRM 48 hr PRM 72 hr ____ 96 hr ____

Time: 0 hr 1500 24 hr 1050 48 hr 1515 72 hr ____ 96 hr ____

Conc. ~~or~~ Percent	Test Container Number	Acclimation* Salinity (mg/ml)	Test* Salinity (mg/ml)	Number of Live Organisms					Dissolved Oxygen (mg/L)					pH					Conductivity (umhos/cm)				
				0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96
0.0	A	NA	NA	10	10	10			8.7	7.7	7.5			7.8	7.8	7.7			269	265	266		
0.0	B			10	10	10			8.7	7.8	7.5			7.8	7.7	7.7			269	264	268		
100	740 A			10	10	10			8.0	7.4	7.3			7.0	7.4	7.7			350	353	348		
100	740 B			10	10	10			8.0	7.3	7.3			7.0	7.4	7.6			350	352	354		
100	741 A			10	10	10			8.5	7.3	6.9			7.3	7.6	7.8			377	399	401		
100	741 B			10	10	10			8.5	7.3	6.7			7.3	7.7	7.8			377	400	405		
100	742 A			10	10	10			7.6	7.3	6.9			7.2	7.6	7.9			389	407	408		
100	742 B			10	10	10			7.6	7.3	7.0			7.2	7.6	7.9			389	407	411		
100	743 A			10	10	10			6.7	4.4	3.9			6.9	7.3	7.6			397	403	401		
100	743 B			10	10	10			6.7	4.6	4.0			6.9	7.3	7.6			397	401	403		
100	744 A			10	10	10			7.5	8.2	8.1			6.9	8.0	8.2			381	371	373		
100	744 B			10	10	10			7.5	8.5	8.2			6.9	8.2	8.2			381	371	372		
100	745 A			10	10	10			8.5	7.5	7.3			6.7	7.6	7.7			158	157	167		
100	745 B			10	10	10			8.5	7.5	7.2			6.7	7.4	7.6			158	159	163		
100	746 A			10	10	10			8.2	7.7	7.2			6.7	7.2	7.5			154	159	160		
100	746 B			10	10	10			8.2	7.7	7.2			6.7	7.3	7.4			154	155	161		

*Saltwater Studies Only

Appendix B
CHAIN OF CUSTODY RECORD

CH2M HILL

Chain of Custody Record for NPDES Compliance Biomonitoring

Client Name: Dupont - Kents	Address	County / State: N.C.
NPDES Number	Description of Sampling Site: DRAINAGE DITCH	
CH2M HILL Laboratory	Sample Container Type: Glass ☐ Plastic ☑ Size ____	

Sample(s) Shipped Via: UPS ☐ Bus ☐ Federal Express ☑ Other ☐

Special Instructions: 48 h SCREEN; Cd, Pb

Composite Sample Information

Samples / Hour ____ Volume / Sample ____

Total Hours ____ Total Volume ____

Initiated: Date ____ Time ____

Ended: Date ____ Time ____

Chilled During Collection Yes ☐ No ☐

Temperature Upon Arrival ____

Outfall Number	Date	Time	Composite	Grab	No. of Containers	Sample ID Number	Sampled by (Signature)	Remarks
1	11/14/89	1330		✓	1	740	John R. Martin	STATION 1
2	↓	1330		✓	1	741	↓ JRM	" 2
3	↓	1330		✓	1	742	↓	" 3
4	↓	1330		✓	1	743	↓	" 4
5	↓	1330		✓	1	744	↓	" 5
6	↓	1330		✓	1	745	↓	" 6
7	↓	1330		✓	1	746	↓	" 7

Sampled By and Title (Signature)	Date	Time	Relinquished By: (Signature)	Date	Time	Received By: (Signature)
John R. Martin	11/14/89	1400	John R Martin	11/14/89	1400	

Relinquished By: (Signature)	Date	Time	Received By: (Signature)	Relinquished By: (Signature)	Date	Time	Received By Lab: (Signature)
							John R. Martin

Distribution: White - CH2M HILL Copy;

1145 11/14/89