



# Capstone Report on the Application, Monitoring, and Performance of Permeable Reactive Barriers for Ground-Water Remediation:

## Volume 2

### Long-Term Monitoring of PRBs: Soil and Ground Water Sampling



# Report Documentation Page

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# **Capstone Report on the Application, Monitoring, and Performance of Permeable Reactive Barriers for Ground-Water Remediation:**

## **Volume 2 - Long-Term Monitoring of PRBs: Soil and Ground Water Sampling**

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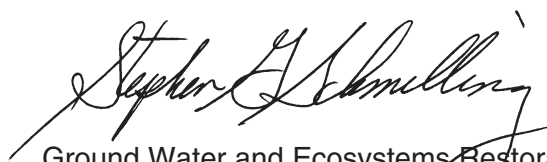
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## Foreword

The U.S. Environmental Protection Agency (EPA) is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory (NRMRL) is the Agency's center for investigation of technological and management approaches for preventing and reducing risks from pollution that threatens human health and the environment. The focus of the Laboratory's research program is on methods and their cost-effectiveness for prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites, sediments, and ground water; prevention and control of indoor air pollution; and restoration of ecosystems. NRMRL collaborates with both public and private sector partners to foster technologies that reduce the cost of compliance and to anticipate emerging problems. NRMRL's research provides solutions to environmental problems by developing and promoting technologies that protect and improve the environment; advancing scientific and engineering information to support regulatory and policy decisions; and providing the technical support and information transfer to ensure implementation of environmental regulations and strategies at the national, state, and community levels.

This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by EPA's Office of Research and Development (ORD) to assist the user community and to link researchers with their clients. The purpose of this document is to provide detailed sampling methods and procedures used to collect soil and ground-water samples in order to evaluate the long-term performance of full-scale permeable reactive barriers (PRBs) installed to treat contaminated ground water at two different sites. This report provides methods to obtain representative ground-water samples and to evaluate geochemical parameters within and around a PRB. Proper analytical and quality control procedures, both in the field and in the laboratory, are also discussed for obtaining accurate and representative data for PRB evaluation and site assessment. The information provided in this document will be of use to stakeholders such as state and federal regulators, Native American tribes, consultants, contractors, and other interested parties.



Ground Water and Ecosystems Restoration Division  
National Risk Management Research Laboratory

## **Abstract**

This report discusses soil and ground-water sampling methods and procedures used to evaluate the long-term performance of permeable reactive barriers (PRBs) at two sites, Elizabeth City, NC, and the Denver Federal Center near Lakewood, CO. Both PRBs were installed in 1996 and have been monitored and studied since installation to determine their continued effectiveness for removing contaminants from ground water. An effective monitoring program requires appropriate soil and ground-water sampling techniques.

For ground-water sampling, water quality indicator parameters must be monitored to determine when formation water has been accessed. Geochemical parameters include oxidation-reduction potential (ORP), pH, specific conductance, dissolved oxygen (DO), and turbidity. Field analytical methods are discussed along with interferences and issues which may arise when using certain electrodes or instruments in the field. Detailed field analytical procedures for hexavalent chromium, ferrous iron, alkalinity, hydrogen sulfide, and dissolved oxygen are described. Also included are laboratory methods for sample analyses for organics, cations, anions, and carbon. Sample collection methods, sample containers, preservation methods, and sample storage techniques are also discussed.

An effective soil sampling program also depends on methods employed to collect, preserve, and characterize solid materials. Core samples from the PRBs were collected to assess the distribution of mineral and biomass concentrations. Proper use of a conductivity probe to verify the exact position of the iron/aquifer interface prior to collecting core material is described, along with core collection methods. Laboratory methods for core processing prior to analyses are also detailed. Procedures for inorganic carbon, sulfur, and X-ray diffraction analyses, electron microscopy, and microbial characterization are discussed in detail.

In order to properly evaluate PRBs for long term performance, proper sampling methods and procedures must be employed, both in the field and in the laboratory, to provide accurate and representative soil and ground water data. Proper analytical and quality control (QC) procedures are also necessary to ensure accurate and representative data for PRB evaluation and site assessment.

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## 1.0 Introduction

Permeable reactive barrier (PRB) technology is an in-situ method for remediating contaminated ground water which combines a passive chemical treatment zone with subsurface fluid flow management (Wilkin et al., 2002). PRBs are most often composed of granular, zero-valent iron which is emplaced in the subsurface to intercept contaminant plumes. Contaminated water flows through the PRB and clean water emerges downgradient of the reactive treatment zone. Analysis and discussion of monitoring data collected at two PRBs are presented in Volume 1 of this EPA Report series. This report describes ground-water and soil core sampling, preservation, and analytical methods used in a five-year investigation of PRB performance for ground-water remediation.

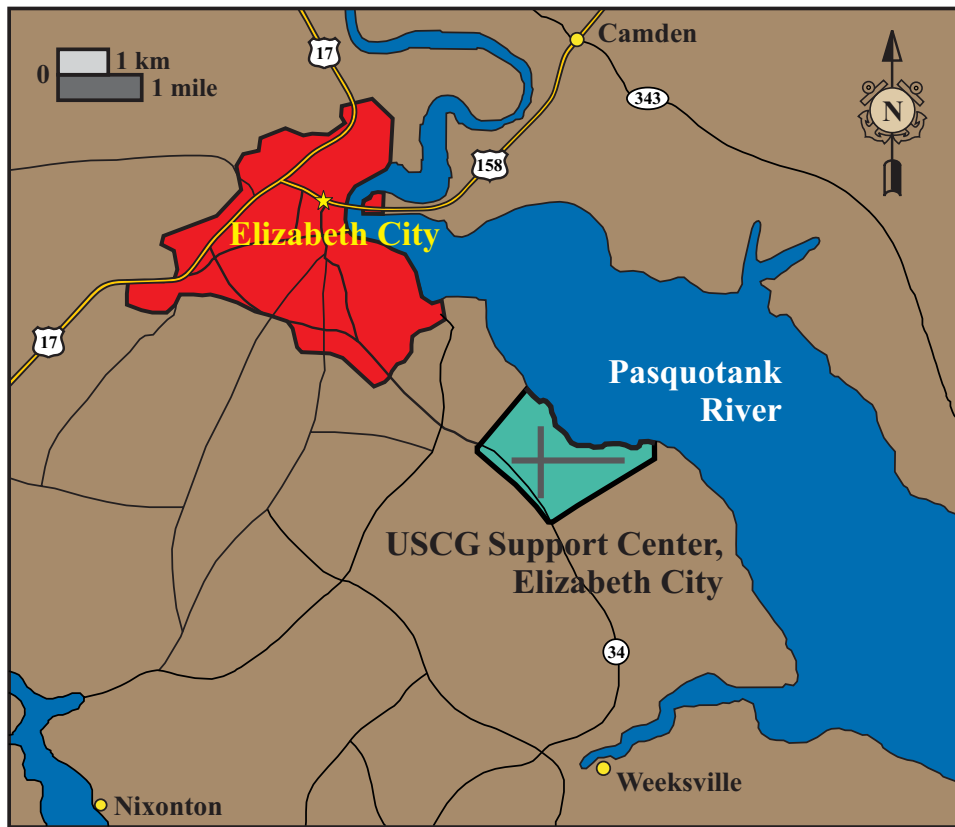
Two permeable reactive barriers (PRBs) were installed in 1996, one at the U.S. Coast Guard (USCG) Support Center near Elizabeth City, NC and the other at the Denver Federal Center (DFC) near Lakewood, CO. Both PRBs are composed of Peerless® granular iron; however, they differ in their installation methods and design configurations. Both of these PRBs have been monitored and studied since installation to evaluate their continued effectiveness for removing contaminants from ground water.

An integral part of the PRB study has been the sampling methods and procedures used to collect soil and ground-water samples at regular intervals in order to evaluate the long term performance of PRB technology. An effective ground-water sampling program consists of several components, all necessary to obtain representative ground-water samples and properly evaluate geochemical parameters within and around a PRB. These components include well location and installation, ground-water sampling techniques and sampling device used, water quality indicator parameters, and water level monitoring for draw-down during purging. Other important factors include the type of sample containers, preservation methods, and sample storage and shipment techniques. Similarly, an effective soil sampling program depends on the methods employed to collect, preserve, and characterize solid materials. Proper analytical and quality control (QC) procedures, both in the field and in the laboratory, are also necessary for obtaining accurate and representative data for PRB evaluation and site assessment.

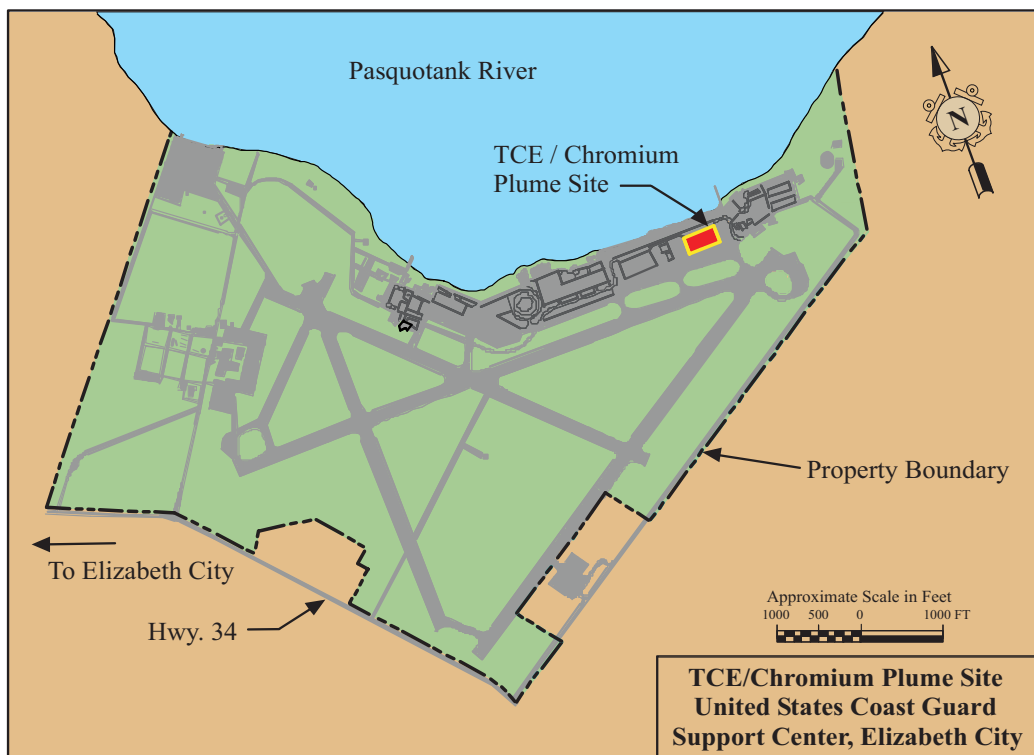
### 1.1 Site Description: USCG Support Center, Elizabeth City, North Carolina

The U.S. Coast Guard (USCG) Support Center is located near Elizabeth City, NC which is about 100 km south of Norfolk, VA and 60 km inland from the Outer Banks region of NC. The USCG base lies on the southern end of Elizabeth City (Figure 1.1) on the southern bank of the Pasquotank River (Figure 1.2). An old chrome-plating shop, located within a hangar (building 79), was in use for approximately 30 years until the discovery of a hole in the plating shop floor in 1984. Site geology is described elsewhere (Puls et al., 1999a). Chromic and sulfuric acid wastes had discharged into the soils and ground water beneath the hangar resulting in a diffuse chromium plume that migrated north from the plating shop toward the Pasquotank River (Paul et al., 2002). Ground-water movement at the site is generally toward the Pasquotank River to the north and ground-water levels at the site range from 1.5-2.0 m (4.9 - 6.6 ft) below ground surface (bgs). Ground-water flow velocity is extremely variable with depth, ranging from 0.3 to 8.6 m/day (Wilkin et al., 2002). Site characterization studies conducted by National Risk Management Research Laboratory (NRMRL) personnel revealed the presence of a chromium plume about 35 m wide which extends to 6.5 m below ground surface and extends laterally about 60 m from the hangar to the Pasquotank River (Figure 1.3). An overlapping trichloroethene (TCE) plume was also discovered. Maximum aqueous concentrations in excess of 10 mg/L Cr and 19 mg/L TCE have been detected at the site since 1991 (Puls et al., 1999a).

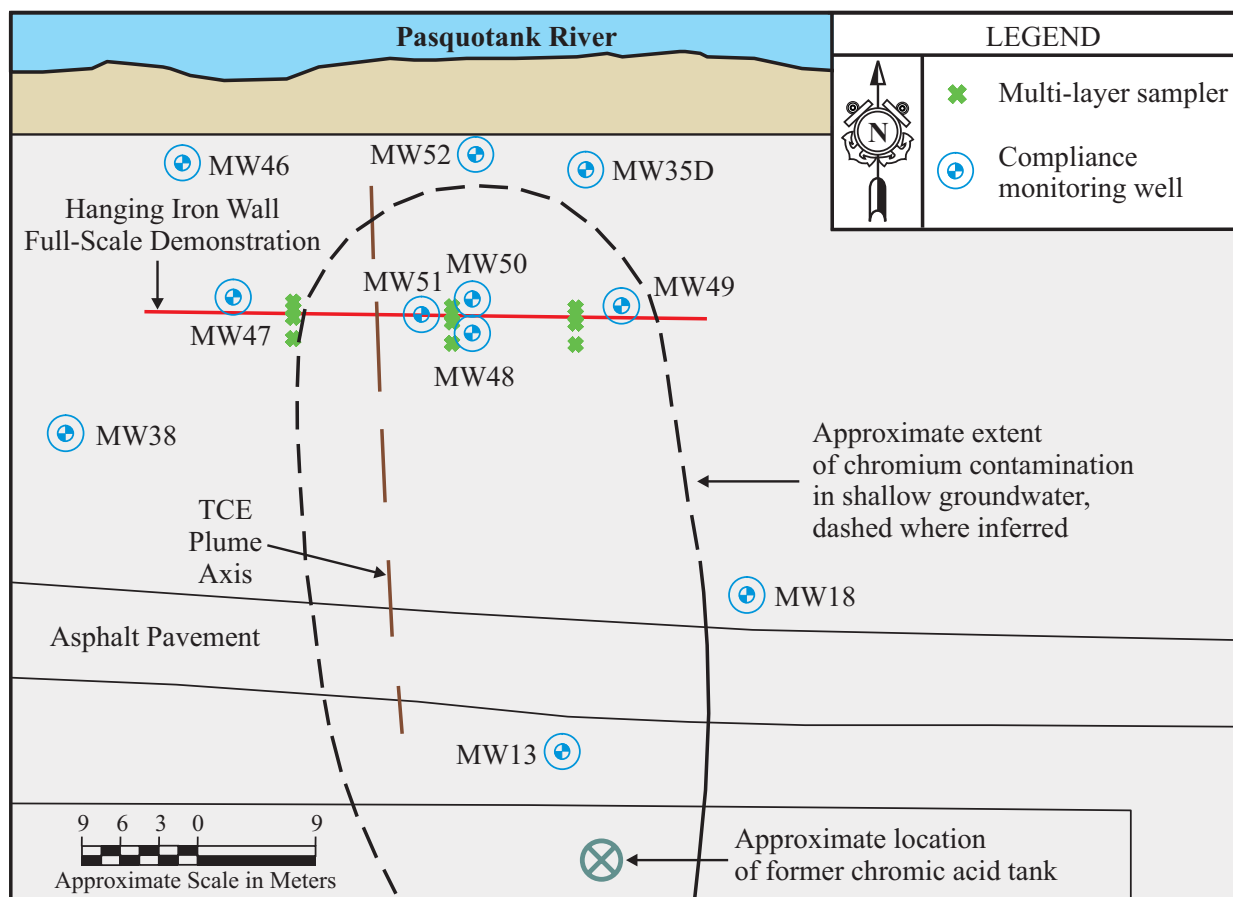
Laboratory studies and a field-scale pilot study using zero-valent iron led to the installation of an *in situ* permeable reactive barrier (PRB) in June 1996 at the site to remediate the chromate plume (Puls et al., 1999a; 1999b) and portions of an overlapping TCE plume. The USCG PRB was installed in a hanging wall design where granular iron was emplaced into the subsurface in a 46 m long, 7.3 m deep and 0.6 m wide trench perpendicular to the contaminant plume (Puls et al., 1999b). The performance objective of the PRB was to reduce ground-water concentrations of Cr(VI), TCE, and degradation products to levels below regulatory target limits. The PRB was installed in a continuous, hanging wall fashion 46 m long, 7.3 m deep, and 0.6 m wide using zero-valent iron.



**Figure 1.1** Location of the U.S. Coast Guard Support Center site in relation to Elizabeth City, NC (after Puls and Paul, 1997).



**Figure 1.2** Proximity of the U.S. Coast Guard Support Center to the Pasquotank River.



**Figure 1.3** Location of the chromium plume and permeable reactive barrier at the Elizabeth City site (after Puls et al., 1999a).

## 1.2 Site Description: Denver Federal Center, Lakewood, Colorado

The Denver Federal Center (DFC) site is located near Lakewood, CO, about 10 km west of downtown Denver, Colorado (Figure 1.4). Site geology is described elsewhere (McMahon et al., 1999; Wilkin et al., 2002). The site is contaminated primarily with TCE, *cis*-dichloroethene (*cis*-DCE), 1,1,1-trichloroethane (TCA), and 1,1-dichloroethene (1,1-DCE) from a leaking underground storage tank used by the Federal Highway Administration (FHWA) to store waste and other contaminant sources. Maximum concentrations for TCE, *cis*-DCE, and 1,1,1-TCA were 700 µg/L, 360 µg/L, and 200 µg/L, respectively. Ground water generally moves from west to east with an average hydraulic velocity of approximately 0.3 m/day.

A permeable reactive barrier was installed in the fall of 1996 at the eastern edge of the property by FHWA and the General Service Administration (GSA). Unlike the continuous wall design at the USCG, a funnel and gate approach was used at the DFC because of a long plume front that exceeds 350 m in length. This design uses metal sheet pile driven to the bedrock or resistance in the formation. The depths of the funnel ranged from 7.0 to 10.0 m. The PRB consists of four reactive gates, each 12.2 m long and up to 9.5 m deep. Gate widths are 1.8 m for Gate 1, 1.2 m for Gate 2, and 0.6 m for Gates 3 and 4 (Wilkin et al., 2002). Gate thickness varied due to expected differences of contaminant fluxes at each gate location.



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## 2.0 Monitoring Network

### 2.1 U.S. Coast Guard Support Center, Elizabeth City, NC

#### 2.1.1 Monitoring Wells.

At the Elizabeth City (EC) site, ten 5-cm monitoring wells were installed in the vicinity of the PRB for long-term monitoring of ground-water quality and regulatory compliance (Figure 2.1) (Wilkin et al., 2002). The monitoring wells were constructed of 5-cm diameter schedule 40 PVC with 0.25-mm slotted screens. Two wells (MW13, MW48) were installed upgradient of the PRB to monitor contaminant concentrations entering the PRB. MW38 and MW18 were installed upgradient of the PRB and on the outer perimeters of the plume to monitor background concentrations. Five wells (MW46, MW47, MW49, MW50 and MW52) were installed downgradient of the PRB to monitor contaminant concentrations as ground water passes through the PRB (see Table 2.1 for individual well details). An additional well, MW35D, was installed downgradient of the PRB near the river to monitor contaminant concentrations in the lower portion of the aquifer. These compliance wells were installed using a hollow stem auger (Parsons Engineering Science, 1995) and were sampled on a quarterly basis from June 1997 through September 2001. The North Carolina Department of Environmental and Natural Resources (NCDENR) reduced sampling requirements to a biannual basis beginning in March 2002. Ground-water data for the monitoring wells are shown in Appendix A.

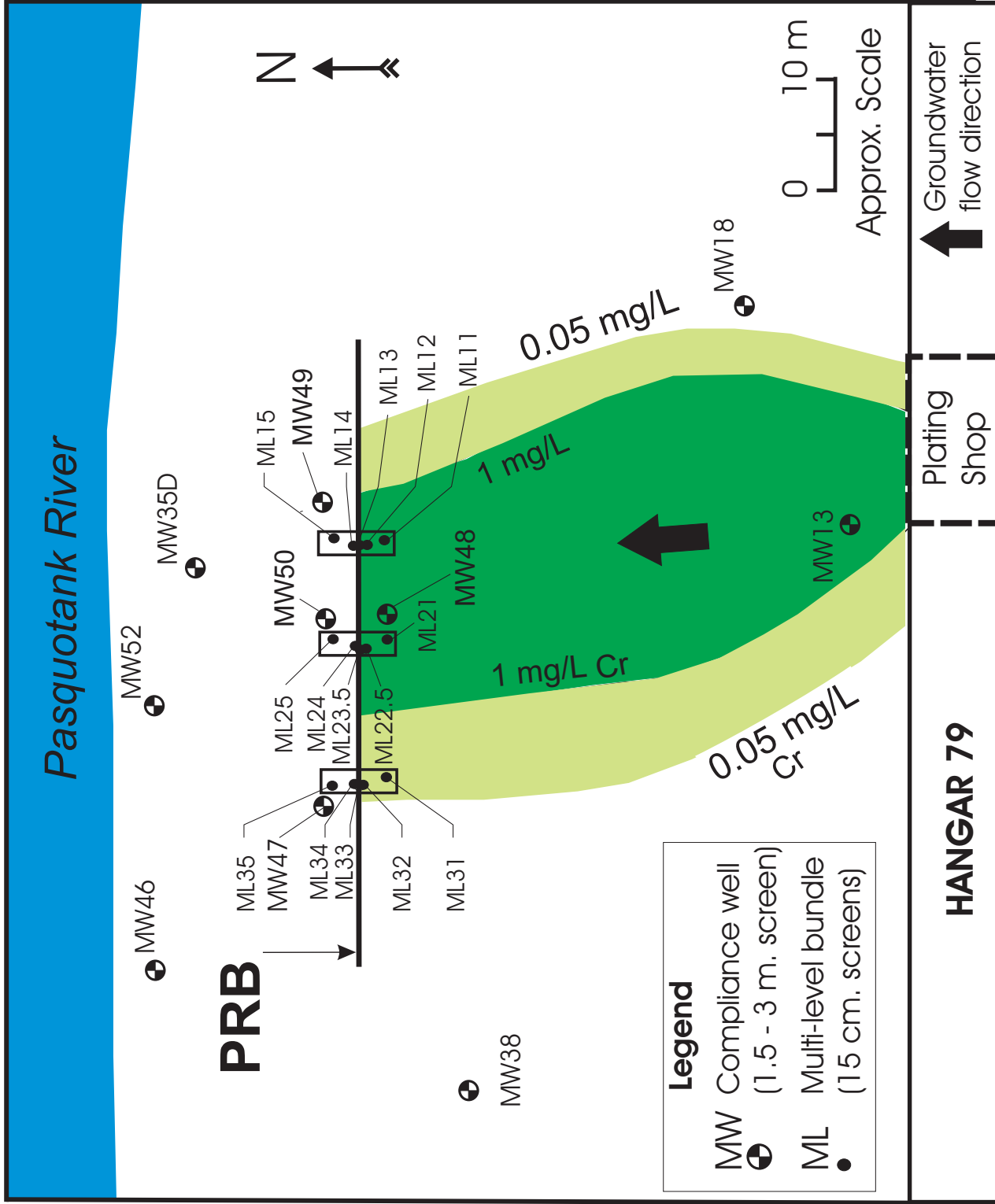
#### 2.1.2 Multi-Level Samplers (MLS)

An additional monitoring network was installed across the PRB for monitoring the performance of the reactive barrier. This network consists of two multi-level sampling bundles (Transects 1 and 3) and one set of well clusters (Transect 2) (Figure 2.1). Six of the multi-level sampling bundles in Transects 1 and 3 (ML11, ML14, and ML15; ML31, ML34, and ML35) are composed of ten 0.32-cm i.d. Teflon® sampling tubes. Four of the multi-level sampling bundles (ML12, ML13, ML32 and ML33) are composed of ten 0.95-cm i.d. (0.95 cm) Teflon sampling tubes. A 15-cm slotted, stainless steel wire screen is attached at the end of each sampling tube. Transect 2 is composed of seven 1.25-cm i.d. schedule 80 PVC wells. These wells are fitted with 15-cm slotted screens over the bottom section with 0.025-cm slots (see Table 2.2 for individual MLS details). Transect 2 originally consisted of five clusters of seven 1.25-cm i.d. PVC wells; however, it was determined by electrical conductivity surveys and core sampling that ML22 and ML23 were not located where originally thought. Therefore, two additional clusters (ML22.5 and ML23.5) composed of tubing bundles in the manner of Transects 1 and 3 were installed to replace ML22 and ML23. Upgradient and downgradient bundles or well clusters (ML11, ML15, ML21, ML25, ML31, and ML35) were installed using a 7-cm i.d. hollow stem auger. Bundles located on the fringes of the PRB (ML12, ML13, ML22, ML22.5, ML23, ML23.5, ML32, and ML33) and within the PRB (ML14, ML24, and ML34) are located within roadboxes and were installed using 3.75-cm E/W flush joint drive casing to minimize disturbance within the vicinity of the iron barrier.

Although the MLS clusters were primarily installed for research purposes, results have been used to monitor the permeability of the wall. The MLS clusters ML1 and ML3 were not sampled on a regular basis; therefore, only data for ML2 are included in this report (Appendix C).

### 2.2 Denver Federal Center, Lakewood, CO

The funnel and gate design at the DFC is composed of 24 monitoring wells. Gate 1 consists of six 5-cm i.d. wells (GSA21, GSA20, C1-GU1, C1-GD1, C1-I1, and C1-I2). Gate 2 consists of five 5-cm i.d. wells (GSA-26, GSA-25, C2-GU2, C2-I1, and C2-I2) and five 2.5-cm i.d. wells (C2-USGS4, C2-USGS5, C2-USGS10, C2-USGS11, and C2-USGS13). Gate 3 consists of six 5-cm wells (GSA-31, GSA-30, C3-GU2, C3-I1, C3-I2, and C3-GD2) and two 2.5-cm i.d. wells (C3-USGS6 and C3-USGS9). Gate 4 never functioned properly. Therefore, it was not sampled consistently, and no data are included in this report. All wells were constructed of schedule 40 PVC with standard 20 slot screens. Individual well information is given in Table 2.3. Approximately 18 were sampled annually in 1999 and 2000. While wells were sampled quarterly since installation of the PRB, the sampling methodologies discussed in this paper were only initiated in 1999; therefore, previous data are not included but can be found in Pacific Western Technology (2000). Only data collected by the U.S. EPA for 1999, 2000, 2001 are included in this report (Appendix B). Well locations are shown in Figures 2.2, 2.3, and 2.4.



**Figure 2.1** Monitoring well and multi-level sampler locations at the U.S. Coast Guard Support Center site (after Wilkin et al., 2002).

**Table 2.1.** Elizabeth City Site Monitoring Well Information

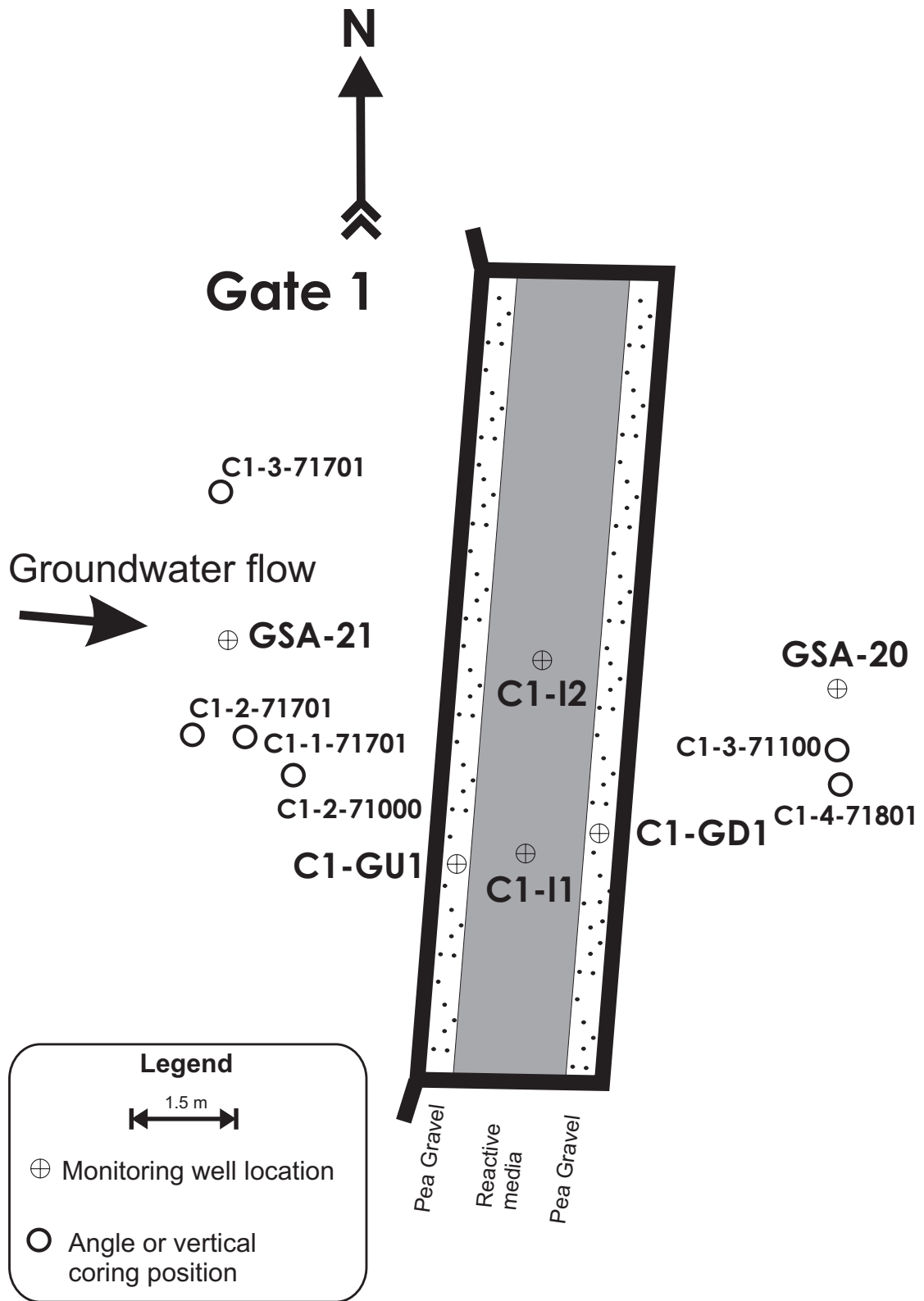
Well ID	Well Diameter (cm)	Screen Length (m)	Depth to Water (m bls)	Well Depth (m bls)
MW13	5.08	1.54	1.88	4.5
MW18	5.08	1.54	1.63	4.5
MW35D	10.2	3.05	1.80	19.2
MW38	5.08	3.05	1.43	7.3
MW46	5.08	3.04	1.19	7.3
MW47	5.08	3.05	1.39	7.3
MW48	5.08	3.05	1.33	7.3
MW49	5.08	3.05	1.43	7.3
MW50	5.08	1.54	1.62	9.7
MW52	5.08	6.10	1.34	9.5

**Table 2.2.** Multi-level Sampler Depths (m) below Land Surface (bls) at the Elizabeth City Site

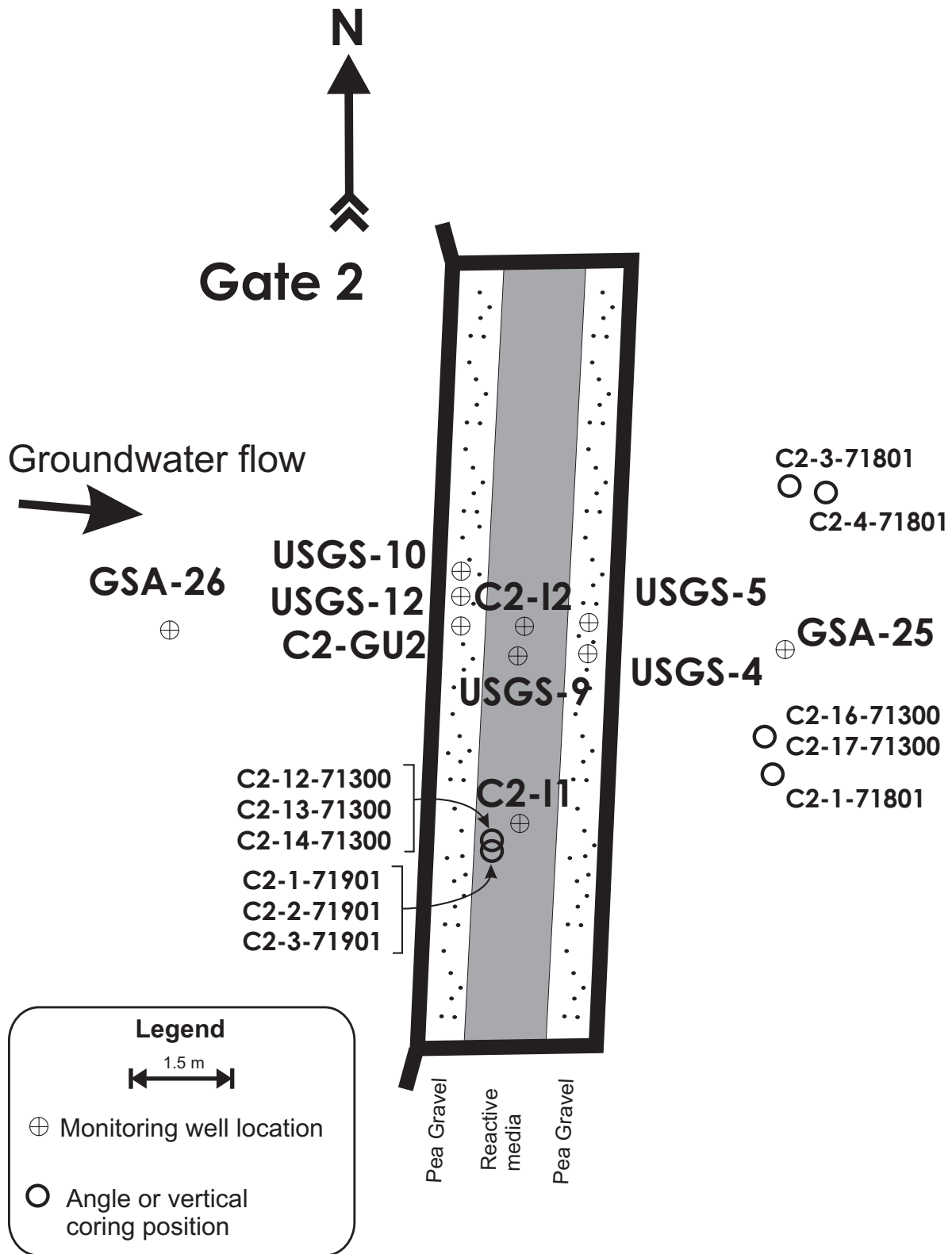
ML21		ML22		ML22.5		ML23		ML23.5		ML24		ML25	
Well ID	Depth	Well ID	Depth	Well ID	Depth	Well ID	Depth	Well ID	Depth	Well ID	Depth	Well ID	Depth
ML21-1	7.0	ML22-1	7.0	ML22.5-0	7.2	ML23-1	7.0	ML23.5-0	7.2	ML24-1	7.0	ML25-1	7.0
ML21-2	6.5	ML22-2	6.5	ML22.5-1	7.0	ML23-2	6.5	ML23.5-1	7.0	ML24-2	6.5	ML25-2	6.5
ML21-3	6.0	ML22-3	6.0	ML22.5-2	6.5	ML23-3	6.0	ML23.5-2	6.5	ML24-3	6.0	ML25-3	6.0
ML21-4	5.5	ML22-4	5.5	ML22.5-3	6.0	ML23-4	5.5	ML23.5-3	6.0	ML24-4	5.5	ML25-4	5.5
ML21-5	5.0	ML22-5	5.0	ML22.5-4	5.5	ML23-5	5.0	ML23.5-4	5.5	ML24-5	5.0	ML25-5	5.0
ML21-6	4.5	ML22-6	4.5	ML22.5-5	4.5	ML23-6	4.5	ML23.5-5	4.5	ML24-6	4.5	ML25-6	4.5
ML21-7	4.0	ML22-7	4.0	ML22.5-6	4.5	ML23-7	4.0	ML23.5-6	4.5	ML24-7	4.0	ML25-7	4.0
				ML22.5-7	3.5	ML23-8	3	ML23.5-7	3.5				
				ML22.5-8	3			ML23.5-8	3				

**Table 2.3.** Denver Federal Center Site Monitoring Well Information

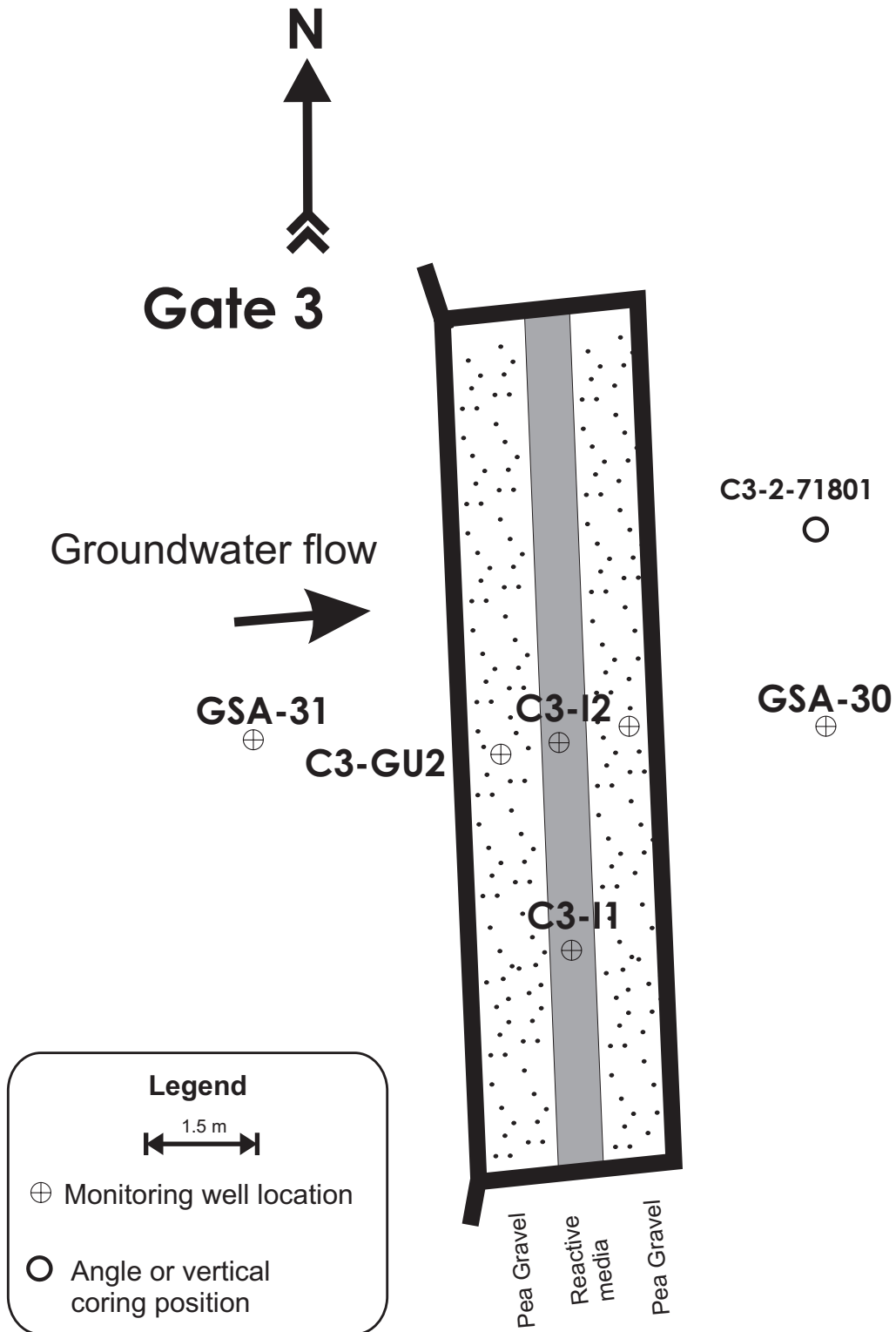
Well ID	Well Diameter (cm)	Screen Length (m)	Depth to Water (m bls)	Well Depth (m bls)
<b>Gate 1</b>				
GSA-21	5.08	6.10	2.77	8.53
GSA-20	5.08	6.10	4.33	8.53
C1-GU1	5.08	3.05	4.51	6.10
C1-GD1	5.08	3.05	4.33	6.10
C1-I1	5.08	3.05	4.45	6.10
C1-I2	5.08	3.05	4.48	6.10
<b>Gate 2</b>				
GSA-26	5.08	6.10	2.56	9.14
GSA-25	5.08	6.10	4.66	9.75
C2-GU2	5.08	3.05	3.44	8.53
C2-I1	5.08	3.05	4.21	8.53
C2-I2	5.08	3.05	4.15	8.53
C2-USGS4	2.54	1.54	4.05	8.53
C2-USGS5	2.54	1.54	4.02	8.53
C2-USGS10	2.54	1.54	4.18	8.53
C2-USGS11	2.54	1.54	4.18	8.53
C2-UGS13	2.54	1.54	4.21	8.53
<b>Gate 3</b>				
GSA-31	5.08	7.62	1.80	4.57
GSA-30	5.08	7.62	4.70	4.57
C3-GU2	5.08	7.62	1.89	3.05
C3-I1	5.08	7.01	1.89	3.05
C3-I2	5.08	7.01	1.92	3.05
C3-GD2	5.08	7.01	2.04	3.05
C3-USGS6	2.54	7.01	2.07	3.05
C3-USGS9	2.54	6.71	1.92	3.05



**Figure 2.2** Monitoring well locations in Gate 1 at the Denver Federal Center site.



**Figure 2.3** Monitoring well locations in Gate 2 at the Denver Federal Center site.



**Figure 2.4** Monitoring well locations in Gate 3 at the Denver Federal Center site.



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## 3.0 Ground-Water Sampling

### 3.1 Monitoring Wells

Ground-water sampling criteria used at the USCG and the DFC sites were established based on equipment specifications as well as historical plots generated for all wells and sampling points at each site. Dedicated Grundfos® Redi-Flo2 submersible pumps, attached to dedicated Teflon-lined tubing, were used to sample the 5-cm diameter monitoring wells at the USCG site. Portable Grundfos® Redi-Flo2 submersible pumps were used to sample the 5-cm wells at the DFC site. The pumps were installed in the wells 24 hours prior to sampling to allow for equilibration of the adjacent formation and to minimize adverse impacts on samples due to disturbance caused by pump installation. Several wells at the DFC site are 2.5-cm i.d. Due to the small diameter and shallow water levels at the site (<9-m), a peristaltic pump was used for sampling these wells. PharMed® pharmaceutical grade pliable tubing was used in the peristaltic pump head and replaced prior to sampling each well. PharMed® tubing was used because it is more durable and less permeable to gases and vapors than silicone tubing. Peristaltic pumps apply a vacuum to ground-water samples which can result in depressurization and possible degassing of the sample during collection. Observation of air bubbles in the sample tubing during pumping is indicative of sample degassing and adverse impacts on VOC concentrations. The use of PharMed® tubing on the pump head and Teflon®-lined sample tubing can minimize these adverse impacts on sample quality.

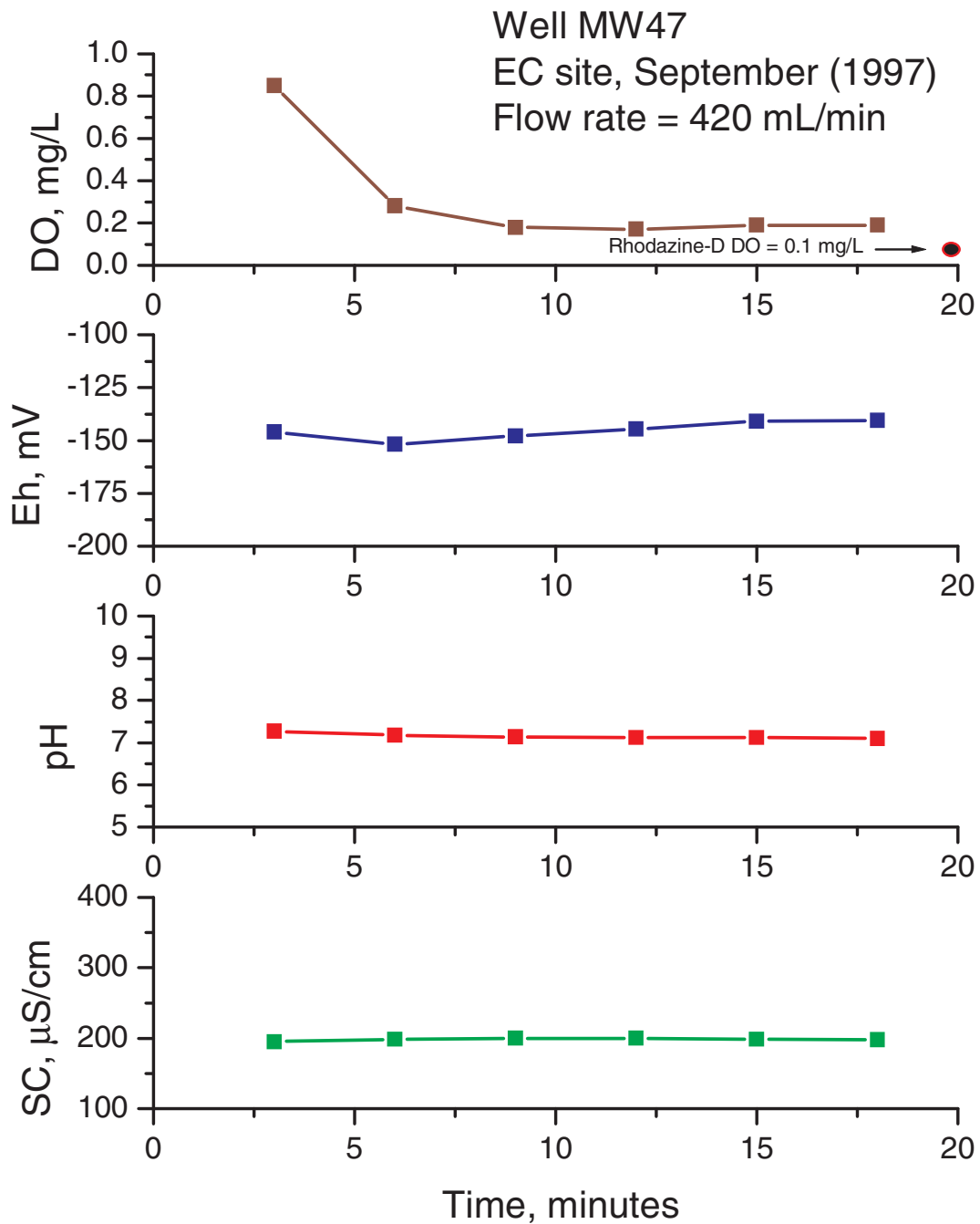
The pump intake was placed at mid-screen in all monitoring wells. Low-flow purging and sampling techniques (Puls and Barcelona, 1996; Puls and Paul, 1995) were employed at both field sites. Low-flow refers to the velocity at which water enters the pump intake and should be the same as the recharge within the well (Puls and Barcelona, 1996), generally <500 mL/min during both purging and sampling. Water levels were measured in the 5-cm i.d. wells prior to pumping and periodically throughout purging and sampling to monitor draw-down for flow rate adjustment. Flow-rate generally ranged from 240 to 420 mL/min for the 5-cm wells at the USCG site and from 80 to 140 mL/min for the 2.5-cm i.d. wells and approximately 300 mL/min for the 5-cm i.d. wells at the Denver Federal Center site. Monitoring well data for the USCG and DFC sites are given in Appendices A and B, respectively.

### 3.2 Multi-level Samplers

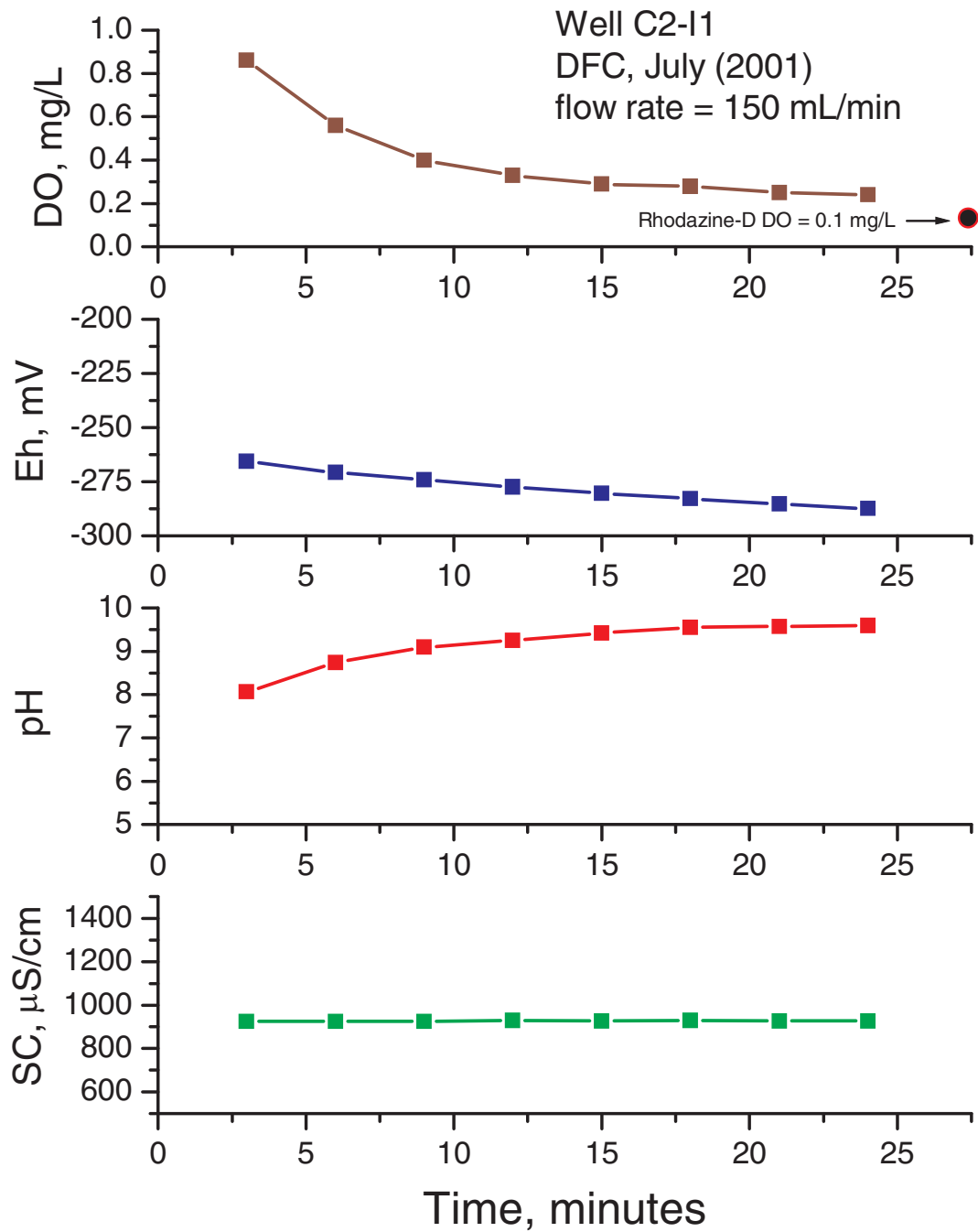
A peristaltic pump was used to sample the multi-level transects at the USCG site due to the small diameter of the wells and the shallow depth to water. PharMed® pliable tubing was used in the peristaltic pump head and replaced prior to sampling each well. Each sampling port in ML21, ML22, ML23, ML24, and ML25 was equipped with dedicated Teflon-lined tubing with the intake placed approximately 2.54 cm above the bottom of the well screen. Transects 1 and 3 and ML22.5 and ML23.5 consisted of tubing bundles which were directly connected to the pump intake for purging and sampling. Multi-level sampler data for the USCG site are given in Appendix C.

### 3.3 Geochemical Parameters

Water quality indicator parameters (WQPs) were monitored during purging until stabilized to determine when formation water was accessed prior to collecting water samples (Puls and Paul, 1995). A multi-parameter instrument with a flow-through cell (YSI® Sonde) equipped with an automated data logger was used initially to monitor WQPs for the monitoring wells at the USCG site while a smaller volume Geotech® flow-through cell (250 mL volume), equipped with individual electrodes and manual readings, was used for the small diameter multi-level samplers. This set-up was eventually adopted for all of the monitoring wells at both field sites. Parameters monitored included pH, oxidation-reduction potential (ORP), specific conductance, dissolved oxygen (DO), temperature, and turbidity. Individual electrodes for ORP, pH, specific conductance, and DO were inserted in the flow-through cell and connected to appropriate meters for measurements during purging. Water was allowed to flow through the cell until WQPs reached equilibration and sampling was initiated. Initially, WQPs were recorded at three-minute intervals until equilibration was achieved (Figures 3.1 and 3.2). Equilibration was defined as three successive readings within  $\pm 10$  percent for DO and turbidity,  $\pm 3$  percent for specific conductance,  $\pm 5$  mV for ORP, and  $\pm 0.05$  for pH (Puls and Paul, 1995). Temperature was recorded for adjustment of specific conductance and ORP measurements. Turbidity of unfiltered ground water was measured separately, in nephelometric turbidity units (NTUs), using a Hach® 2100P portable turbidimeter. Where possible, the well was purged until turbidity was <5 NTUs, which allowed for less interference with colorimetric indicators and spectrophotometric determinations.



**Figure 3.1** Equilibration of water quality parameters in monitoring well MW47 at the Elizabeth City site in September 1997.



**Figure 3.2** Equilibration of water quality parameters in monitoring well C2-I1 at the Denver Federal Center site in July 2001.

After evaluation of historical WQP data, a purge volume was calculated for each monitoring well and multi-level sampler. Following establishment of the purging volumes, each sampling point was pumped to remove the appropriate volume of water and then the tubing was connected to the multi-port flow cell. The cell was allowed to flow for five minutes to allow for electrode stabilization and then WQP measurements were recorded. It should be noted that some parameters, particularly DO, are more sensitive than others (Wilkin et al., 2001) and should be evaluated carefully with time over several sampling events before establishing a sampling protocol.

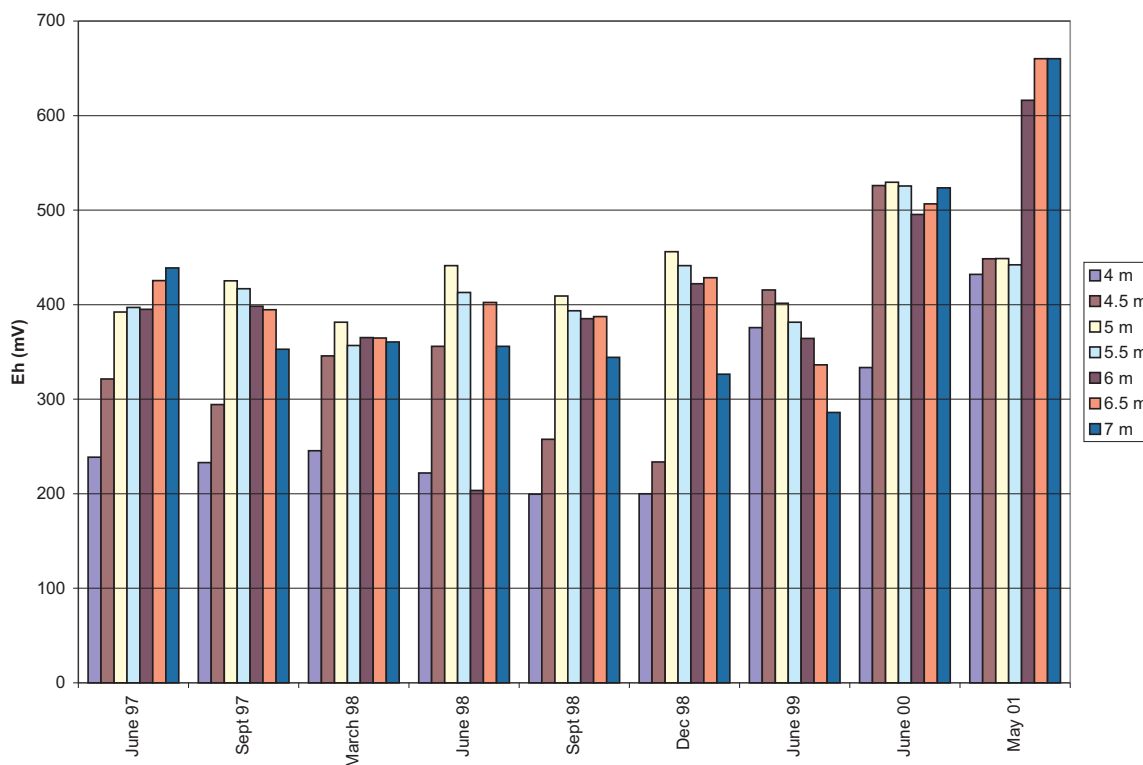
### 3.3.1 Oxidation-Reduction Potential (ORP)

Oxidation-reduction potential (ORP) is an overall measure of the state of oxidation or reduction of a ground-water sample. An Orion® 9678 BN ORP platinum electrode filled with an Ag/AgCl (Orion® #900011) reference electrode and saturated KCl filling solution was used to determine ORP values in millivolts (mV). These measurements were then converted to Eh values by using measured temperature values in order to establish standard hydrogen electrode (SHE) corrections. Measured ORP values were converted to Eh values by adding the difference between the measured ORP of the reference solution and the theoretical ORP of the reference solution. Electrode checks were performed each morning prior to purging and periodically throughout the sampling event to ensure proper electrode performance. ORP standard (Orion® #967961) was used to perform ORP electrode checks where the measured value of the standard was  $220 \pm 3$  mV at 25°C. The platinum electrode was cleaned at the end of each sampling day and stored according to manufacturer’s guidelines.

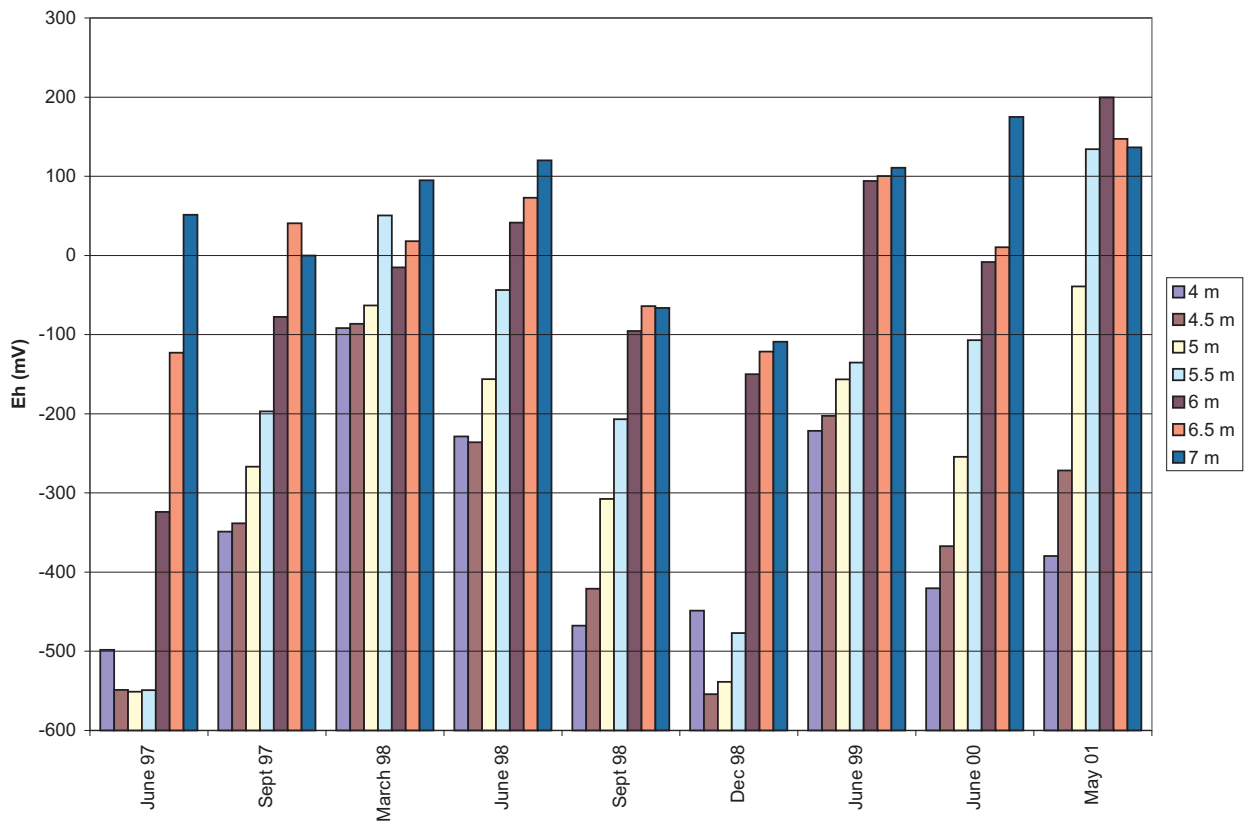
ORP electrodes can be erratic when used in ground water and often do not stabilize rapidly (U.S. EPA, 2002). Measurements should be recorded at appropriate time intervals with the understanding that values can change by several mV while recording a reading.

#### 3.3.1.1 ORP comparison over time

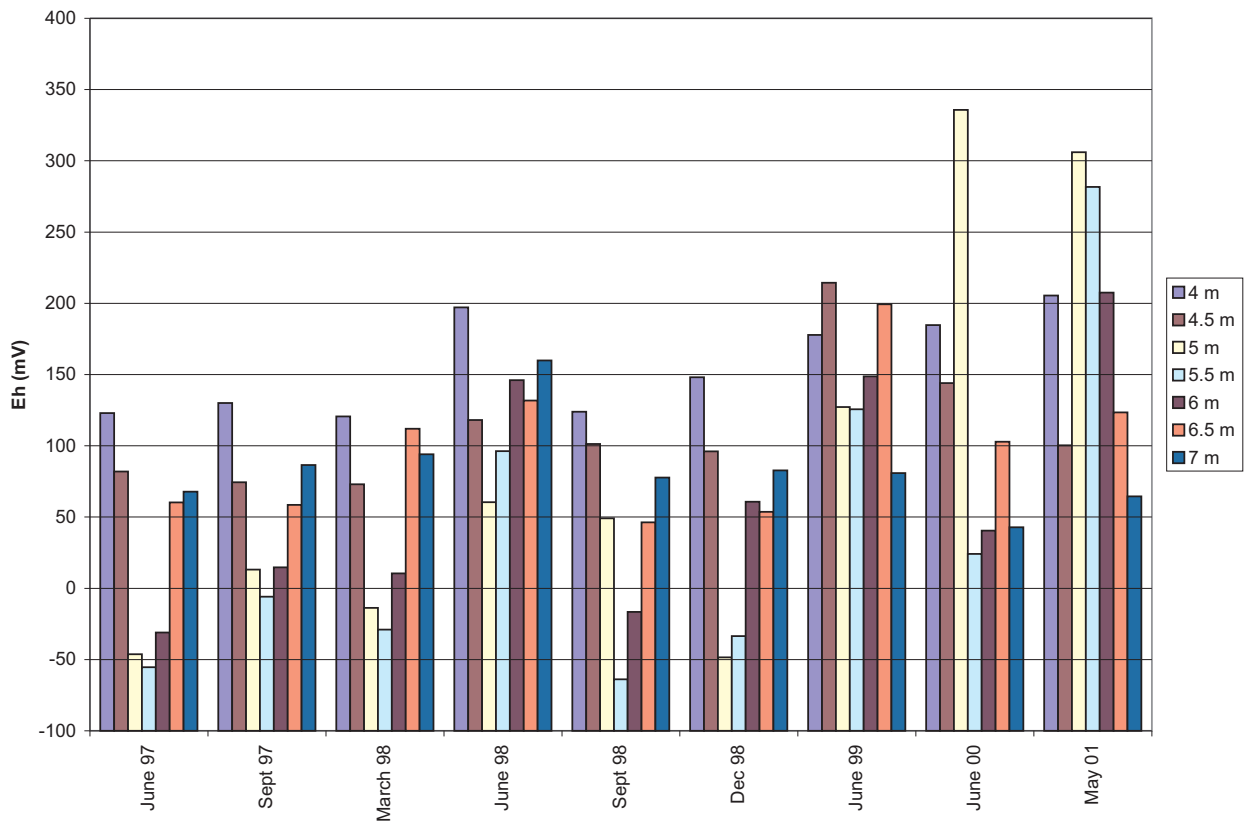
At the USCG site, ORP of the upgradient ground water generally ranged from 200-660 mV. The ORP decreased sharply as ground water entered the barrier, dropping to less than -500 mV in several locations. Values in the treated downgradient water increased, but not to upgradient levels. Figures 3.3, 3.4, and 3.5 compare ORP values over time in ML21 (upgradient of the barrier), ML24.5 (within the barrier), and ML25 (downgradient of the barrier) multi-level samplers in Transect 2. Only slight variation is seen over time until June 2000, where values increased by approximately 100 mV. A sharp increase was seen in the deeper locations in May 2001. Within the barrier, values fall to almost -200 mV by



**Figure 3.3** Upgradient Eh values in ML21 from June 1997 through May 2001 at the U.S. Coast Guard site.



**Figure 3.4** Eh values within the barrier in ML24 from June 1997 through May 2001 at the Elizabeth City site.



**Figure 3.5** Downgradient Eh values in ML25 from June 1997 through May 2001 at the Elizabeth City site.

December 1998, but then show sharp increases in the more shallow depths. Lower values are generally seen at the 5-5.5 m depths in ML25 downgradient of the barrier; however, values are significantly lower than in upgradient locations. Values increased in both ML21 and ML25 in June 2000 and May 2001. ORP data for the monitoring wells at the USCG site are given in Table A1. Multi-level sampler ORP data are given in Table C1.

### 3.3.2 pH

Values for pH tend to stabilize very quickly and this is generally one of the first parameters to reach equilibrium with the formation water (Figures 3.1 and 3.2). pH was measured using an Orion® 9107 BN low maintenance triode or Orion 9107 WP pH electrode. A two-point calibration, using either pH 4.00, pH 7.00, or 10.00 buffer solution (VWR #34170-127, #34170-130, or #34170-133, respectively), was performed each morning and periodically throughout the sampling day. Buffers used for calibration were selected based on expected pH ranges in each sampling point or monitoring well. The electrode was cleaned at the end of each sampling day and stored according to manufacturer’s guidelines.

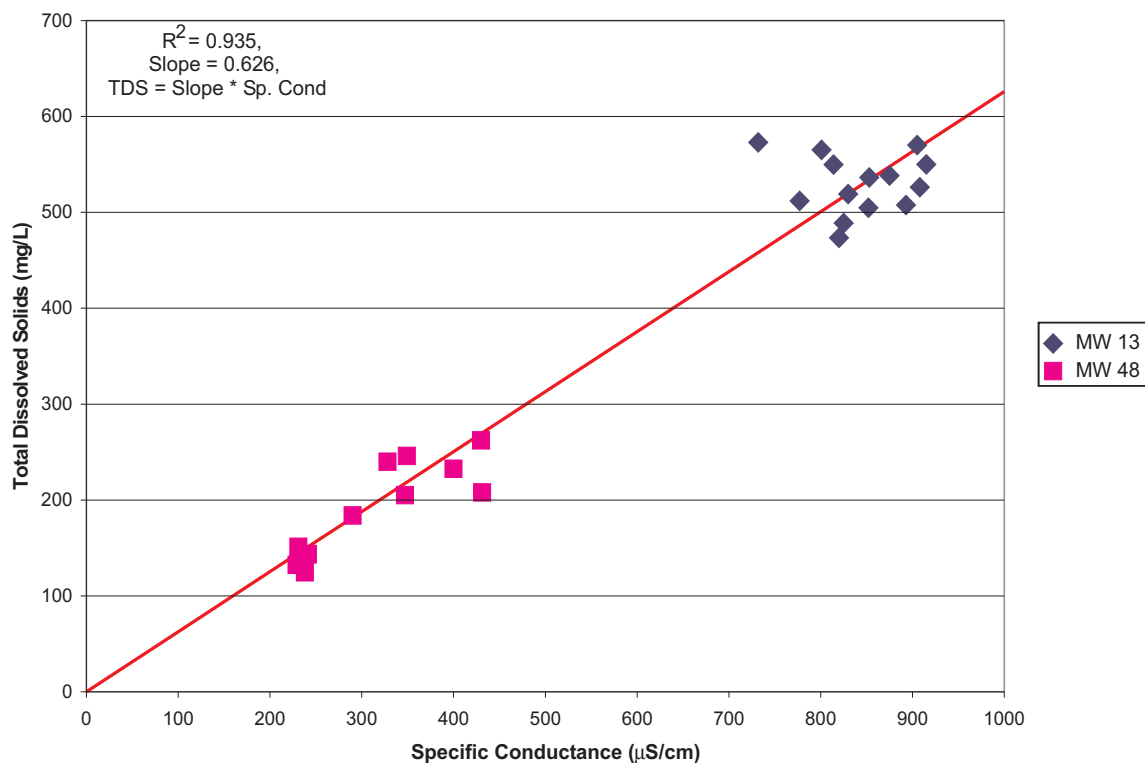
The pH of the upgradient or untreated ground water ranged from 5.6 to 6.5 with a significant increase up to 10.3 within the barrier. Values begin to drop in the downgradient or treated water, suggesting that treated water is being neutralized after flowing through the barrier.

### 3.3.3 Specific Conductance

Specific conductance is usually the first parameter to equilibrate and readings are generally stable (Figures 3.1 and 3.2). One of two types of electrodes was used to measure specific conductance in the field, either an Orion® 013010 conductivity cell with model 1230 meter or an Orion® 011050 specific conductance cell with model 105 meter. Calibration in the field was performed using Oakton® standard 1413 µS at 25°C. The electrode was calibrated each morning prior to initiating purging and checked periodically throughout each sampling day. The electrode was cleaned at the end of each sampling day and stored according to manufacturer’s guidelines.

#### 3.3.3.1 Specific conductance comparison with total dissolved solids

Total dissolved solid (TDS) values were calculated for MW13, MW48, and ML21 at the USCG site and Gates 1, 2, and 3 at the DFC site. TDS values were determined adding alkalinity, sulfate, chloride, sodium, potassium, calcium, magnesium, and iron values. These values were then compared to specific conductance values obtained in the field from the same locations. Figure 3.6 shows regression analysis for MW13 and MW48 comparing TDS and specific

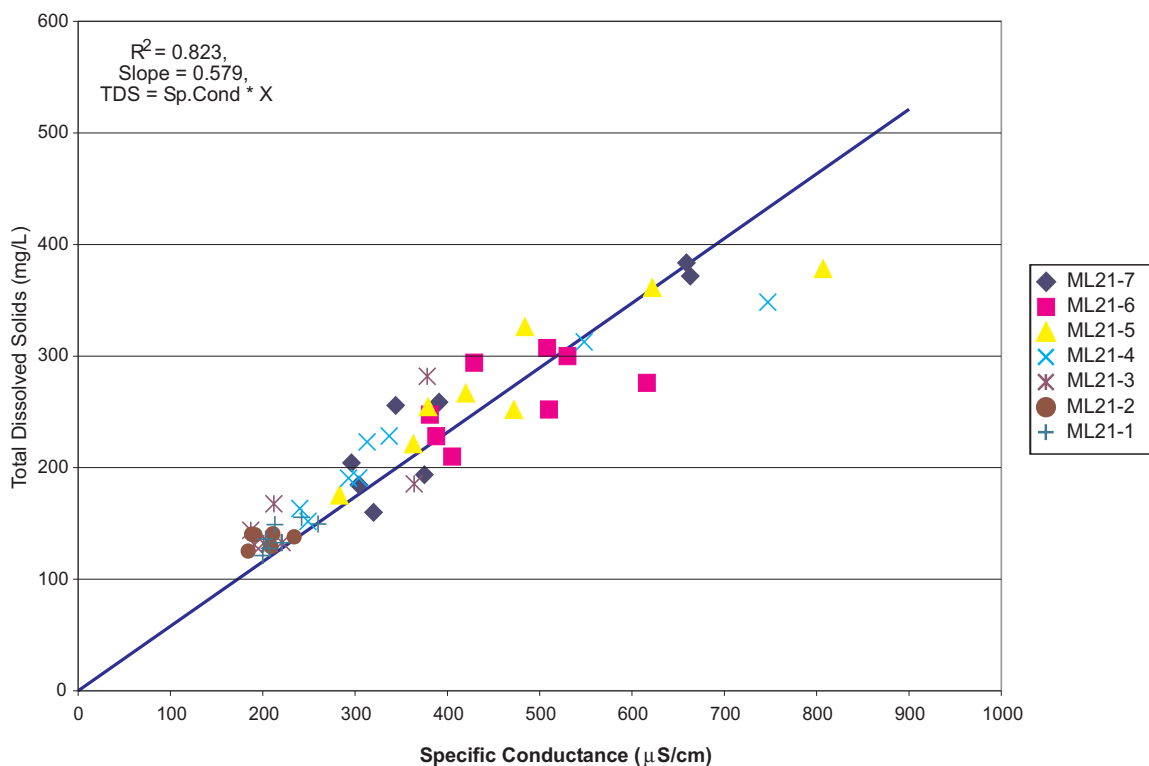


**Figure 3.6** Analysis of MW13 and MW48 comparing total dissolved solids with specific conductance values at the Elizabeth City site.

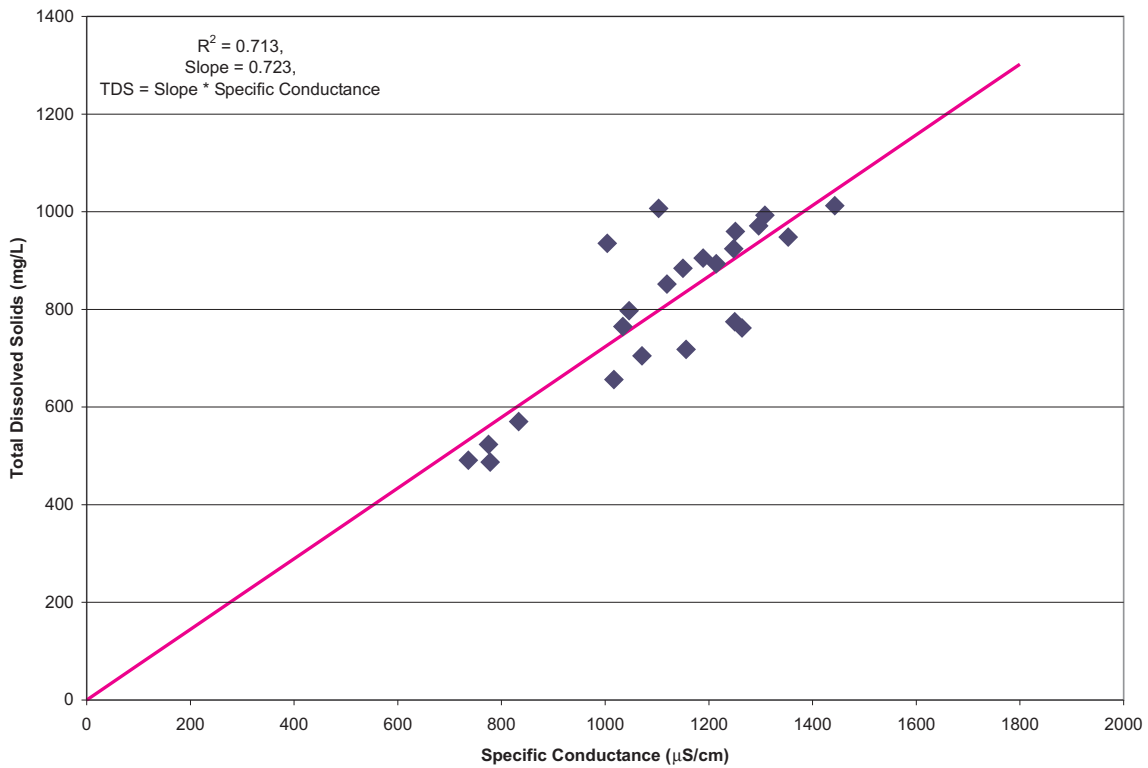
conductance. Excellent correlation was seen with an  $R^2$  value of 0.94 and a slope of 0.63. A similar trend was seen in ML21 with an  $R^2$  value of 0.82 and a slope of 0.58 (Figure 3.7). TDS and specific conductance data for the DFC site are shown in Figures 3.8, 3.9, and 3.10. The good correlation between TDS and specific conductance values indicates that measuring specific conductance in the field is a useful indicator of TDS. Mineral precipitation reactions within iron walls remove dissolved solutes from ground water and result in a lowering of TDS and specific conductance values. Monitoring relative changes in specific conductance values between upgradient, iron barrier, and downgradient locations is a reasonable indicator of potential fouling of the iron wall due to mineral precipitation. However, it should be noted that in addition to mineral precipitation processes, corrosion of iron granules also results in the release of  $\text{OH}^-$  ions (pH increase). The equivalent conductance of  $\text{OH}^-$  ions is comparatively greater than other important anions such as carbonate, bicarbonate, and sulfate. Consequently, changes in specific conductance values may not in all cases be a reliable indicator of changes in solute loads. For example, if  $\text{OH}^-$  becomes a major anion, it is possible to have a drop in TDS accompanied by an increase in specific conductance. Nevertheless, at both the Elizabeth City and Denver Federal Center sites, ground water within the reactive walls is characteristically lower in specific conductance compared to ground water in upgradient locations.

### 3.3.4 Dissolved Oxygen

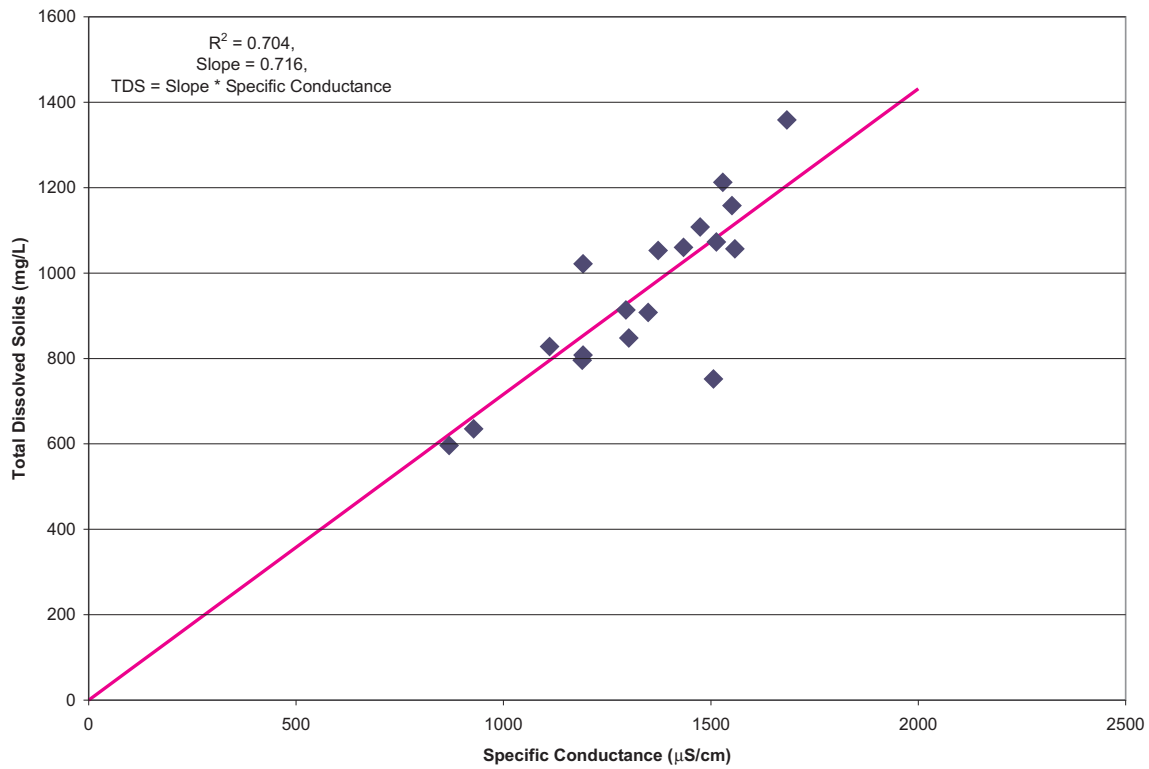
Historically, membrane-covered dissolved oxygen electrodes have been used in the field due to their ease of use and practicality. However, membrane fouling is a common difficulty, and measurements can be inaccurate without any indication (Wilkin et al., 2001). Therefore, several types of probes were used at both field sites for comparison purposes. The rhodazine D (1 to 40 ppb and 0 to 1 ppm) and indigo carmine (1 to 12 ppm) colorimetric methods were used to verify the probe results. Probes used at these field sites included an Orion® 081010 electrode with model 810 meter, Orion® 0083010 DO probe with model 1230 meter, and YSI® 95 DO electrode and meter. It is important to consider potential interferences when using DO electrodes in the field. Several constituents in contaminated ground water may affect electrode accuracy. These include hydrogen sulfide, thio-organic and other organic compounds (Wilkin et al., 2001). Each probe was calibrated according to manufacturer’s recommendations prior to well sampling and rechecked



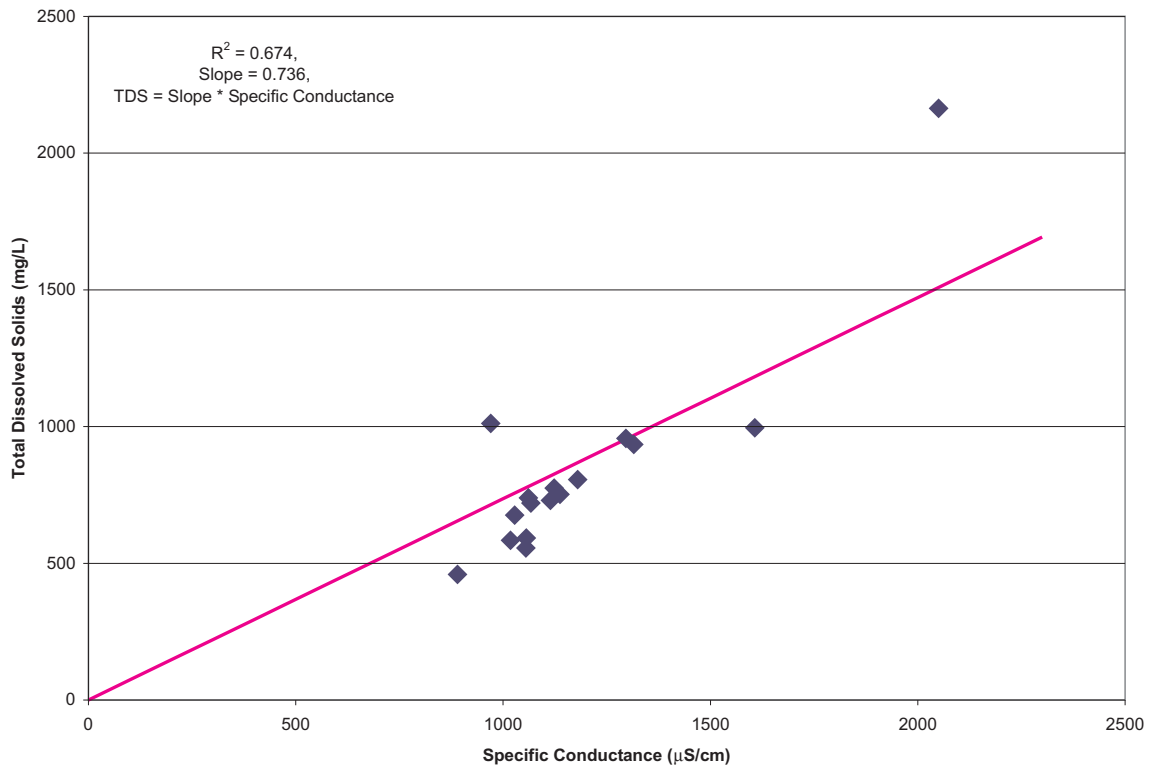
**Figure 3.7** Analysis ML21 comparing total dissolved solids with specific conductance values at the Elizabeth City site.



**Figure 3.8** Analysis of Gate 1 comparing total dissolved solids with specific conductance values at the Denver Federal Center site.



**Figure 3.9** Analysis of Gate 2 comparing total dissolved solids with specific conductance values at the Denver Federal Center site.



**Figure 3.10** Analysis of Gate 3 comparing total dissolved solids with specific conductance values at the Denver Federal Center site.

throughout the sampling day. This consisted of dampening (not soaking) the water reservoir sponge and placing it in the bottom of the autocal air calibration sleeve. The electrode was then inserted into the calibration sleeve and allowed to equilibrate for 30 minutes to one hour until calibration was achieved. When using the YSI® 95 DO electrode and meter at the Elizabeth City site, an altitude of 100 feet above sea level and salinity of 0 were entered prior to calibration. The altitude for the Denver Federal Center site was 5000 feet above sea level with a salinity value of 0. Manufacturer’s recommendations for probe storage were followed at the end of each sampling day.

### 3.3.5 Turbidity

Turbidity was measured in nephelometric turbidity units (NTUs) using a Hach® DR2100P portable turbidimeter. Following initial calibration with formazin standards, secondary standards were used in the field to ensure instrument accuracy. To measure turbidity in the field, a 10 mL sample of ground water was collected in the appropriate turbidity cell and placed in the turbidimeter. Manual readings were recorded until purging was complete. Manufacturer’s recommendations for turbidity calibration and measurements were followed.

### 3.3.6 Temperature

Temperature values were recorded during purging from either the YSI® Sonde or the specific conductance meter via the flow-through cell. Although temperature is not a critically important water quality parameter, it was used for adjustment of specific conductance, ORP measurements, and geochemical modeling of aqueous speciation. It is important to be aware that temperature values obtained at the surface from a flow-through cell are not necessarily reflective of ambient ground water temperatures. Factors such as the length of sample tubing connected to the flow-through cell and flow rate must be considered as well as ambient air temperature. Tubing should be minimized and the flow-cell should be out of direct sunlight where possible. Ground-water temperature values at the DFC and USCG sites generally ranged from 16.5 to 18°C.

## 3.4 Sample Collection

Following equilibration of the WQPs, the multi-probe cell was disconnected or bypassed from the flow path and samples were collected for field analyses. At the DFC site only, the first 25 mL was collected for hydrogen sulfide (H<sub>2</sub>S) analysis using the methylene blue colorimetric method. At both sites, water was allowed to flow through a CHEMets® overflow cell for at least three minutes and sampled with CHEMets® ampoules to determine DO and ferrous iron (Fe<sup>2+</sup>). A 50 mL aliquot was then collected for Fe<sup>2+</sup> determination with a field spectrophotometer using the 1,10 phenanthroline method for

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comparison purposes. At the USCG site, an aliquot was also collected to determine hexavalent chromium (Cr(VI)) concentrations. A 100 mL aliquot was collected at both sites for alkalinity (as CaCO<sub>3</sub>) determination. Field analytical methods used are discussed in section 5.0.

Samples were then collected for laboratory analyses. Unfiltered ground water was collected in two 40 mL volatile organic analysis (VOA) vials for volatile organic contaminants (VOCs) and one 60 mL glass serum bottle was filled for dissolved gas analyses. Samples were collected by placing the tubing in the bottom of the vial, filling the vial to overflowing, and then slowly removing the tubing to allow for zero headspace. Each sample was acidified with one drop of concentrated ultra-pure sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) and immediately capped. Thirty mL polyethylene bottles were used to collect unfiltered samples for major anions (no acidification) and initially used for collection of total organic carbon/dissolved organic carbon (TOC/DOC) samples (acidified with one drop of concentrated ultrapure H<sub>2</sub>SO<sub>4</sub>). As of May 2001, samples for carbon analyses were collected in 40 mL amber glass vials with no acidification due to an instrument change at the analytical laboratory. Filtered samples for cation analyses were collected into 60 mL polyethylene bottles using Gelman® high-capacity in-line 0.45-µm filters for the monitoring wells after allowing 500 mL ground water to flush the filter. Gelman® Aquaprep in-line 0.45-µm filters were used for the multi-level samplers. Samples were collected after flushing the filter with 100 mL of ground water. Cation samples were acidified with concentrated ultra-pure nitric acid (HNO<sub>3</sub>) to pH <2 for preservation. All samples were stored at 4°C after collection and during shipment to the Robert S. Kerr Environmental Research Center for analysis by ManTech Environmental Research Services Corporation, Ada, OK. See section 5.2 for laboratory analytical methods.

### **3.5 Quality Assurance/Quality Control Measures**

To ensure quality performance of the field equipment, all instruments were calibrated each morning prior to use following manufacturer's recommendations. Electrodes were checked at midday and at the end of each sampling day to check accuracy and proper electrode performance. The ORP electrode was calibrated and checked using ORP standard (Orion® #967961), where the measured value of the standard was 220 ± 3 mV at 25°C. Two-point pH calibration and checks were performed using either pH 4.00, pH 7.00, or 10.00 buffer solution (VWR #34170-127, #34170-130, or #34170-133, respectively). Specific conductance calibration and field checks were performed using Oakton® standard 1413 µS at 25°C. The DO electrode was calibrated and checked according to manufacturer's recommendations. Pre-calibrated secondary gel standards were used to check turbidimeter performance while in the field. Equipment accuracies are ± 2% for DO and turbidity, ± 3% for specific conductance, and ±0.05 standard units for pH. Determination of pH accuracy is based on repeated measurements of buffer solutions. For each sampling event, trip blanks, field blanks, and field duplicate samples were collected for quality control requirements.

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## 4.0 Soil Sampling

Continuous core samples of the iron walls and aquifer sediments from the Elizabeth City and Denver Federal Center PRBs were collected in order to assess the distribution of mineral and biomass concentrations. Both angled and vertical cores were collected (Beck et al., 2002). Prior to collecting core samples, an electrical conductivity profile was obtained to verify the exact position of the iron/aquifer interface. The method described here makes use of a conductivity probe (Christy et al., 1994; Beck et al., 2000) to locate soil conductivity changes due, for example, to the presence of a subsurface zone of highly conductive zero-valent iron. The conductivity probe, manufactured by Kejr Incorporated (Salina, KS), was advanced through the subsurface using a direct push (DP) device. This DP device was also equipped with a 5-cm inner diameter core barrel with plastic sleeves. Vertical and angled cores (30°) were collected to recover iron filings from different portions of the PRB systems investigated in this study. Angled cores were obtained to evaluate wall thickness and evaluate geochemical and microbiological changes occurring near the upgradient and downgradient interfaces of the wall. The conductivity probe provides real-time, specific conductance data versus depth on a portable computer. The radius of influence of the probe is approximately 2 to 3 cm. For the application discussed here, iron metal filings are so highly conductive that it is easy to identify precisely where the soil/iron interface is located. The distance the probe traveled before penetrating the wall was used to identify where the piston of the core barrel should be released in order to collect the desired sample.

### 4.1 Conductivity Probe

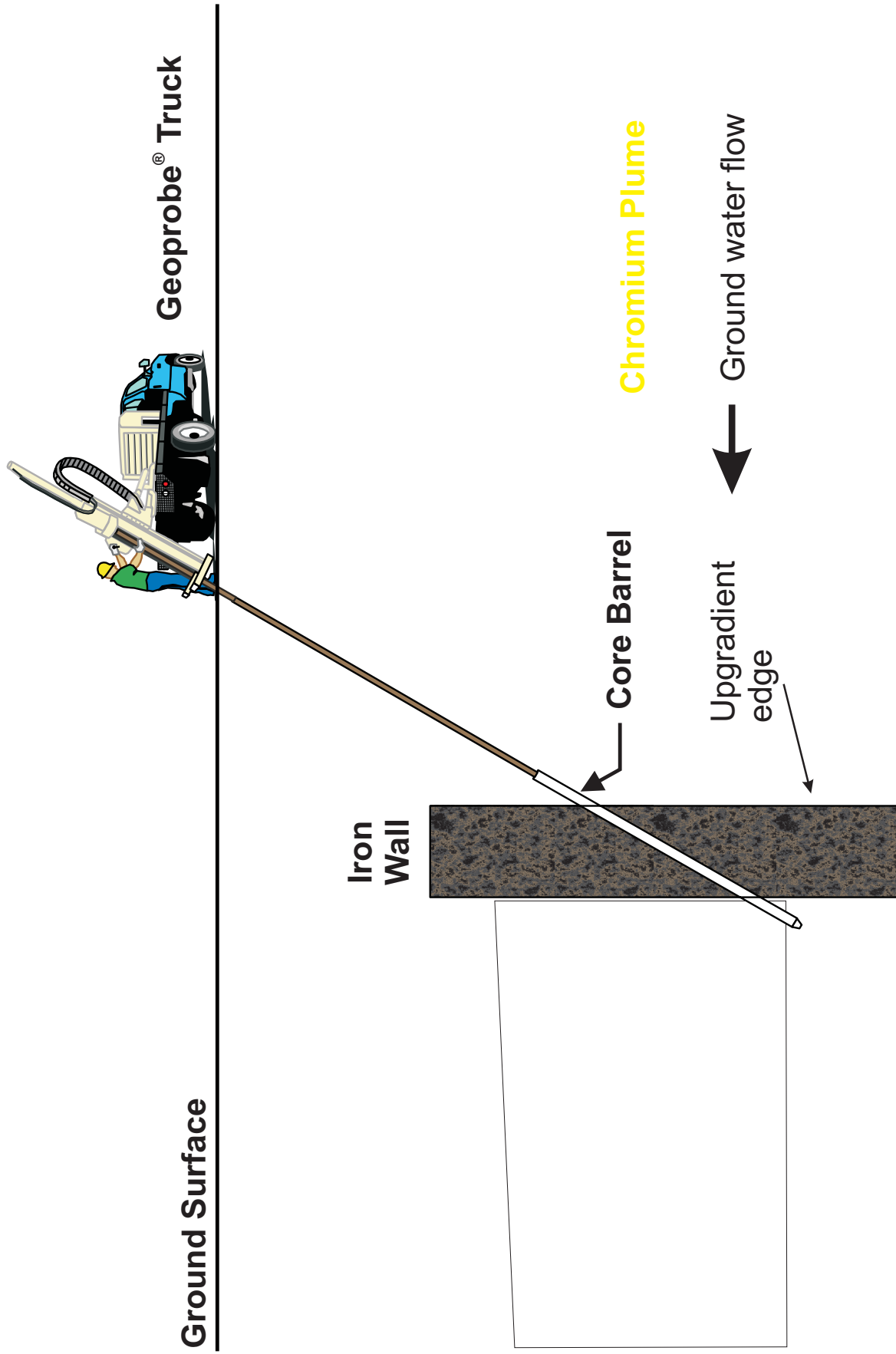
Figure 4.1 illustrates the configuration and the position of the equipment in relation to a target sample location. In order to collect aquifer materials directly upstream of the PRB, the DP device was set some distance away from the approximate front or back edge of the iron/aquifer interface. The depth below ground surface at which the PRB was intercepted can be estimated using the relation:

$$\text{Intercept depth} = \cos(30) \times [\text{push length from the surface to the high conductivity zone}]$$

The probe was assembled to penetrate the soil at a 30° angle (relative to vertical). Due to the large differences in conductivity between the native aquifer sediments and the granular iron (3 to 40 mS/M vs >250 mS/M), the iron wall was easy to locate using the conductivity probe. After intercepting the iron wall the conductivity probe was then removed and a piston core barrel was inserted into the same hole and driven to within about 0.5 m of the aquifer/iron interface. The piston would then be released and the core barrel driven 1.25 to 1.5 m so that a core could be collected. Because the coring was conducted at an angle, it was necessary to tighten the holding pin more than is typically done in vertical coring, so it would not release prematurely. When the core barrel was advanced at an angle, the stop pin on the piston core barrel had a tendency to vibrate loose as the rods and core barrel were driven.

The equipment configuration and the foot extender that was designed and built to allow the foot of the DP device to rest on the ground surface when deployed at a 30-degree angle is illustrated in Figure 4.2. The extender was necessary to hold the push angle steady and to permit extraction of the core barrel. The foot slides onto the normal DP device foot and is secured by two bolts while in use.

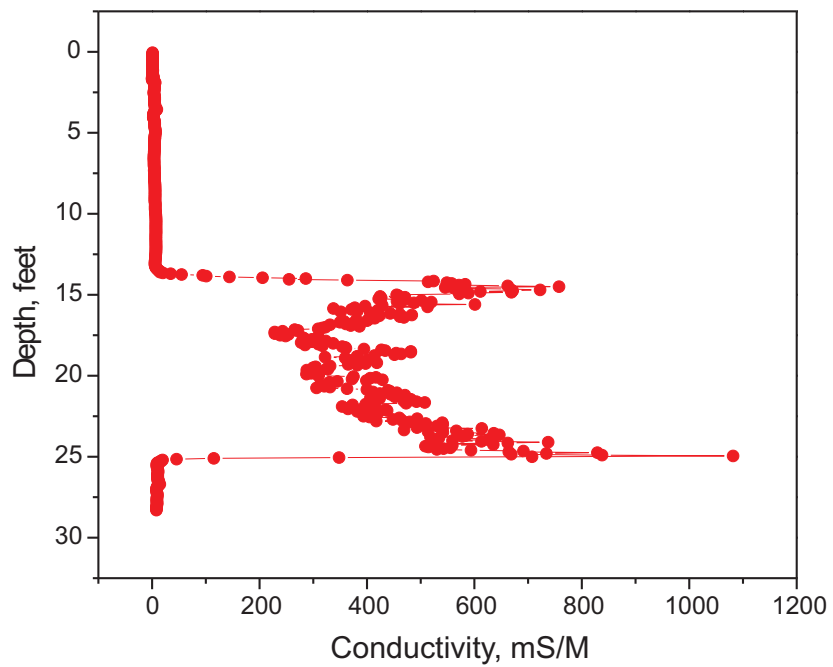
Figure 4.3 is a real-time plot of conductivity for a vertical push with the conductivity probe as it moves through the wall from the surface to below the wall at the Elizabeth City site. The conductivity profile in this trace suggests that the iron may be denser near the top and near the bottom of the wall. The conductivity probe method was used at the Elizabeth City site to attempt to map out the distribution of iron in the subsurface by analyzing conductivity data from a network of vertical profiles. The positions of the vertical traces in relation to the locations of ground-water monitoring wells are shown in Figure 4.4. Results of the profiling effort are shown as a contour diagram in Figure 4.5. The contour diagram shows the vertical and horizontal distribution of soil conductivity values in a vertical plane oriented along the long-axis of the Elizabeth City PRB or the dimension of the PRB oriented perpendicular to ground-water flow. The profiling study generally confirms the presence of zero-valent iron over the planned depth interval from about 2 to 7.5 m below ground surface, especially on the eastern portion of the reactive wall. Interestingly, it was more difficult to intercept the iron media near the western edge of the PRB where trenching and installation of the wall was initiated, and the data suggest that a continuous zone of zero-valent iron is not present along the far western portion of the PRB.



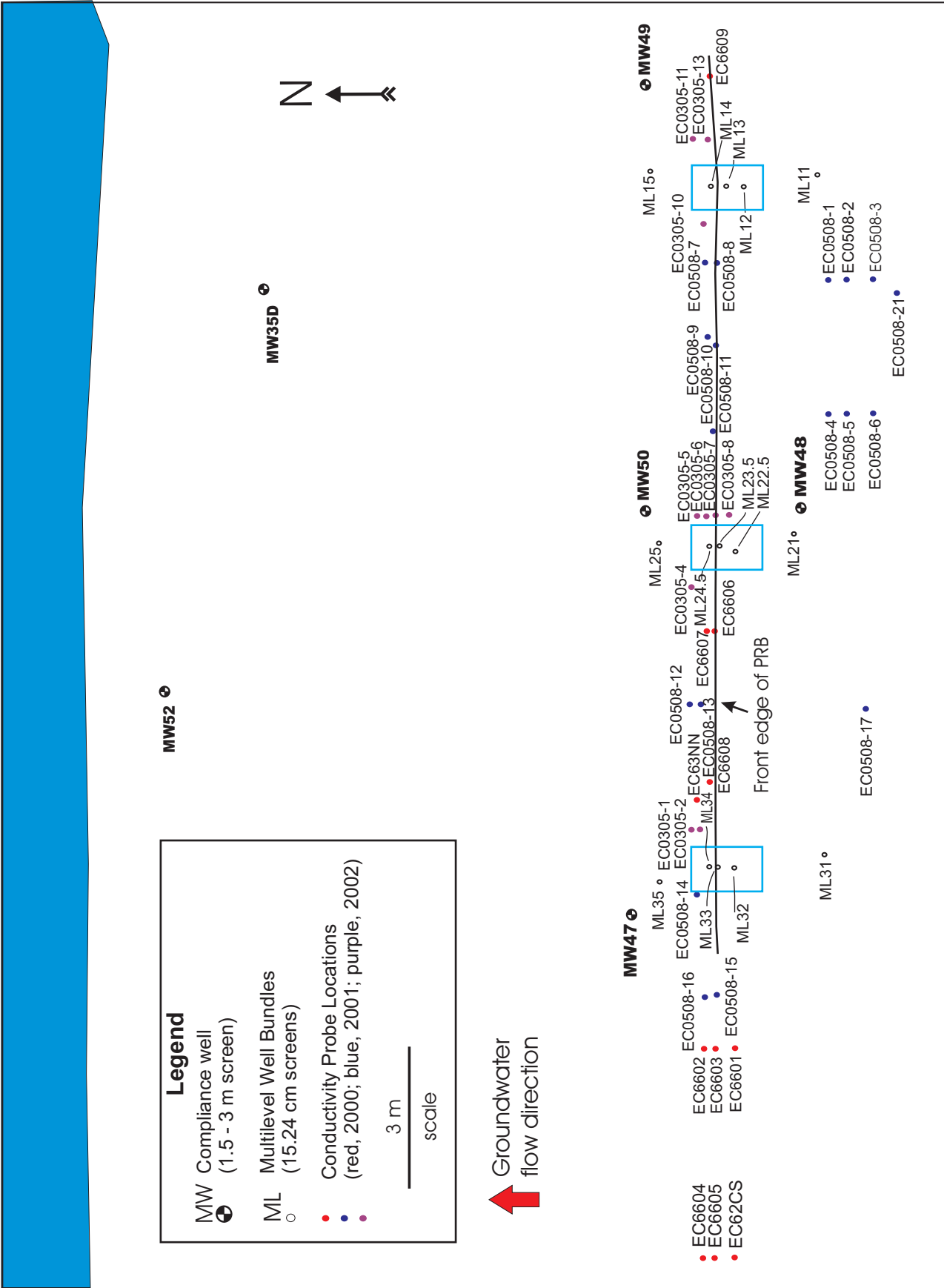
**Figure 4.1** Schematic diagram of angled core collection approach.

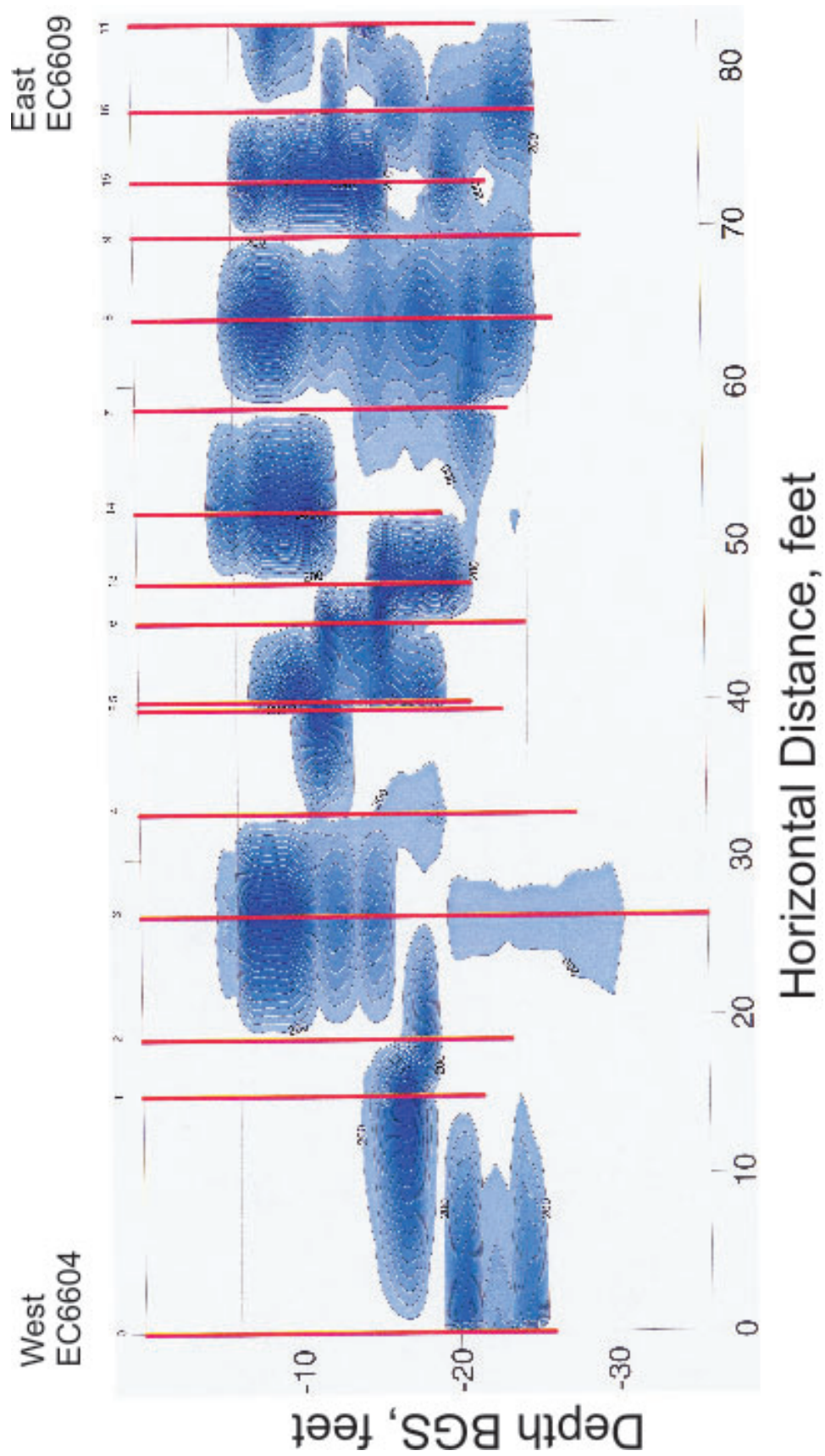


**Figure 4.2** Geoprobe® in angle coring configuration (after Beck et al., 2002).



**Figure 4.3** Soil conductivity trace (vertical profile) starting at the surface and penetrating down through the wall.





**Figure 4.5** Contour diagram showing the vertical and horizontal distribution of soil conductivity values in a vertical plane oriented along the long-axis of the Elizabeth City PRB. (Contour interval = 200 mS/M.)

Figure 4.6 is a plot of conductivity data collected along a 30° angle beginning at the ground surface and fully penetrating the wall. From this data, the wall thickness can be approximated by using the expression:

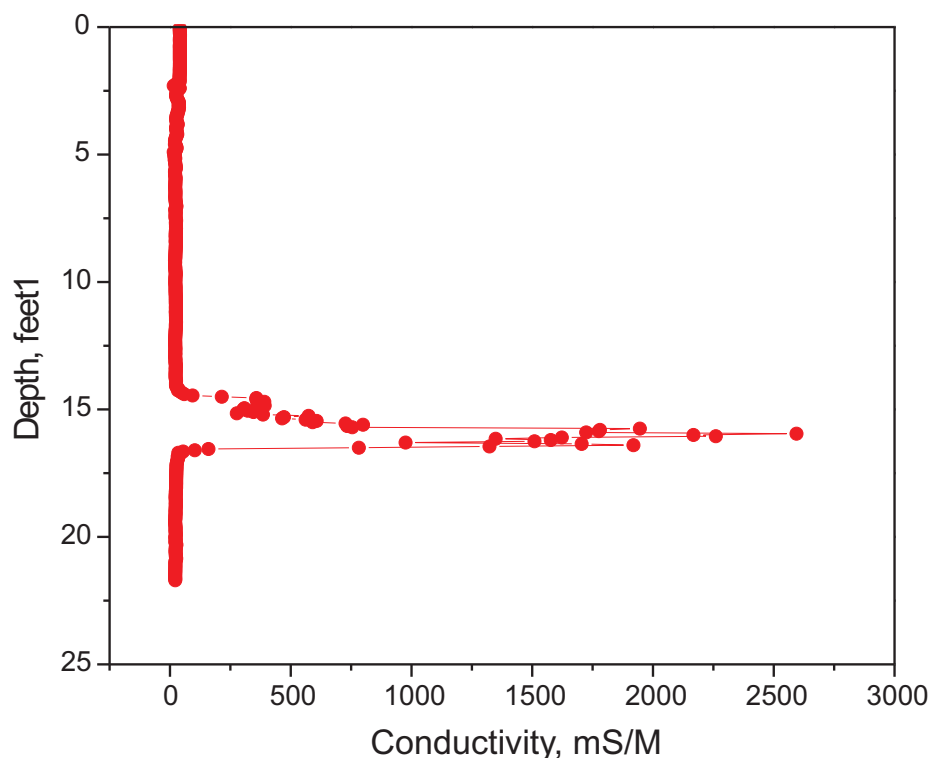
$$\text{Wall thickness} = \sin(30) \times [\text{thickness of high conductivity zone}]$$

For the trace shown in Figure 4.6, the thickness of the high conductivity zone is approximately 1 m so that the horizontal thickness of the iron wall at this location is approximately 0.5 m, which is in reasonable agreement with the planned thickness of 0.6 m.

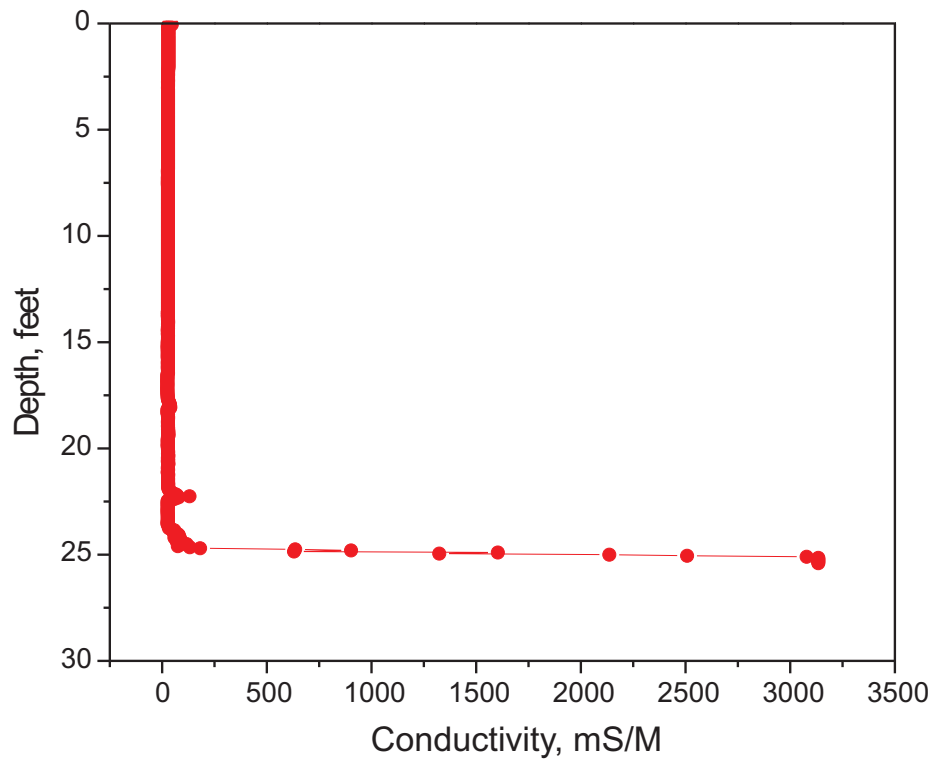
## 4.2 Core Collection

For the purpose of collecting core samples, the conductivity probe push would stop as soon as the conductivity started to change (e.g., see Figure 4.7). After locating the front or back edge of the iron wall, the probe was retrieved and the core barrel was driven to a depth just before the iron wall would be intercepted before releasing the piston so a core could be collected. This method was found to be useful in collecting core samples where the target zone was small but possessed the necessary conductivity contrast. The method also allowed the cores to be collected in such a way to capture the entire reaction zone in addition to adjacent aquifer material. This new method allows one to not only find the treatment zone, but also to evaluate the size and characteristics of the zones adjacent to the wall. In some cases only cores were obtained that had soil at both ends of the sleeve. The success rate with this method for obtaining samples was close to 90% (Beck et al., 2002).

A picture of a core collected with the DP device in an angle configuration is shown in Figure 4.8. Note that by collecting cores at an angle, the contact between the aquifer sediments and the zero-valent iron can be captured. After being brought to the surface, cores were capped and labeled. After the first cap was installed, the sleeve was cut off so that the core was free of any air space before securing the second cap. Following cap installation, the cores were sealed with plastic tape and immediately frozen on site. Cores were shipped frozen (on dry ice) back to the lab for microbiological and geochemical testing. This sample collection and preservation method was able to preserve the redox characteristics of the core materials. As described in Volume 1 of this EPA Report series, concentrations of total sulfur in the core materials were in very good agreement with concentrations of acid-volatile sulfides. This result indicates that there was very little to no oxidation of sulfide minerals that are known to be highly susceptible to oxidation and transformation.



**Figure 4.6** Soil conductivity log collected at a 30 angle and fully penetrating the iron wall at the Elizabeth City site (after Beck et al., 2002).



**Figure 4.7** Soil conductivity trace used to locate position of the aquifer/iron interface. In this example, the aquifer/iron interface is present at 7.62 m along a 30 angle push; the interface is intercepted at approximately 6.61 m below ground surface.



**Figure 4.8** Soil core collected showing aquifer/iron wall interface (after Beck et al., 2002).

### 4.2.1 Lab Studies

In order to better understand the factors that control the conductivity profiles in iron walls, we conducted a calibration test using a model aquifer system. An 20-cm PVC pipe was capped on the bottom end and filled with 0.3 m of sand, starting at the bottom followed by 0.3 m of iron. We then added 0.3 m of 1:1 iron/sand mixture and filled the last 0.6 m with sand. After filling the PVC pipe with these materials, we conducted two series of tests in which the conductivity probe was manually driven through the column. The first test series was conducted with dry soil, and the second with the soil under water-saturated conditions. The results of these tests are plotted in Figure 4.9. The tests show that the conductivity probe responds differently under the two soil moisture conditions. In dry systems, a 50-50 sand-iron mix is indistinguishable from 100% sand, based upon conductivity trends. Maximum conductivity values near 1000 mS/M were obtained in dry, 100% iron materials, or about 30% of the conductivity value observed under water-saturated conditions (Figure 4.9). In water-saturated conditions, iron-sand mixtures are distinguishable from pure sand, but the conductivity response appears to be non-linear with respect to the iron/sand ratio. Clearly, the presence of water in interstitial spaces is essential in order to locate subsurface zones of iron using the conductivity approach.

### 4.3 Laboratory Methods – Soils

Immediately after collection, the cores were frozen and shipped back to the Ground Water and Ecosystem Restoration Division in Ada, OK, for sub-sampling and analysis. The frozen cores were partially thawed and then placed in an anaerobic chamber with a maintained H<sub>2</sub>-N<sub>2</sub> atmosphere. Each core was logged and partitioned into 5- to 10-cm segments. Each segment was homogenized by stirring in the glove box and then split into 4 sub-samples: (1) inorganic carbon analyses, (2) sulfur analyses/X-ray diffraction (XRD), (3) Scanning electron microscopy (SEM), and (4) microbial assays (phospholipid fatty acids, PLFA). All sub-samples were retained in airtight vials to prevent any air oxidation of redox-sensitive constituents. Details of analytical methods used to characterize the core materials are presented below.

#### 4.3.1 Core Processing

To minimize any oxidation of redox-sensitive compounds, each core was allowed to thaw approximately 30 minutes to one hour on the bench top. Cores were then placed inside an anaerobic chamber under a H<sub>2</sub>-N<sub>2</sub> (95:5 vol %) atmosphere. If the core was too long to be placed directly into the chamber (generally > 41 cm), the core was cut into

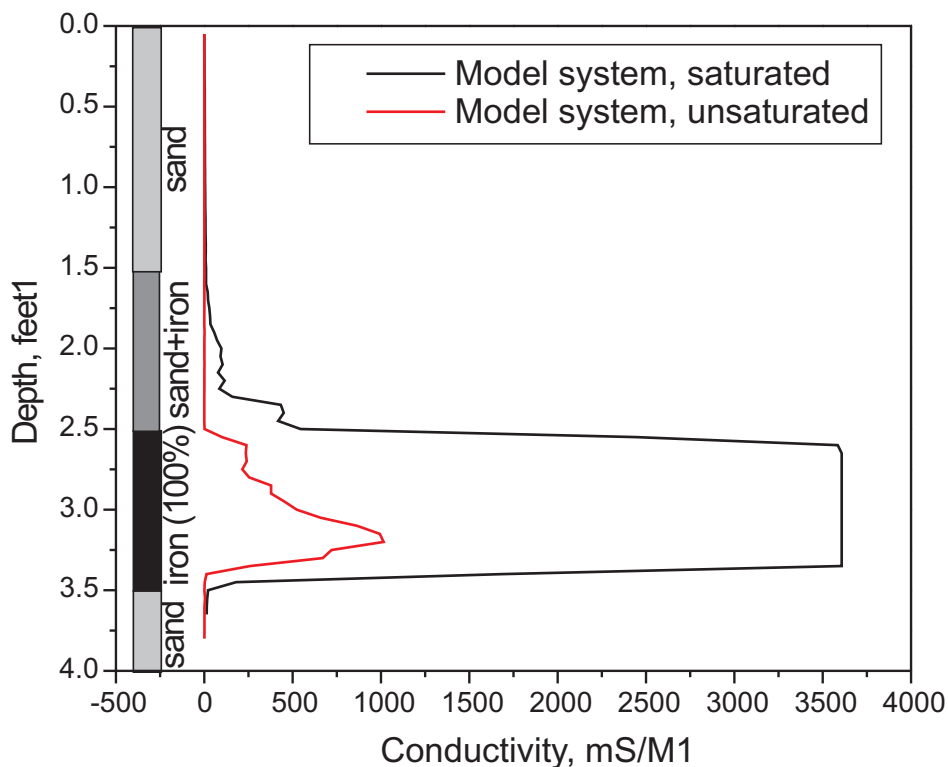


Figure 4.9 Results of conductivity measurements in model systems.

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shorter segments, immediately recapped, and taped to minimize exposure to air. The cores were measured and marked in 5-cm increments. The upgradient aquifer core segments were labeled as +1, +2, +3, etc., and the downgradient iron media segments were identified as -1, -2, -3, etc. The sediment/iron interface was always labeled with the +1/-1 identifier, with the greatest positive or negative segment being farthest from the interface.

Prior to 2000, a Dremel saw was used to cut the core lengthwise within an anaerobic glove box, allowing the top portion of the plastic sleeve to be removed. Subsamples were removed from each 5-cm segment for SEM/XRD, PLFA, carbon, and sulfur analyses. The SEM/XRD samples were collected in 30 mL serum bottles and capped immediately. The PLFA samples were collected in 40 mL conical polyethylene centrifuge tubes. The carbon and iron samples were collected in 30 mL clear and amber polyethylene bottles, respectively. The SEM/XRD, carbon, and Fe samples were stored in an anaerobic environment prior to analyses. The PLFA samples were frozen immediately after processing.

Further processing of the samples was conducted prior to SEM/XRD analysis. Acetone (10 mL) was injected into the sample through the septum using a syringe. After this injection, two syringe needles were placed into the septum. One was used for an outlet and the other was used to input nitrogen gas into the bottle. N<sub>2</sub> was flushed through the sample to allow the iron filings to dry completely.

In 2000, the core processing method was simplified by removing each segment with a stainless steel spatula without cutting the plastic sleeve. Pre-processing remained as previously described. Samples were collected for SEM/XRD, sulfur, PLFA, and carbon analyses. The SEM/XRD and sulfur samples were collected in 30 mL glass serum bottles and capped immediately. A 40 mL, clear, conical, polyethylene centrifuge tube was used for the PLFA portion of the subsection. Carbon samples were collected in 30 mL polyethylene bottles. Notations were made describing the percentage and material type of each segment. After each core was processed, the PLFA samples were frozen immediately, the SEM/XRD and sulfur samples remained under anaerobic conditions, and the carbon samples were stored in an aerobic environment. Prior to conducting XRD scans, bulk samples were sonicated in acetone to remove and concentrate the fine-grained materials that had accumulated on the coarse iron granules.



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## 5.0 Analytical Methods

### 5.1 Field Analyses

Data for field analyses for the USCG monitoring wells and multi-level samplers are found in Appendices A and C. Monitoring well data for the DFC site are found in Appendix B.

#### 5.1.1 Hexavalent Chromium

At the USCG site, a 20- or 50-mL sample of unfiltered ground water was collected to determine Cr(VI) concentrations colorimetrically with a UV/VIS spectrophotometer (Hach® DR100 or Hach® DR/2010). Cr(VI) was analyzed directly using 1,5-diphenylcarbazide (Chroma-Ver3) as the complexing agent (American Public Health Association et al., 1992). This reagent contains a pH buffer combined with 1,5-diphenylcarbohydrazide, which results in a light purple color which is proportional to the amount of Cr(VI) present. Maximum detection limits for Cr(VI) using the Hach® DR/2010 spectrophotometer and the Hach® Pocket Colorimeter are 0.60 mg/L and 0.50 mg/L, respectively. Samples exceeding these maximum detection limits were diluted in the field prior to analysis. Minimum detection limits using these methods were 0.01 - 0.02 mg/L. Chromium was not a contaminant of concern at the DFC site and, therefore, was not analyzed.

There are very few interferences for this field test kit; however, iron and vanadium will interfere at concentrations >1 mg/L. Generally, the presence of ferrous iron in ground waters is indicative of reducing environments; therefore, Cr(VI) would not be expected in the ground water containing elevated concentrations of iron. Mercurous and mercuric ions may also cause slight interferences. Vanadium interference can be eliminated by waiting 10 minutes following the addition of the Chroma-Ver3 before analyzing the sample. Highly buffered ground water or extreme sample pH may exceed the buffering capacity of the reagents and sample pretreatment may be required.

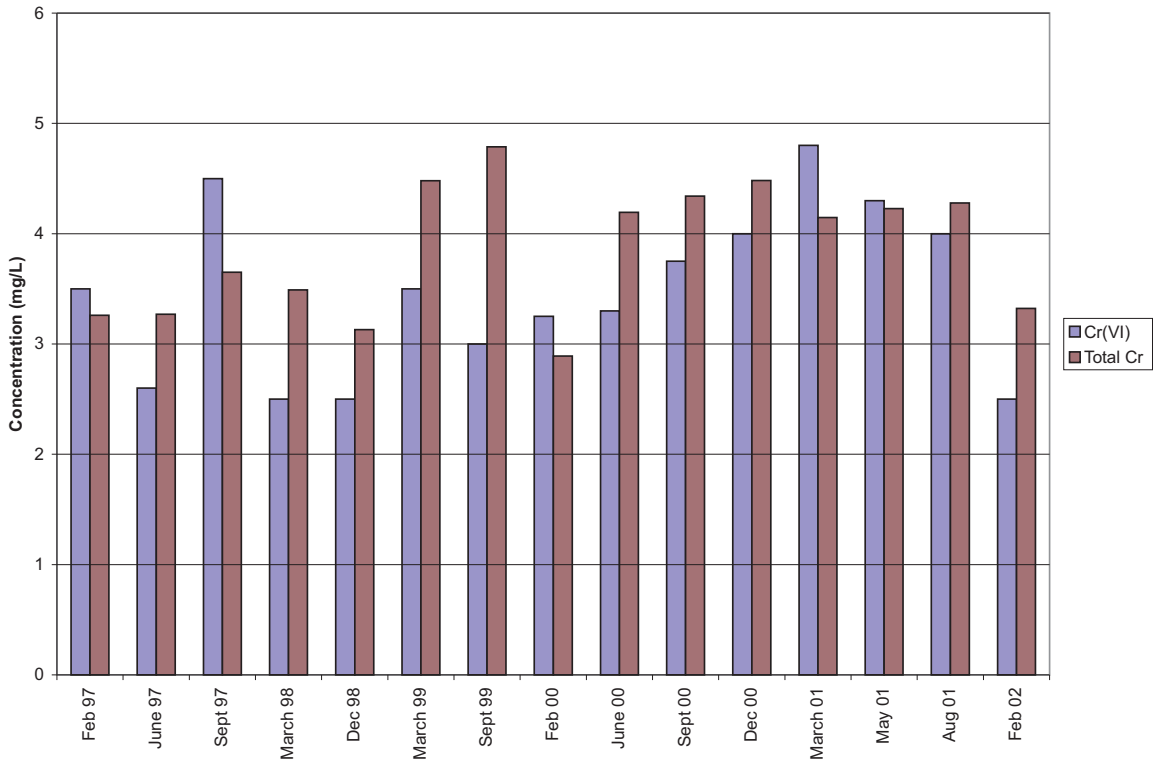
#### 5.1.1.2 Hexavalent chromium comparison with total chromium

At the Elizabeth City site the chromium plume is located upgradient of the PRB between 4.5 and 5.5 m below ground surface. Data show that most of the chromium is present as Cr(VI), which is highly mobile. The highest Cr(VI) concentrations were seen in MW13 just downgradient of the chromium source area. Total chromium and Cr(VI) values for monitoring wells and Transect 2 are shown in Tables A2, C9, C11, and C28, respectively. Figure 5.1 shows slight fluctuations in total chromium and Cr(VI) in MW13 with time; however, no seasonal trends are seen. A dramatic decrease in chromium concentration is seen in MW48 over time as treated water reaches this downgradient monitoring well (Figure 5.2). The regression analysis shown in Figure 5.3 for two monitoring wells MW13 and MW48 indicates an excellent correlation between total chromium and Cr(VI) values with an R<sup>2</sup> value of 0.93 and a slope of 1.06. Regression analysis was conducted for ML21 in Transect 2 and is shown in Figure 5.4. Where slightly higher values of total chromium are seen, colloidal particles could have passed through the 0.45 um filter. Acidification of ground water may have released the colloidal chromium, resulting in the measured total chromium concentrations being higher than the actual aqueous Cr(VI) values measured in the field. Analytical variability, particularly for Cr(VI) where additional error is introduced by dilution of some samples during field analysis, may also be responsible for some of these concentration differences.

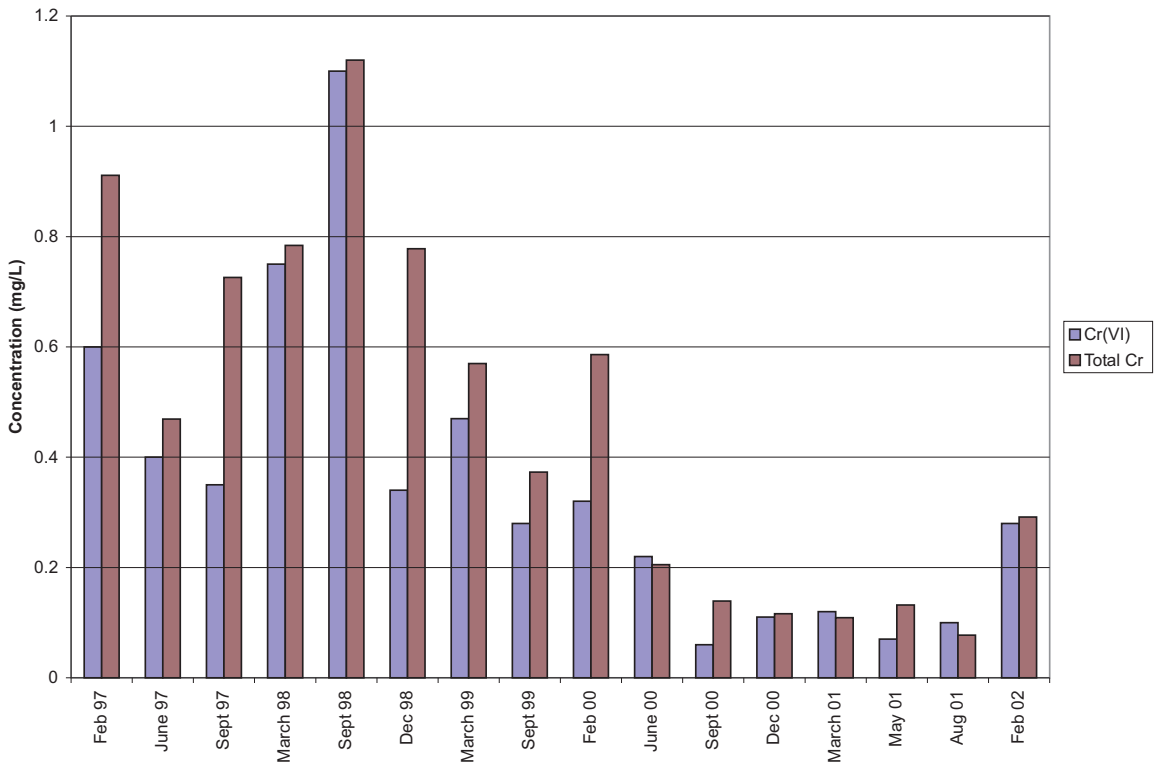
#### 5.1.2 Ferrous Iron

Ferrous iron (Fe<sup>2+</sup>) was measured in the field on unfiltered samples using two methods for comparison purposes. First Fe<sup>2+</sup> was measured using CHEMets® colorimetric test kits. Water was allowed to flow through a CHEMets® over-flow cell for at least three minutes and then sampled into CHEMets® ampoules containing 1,10 phenanthroline reagent (American Public Health Association et al., 1992). Following manufacturer's recommendations, the tip of the ampoule was placed at the bottom of the over-flow cell and then the tip was snapped off, allowing the ampoule to fill with ground water. The contents of the ampoule form an orange color in the presence of Fe<sup>2+</sup>. Following a 30 second equilibration period, the ampoule was visually compared with ampoules of known Fe<sup>2+</sup> concentrations.

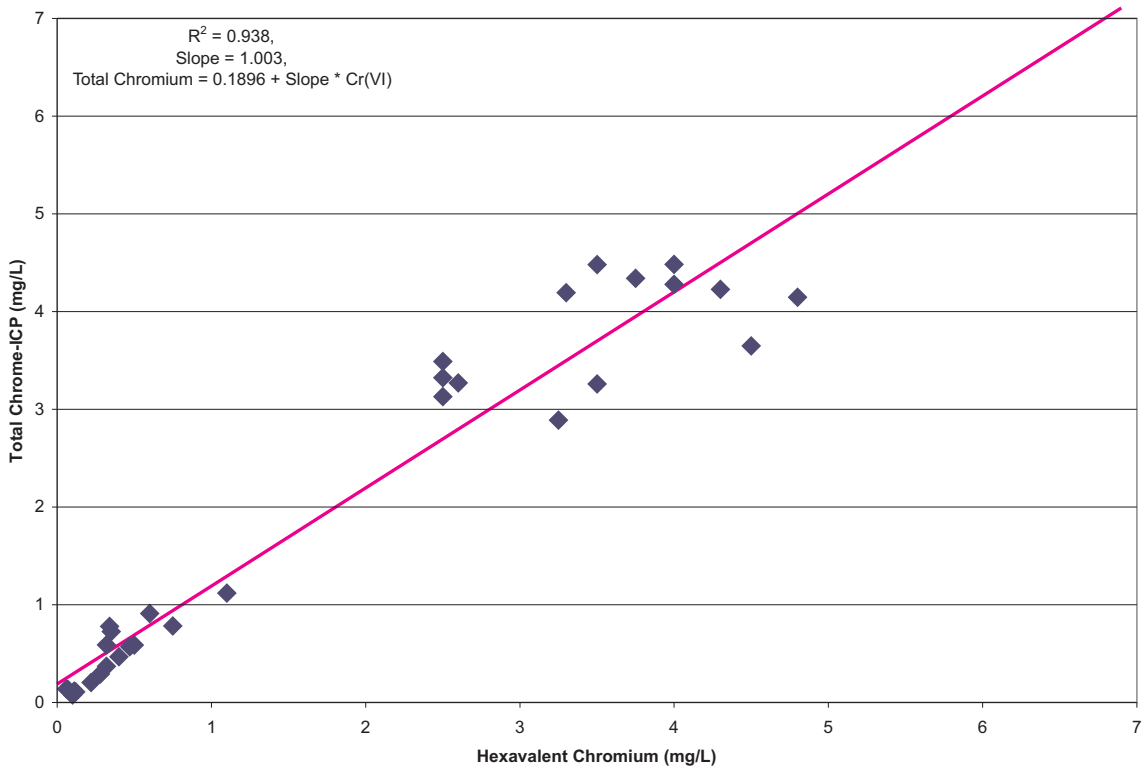
Fe<sup>2+</sup> was also determined using a Hach® DR/2010 spectrophotometer using 1,10 phenanthroline (FerroVer) as a complexing agent. Ferrous iron will oxidize rapidly to form ferric iron, especially at pH >8 which is typical in Fe<sup>0</sup> reactive zones. In order to minimize oxidation reactions, ferrous iron analysis was conducted immediately after sample collection.



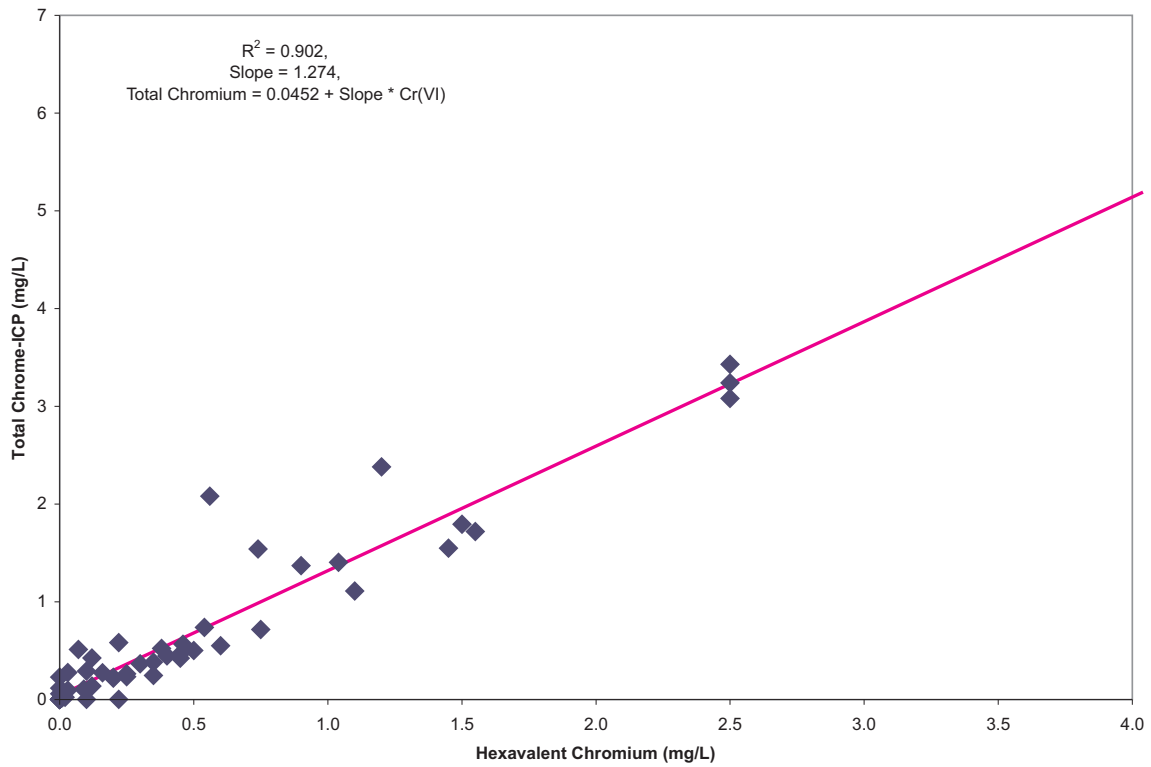
**Figure 5.1** Comparison of total chromium and Cr(VI) in monitoring well MW13 at the Elizabeth City site.



**Figure 5.2** Comparison of total chromium and Cr(VI) in monitoring well MW48 at the Elizabeth City site.



**Figure 5.3** Analysis of MW13 and MW48 comparing total chromium and Cr(VI) at the Elizabeth City site.



**Figure 5.4** Analysis of ML21 comparing total dissolved solids with specific conductance values at the Elizabeth City site.

It is important to add the FerroVer to the sample cell prior to adding the water sample in order to minimize oxidation of the  $\text{Fe}^{2+}$  prior to analysis.

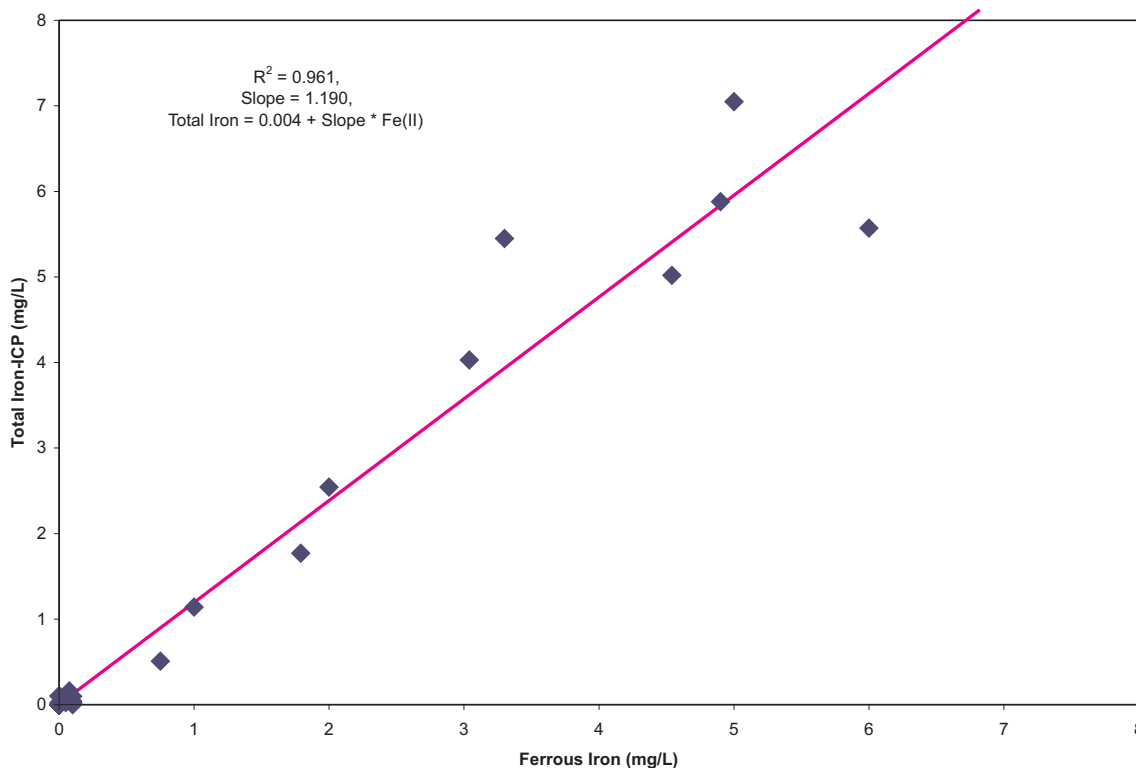
The maximum detection limit of the Hach® DR/2010 spectrophotometer is 3.00 mg/L. Where initial  $\text{Fe}^{2+}$  concentrations using the CHEMets® kit were determined to be  $>3.00$  mg/L, the sample was diluted prior to analysis using the Hach® DR/2010 spectrophotometer. It is important to consider potential interferences using these field test methods which can adversely impact  $\text{Fe}^{2+}$  measurements. Interferences include strong oxidizing agents, cyanide, nitrite, and phosphates. Polyphosphates have greater impact than orthophosphates. Certain metals may also interfere with  $\text{Fe}^{2+}$  measurements, including chromium, zinc, copper, nickel, and cobalt. However, chromium and zinc concentrations must be ten times greater than the ferrous iron present. Cobalt and copper must be greater than 5 mg/L and nickel in excess of 2 mg/L. Additionally, bismuth, cadmium, mercury, molybdate, and silver all precipitate the phenanthroline used in the analysis (American Public Health Association et al., 1992).

### 5.1.2.1 Ferrous iron comparison with total iron

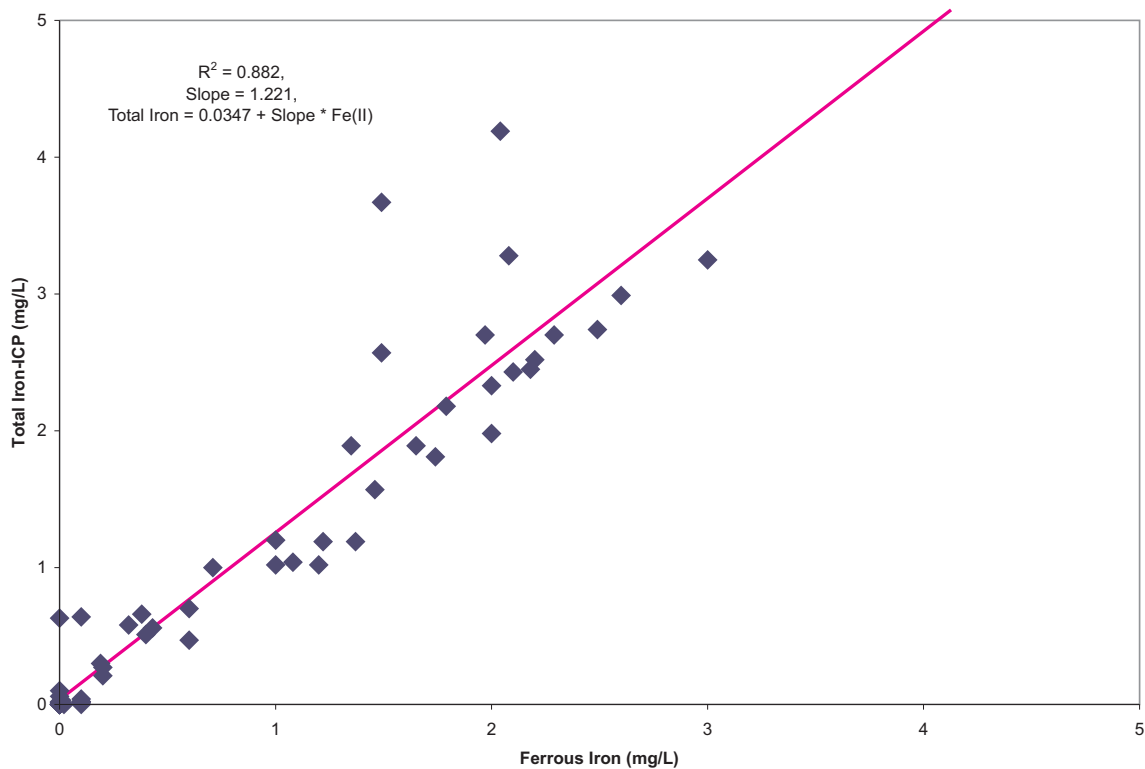
Comparisons were made between the field  $\text{Fe(II)}$  values and total Fe values determined by ICP-OES in the laboratory. Figure 5.5 shows a fairly good correlation between  $\text{Fe(II)}$  and total Fe values for ML21 which is upgradient of the barrier at the USCG site with a regression  $R^2$  of 0.89 and a slope of 1.24. Figure 5.6 shows the downgradient total iron data in ML25 to be somewhat higher than  $\text{Fe(II)}$ . This may be due to colloids passing through the filter and followed by  $\text{Fe(OH)}_3$  dissolution after acidification with  $\text{HNO}_3$ . It is important to acidify samples to  $\text{pH} < 2$  immediately after collection to prevent oxidation of  $\text{Fe(II)}$  to  $\text{Fe(III)}$  and subsequent precipitation. This would result in artificially low total Fe values compared to dissolved  $\text{Fe(II)}$  measure in the field.

### 5.1.3 Alkalinity

A Hach® digital titration kit (Method 8203) was used to determine alkalinity concentrations as  $\text{CaCO}_3$ . A 100 mL unfiltered ground-water sample was placed in a 250 mL Erlenmeyer flask and the contents of one bromocresol green-methyl red indicator packet was added. The sample was titrated using 1.6 N sulfuric acid ( $\text{H}_2\text{SO}_4$ ) until a purple/pink colorimetric endpoint ( $\text{pH} 4.5$ ) was reached. There are very few interferences with this method; however, highly turbid or colored samples may mask a true visual endpoint. If this occurs, sample  $\text{pH}$  would need to be monitored to determine when the endpoint was reached. The presence of chlorine may interfere with the indicator and impact alkalinity measurements. However, the addition of one drop of 0.1 N sodium thiosulfate will eliminate this interference.



**Figure 5.5** Analysis of ML21 comparing total iron and ferrous iron at the Elizabeth City site.



**Figure 5.6** Analysis of ML25 comparing total iron and ferrous iron at the Elizabeth City site.

### 5.1.4 Dissolved Oxygen

Dissolved oxygen (DO) was measured using CHEMets® colorimetric test kits. Rhodazine D method (White et al., 1990) was used for the 0-100 ppb or 0-1 ppm range and the indigo carmine method was used for the 1-12 ppm range. Water was allowed to flow through an overflow cell for at least three minutes, then the tip of the appropriate CHEMets® ampoule was placed in the bottom of the overflow cell, snapped off, and allowed to fill with the ground-water sample. The ampoules were visually compared with standards of known DO concentrations after allowing for the appropriate equilibration times (30 seconds for the rhodazine D method and two minutes for the indigo carmine method). It is important to note that the CHEMets® ampoules must be stored in the dark in order to prevent deterioration of the reagent.

The most difficult problem with field measurements for DO is the introduction of oxygen to the ground-water sample prior to measuring (Rose and Long, 1988). When using the overflow cell, the sample stream must be completely leak free. Copper tubing, long sections of neoprene, or other polymeric tubing should not be used with the CHEMets® test kit. Several other factors may lead to erroneously high DO values. Although using a membrane electrode is the easiest and fastest method for determining DO in the field, electrodes lack accuracy at low levels (<1 ppm) (Wilkin et al., 2001). Colorimetric tests will accurately measure DO concentrations <1 ppm, but interferences can adversely impact measurements. Since colorimetric reagents involve oxidation-reduction reactions, redox species may greatly influence results. The presence of reduced species such as Fe(III), Cr(VI), and Cu(II) can lead to inaccurate measurements when using the rhodazine D method. The presence of Fe(II), Fe(III), and nitrite has been shown to result in false measurements when using the indigo carmine method (Gilbert et al., 1982). Hydrogen sulfide apparently does not interfere with either colorimetric method, and the effects from the presence of total organic carbon (TOC) are not well understood. However, these problems can be minimized by using proper sampling techniques (Hitchman, 1978).

### 5.1.5 Hydrogen Sulfide

Hydrogen sulfide (H<sub>2</sub>S) was analyzed at the DFC site only. The first 25 mL of sample was collected for H<sub>2</sub>S analysis. This analysis was conducted using the Hach® DR/2010 portable spectrophotometer using methylene blue colorimetric indicator (American Public Health Association et al., 1992). Additionally, CHEMets® sulfide ampoules (0-1 ppm range), which also utilize the methylene blue colorimetric method, were used to measure H<sub>2</sub>S in the field. Ground water was

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allowed to flow through an overflow cell for two to three minutes. The tip of the ampoule was placed in the bottom of the overflow cell, snapped off, and allowed to fill with ground water. The ampoule was allowed to equilibrate for five minutes prior to visual comparison with standards of known H<sub>2</sub>S concentrations. This measurement was carried out rapidly to ensure that no H<sub>2</sub>S would be lost due to degassing or oxidation. In acidic waters, sulfide reacts with N,N-dimethyl-p-phenylenediamine and ferric chloride to produce methylene blue. The resultant color is directly proportional to the sulfide concentration in the sample. The presence of strong reducing substances including sulfite, thiosulfate, and hydrosulfite may interfere with the precision of the instrument. These interfere by reducing the blue color or preventing color development. High concentrations of sulfide may also inhibit full color development. Sample dilution may be required to reduce these effects. The detection limit for the Hach DR/2010 for S<sup>2-</sup> is 0.01 mg/L.

## 5.2 Laboratory Methods - Ground Water

Data quality was assessed using blanks and duplicate samples. The majority of the analytical results for blank samples were reported as not detected (ND) or below level of quantitation (BLQ), indicating little or no contaminant effects in nearly all cases. A few false positive results were seen for Cr and TCE at the USGS site. Cr values in the majority of field blanks were BLQ with all field and trip blanks at <0.006 µg/L. TCE contamination was only observed in June 1997 in one field blank at 1.1 µg/L where the limit of quantitation was 1 µg/L.

Analytical results for duplicate samples are shown in Appendices D, E, and F. Statistical analyses were performed on selected components of interest. Generally the variability of the results is low and within acceptable limits (<5% difference). The relative percent difference (RPD) calculation shows a spread between 0% - 10%, with some exceptions.

All ground-water samples collected from both sites were analyzed by ManTech Environmental Research Services Corporation, Ada, OK, using methods developed for, or recommended by, the U.S. EPA NRMRL. All analytical results and quality control (QC) measurements, including duplicates, known standards, spikes, and blanks, were reported to NRMRL researchers. Data for laboratory analyses for both field sites are found in Appendices A, B, and C.

### 5.2.1 Organic Analyses

VOA vials were analyzed for TCE, *cis*-DCE, 1,1-DCE, 1,1,1-TCA, and vinyl chloride by purge and trap method with a Tekmar LSC 2000 sample concentrator and Hewlett-Packard model 5890 gas chromatograph (GC) equipped with a flame ionization detector (FID). Dissolved gases including ethene, ethane, and methane were analyzed using a Microsensor Technology Inc. (MTI) GC equipped with a thermal conductivity detector (Kampbell and Vandegrift, 1998). Quantitation limits for organics analysis were 1 µg/L.

### 5.2.2 Cation Analyses

Cation samples were analyzed with a Perkin Elmer® Optima 3300 DV inductively coupled plasma spectrometer (ICP-OES). Concentrations of silver (Ag), aluminum (Al), arsenic (As), boron (B), barium (Ba), beryllium (Be), calcium (Ca), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), molybdenum (Mo), sodium (Na), nickel (Ni), lead (Pb), antimony (Sb), selenium (Se), strontium (Sr), titanium (Ti), thallium (Tl), vanadium (V), and zinc (Zn) were determined. The analytical method involves the samples being nebulized into a spray chamber where argon carries the sample aerosol into the plasma at high temperature (~6000 K). Sample particles become atomized, ionized, and excited. The optical emission of each element is then detected by a charge coupled device (CCD) detector. Elemental concentration is determined by comparing the resultant signal with standards of known concentration. Table 5.1 shows the instrument minimum limits of detection for each element measured.

Cation analysis using this method is ideally performed on aqueous solutions ranging from acidic to nearly neutral that are free of particles and organic substances. Total dissolved metals must be < 0.5% dissolved matter; however, <0.2% is preferable.

### 5.2.3 Anion Analyses

Analyses were performed for chloride (Cl<sup>-</sup>) and sulfate (SO<sub>4</sub><sup>2-</sup>) using capillary electrophoresis (Waters® Quanta 4000E) method N-601 with Lachat® flow injection analyses and Mettler® DL21 autotitration. Nitrate (NO<sub>3</sub><sup>-</sup>) and nitrite (NO<sub>2</sub><sup>-</sup>) values were determined using hydrazine reduction with flow injection analysis colorimetry (Lachat Instruments® QuikChem Method 10-107-04-2-A) (Kamphake et al., 1967). Nitrate is reduced to nitrite with hydrazine sulfate. Nitrite concentration is then determined by diazotizing with sulfanilamide followed by coupling with N-(1-naphthyl)-ethylenediamine dihydrochloride. The resulting water soluble dye produces a magenta color. Nitrite alone can be determined by substituting deionized water for the hydrazine reagent. Method interferences include sulfide ion concentrations of 10 mg/L, which will cause a negative 10% error in nitrate and nitrite determinations within the range of the method (0.02 - 22.6 mg N/L as NO<sub>3</sub><sup>-</sup>).

**Table 5.1** Detection Limits (D.L.) for Cation Analyses

Element	Min. D.L. mg/L	Element	Min. D.L. mg/L	Element	Min. D.L. mg/L
Na	0.03	K	0.8	Be	0.0005
Mg	0.07	Ca	0.01	Sr	0.0002
Ba	0.002	Ti	0.01	V	0.008
Cr	0.005	Mn	0.003	Fe	0.006
Co	0.006	Ni	0.01	Cu	0.002
Zn	0.001	Mo	0.004	Ag	0.1
Cd	0.002	Hg	0.07	B	0.1
Al	0.02	Tl	0.02	Pb	0.01
As	0.02	Sb	0.02	Se	0.02

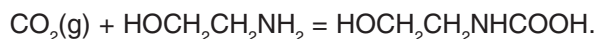
### 5.2.4 Carbon Analyses

Samples were not analyzed for total carbon (TC) and total organic carbon (TOC) concentrations for each sampling event. However, when samples were analyzed for these constituents, TC concentrations were determined using a Dohrmann® DC-80 instrument. TOC was determined by acidifying an aliquot of the sample with ultra-pure phosphoric acid (H<sub>3</sub>PO<sub>4</sub>), purging with ultra high purity nitrogen for three minutes to remove the inorganic carbon prior to analysis. The sample was injected into a reaction chamber where organic carbon was converted to CO<sub>2</sub> followed by infrared detection.

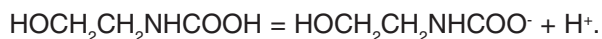
## 5.3 Laboratory Methods - Soils

### 5.3.1 Inorganic Carbon Analysis

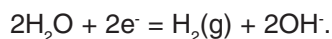
Concentrations of inorganic carbon in core samples were determined with a carbon coulometer system (UIC, Inc. Model CM5014). The carbon coulometer system measures carbon as carbon dioxide in a carrier gas (Figure 5.7). A gas stream containing carbon dioxide is evolved from a sample by acidification and then bubbled into the coulometer titration cell, which contains a CO<sub>2</sub>-sensitive ethanolamine solution and a platinum electrode (Huffman, 1977; Engleman et al., 1985). Before entering the titration cell, the gas stream is passed through a silver nitrate solution to remove potentially interfering species (e.g., hydrogen sulfide). In the titration cell, carbon dioxide reacts to form a titratable acid and causes the ethanolamine solution colorimetric pH indicator to fade from blue to clear. The incoming CO<sub>2</sub> reacts with the ethanolamine to form N-carboxy-2-amino ethanol:



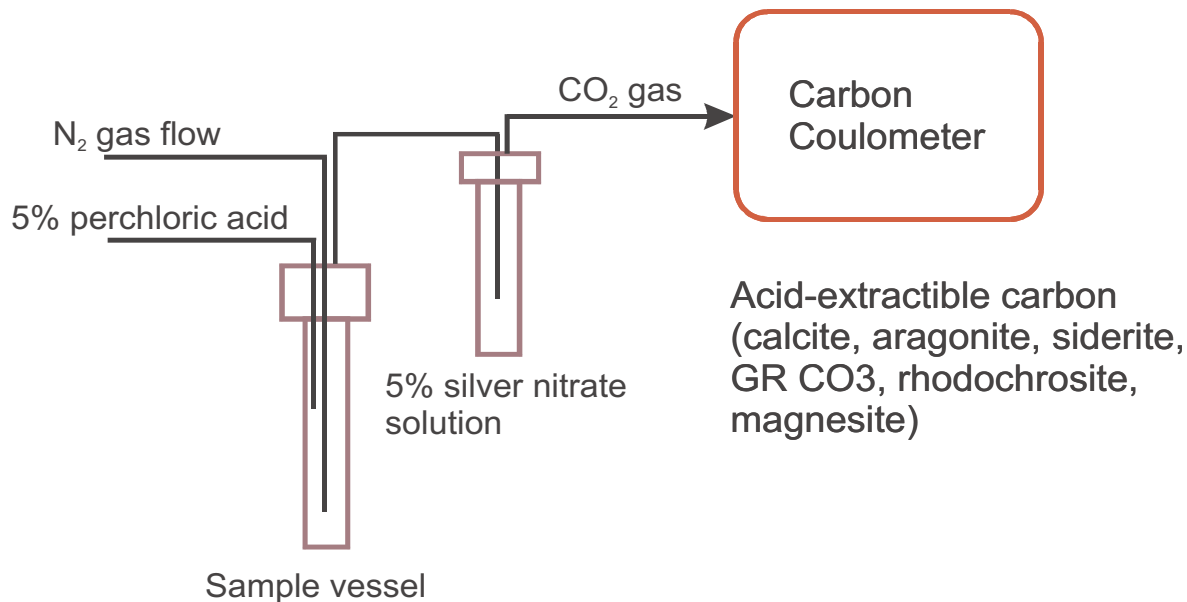
The N-carboxy-2-amino ethanol dissociates, and the pH of the solution decreases, which causes the indicator color to fade:



A photometer in the CM5014 detects the color change and initiates a current within the cell. The reaction at the platinum electrode produces OH<sup>-</sup>:



The current electrochemically generates a base at a maximum rate equivalent to about 1500 micrograms of carbon per minute. As base is produced, the pH of the cell solution gradually returns to its initial level, and the colorimetric indicator returns to blue. The amount of current necessary to reach the endpoint is electronically integrated and converted into a quantity of carbon present in the sample.



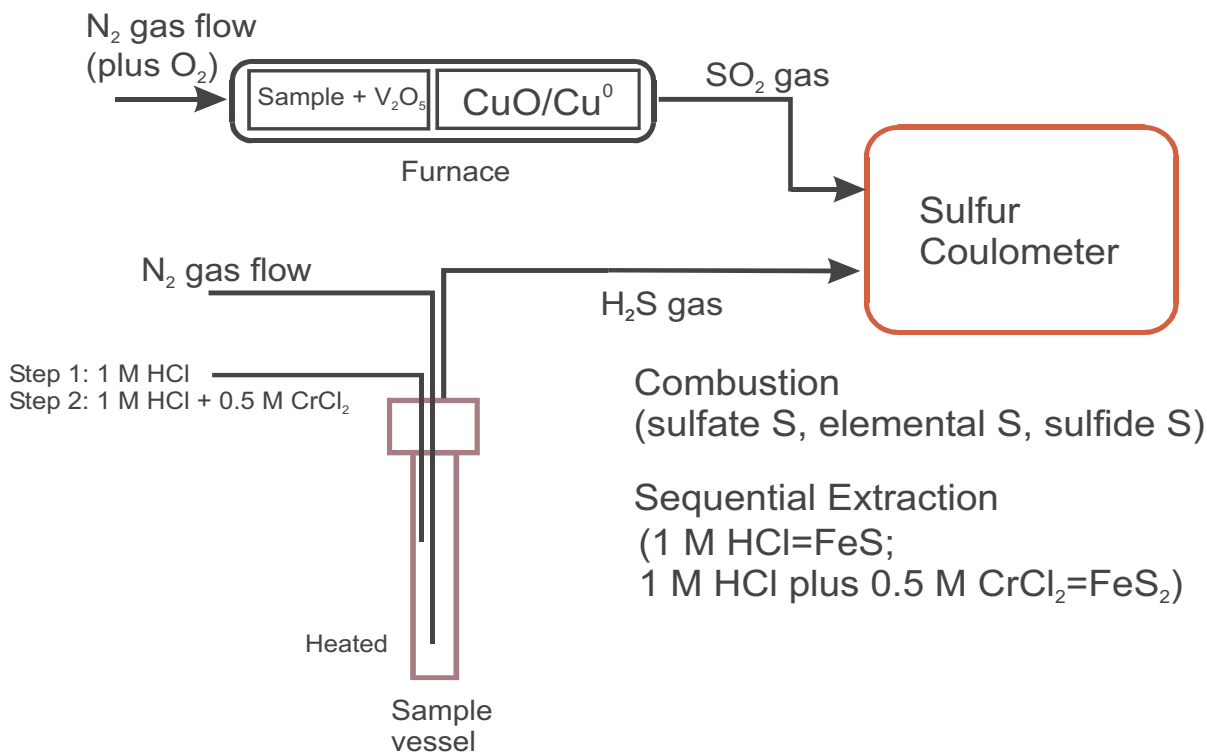
**Figure 5.7** Schematic diagram of the carbon coulometer system for core sample characterization.

Inorganic carbon analysis results are given in weight percent C based upon carbon that is released from a sample after acidification with hot 5% phosphoric acid. This acid digestion procedure releases inorganic carbon present in minerals such as calcite (trigonal CaCO<sub>3</sub>), aragonite (orthorhombic CaCO<sub>3</sub>), siderite (FeCO<sub>3</sub>), magnesite (MgCO<sub>3</sub>), rhodochrosite (MnCO<sub>3</sub>), iron carbonate hydroxide (Fe<sub>2</sub>(OH)<sub>2</sub>CO<sub>3</sub>), and carbonate green rust (Fe<sub>6</sub>(OH)<sub>12</sub>CO<sub>3</sub> · nH<sub>2</sub>O). The sample size used was varied so that 0.1 to 5 mg of C was titrated. In general, sample weights of 0.5 to 5 grams were used. A typical sample analysis required 7 to 10 minutes to completely titrate all CO<sub>2</sub> released during acidification. The detection limit was determined to be 0.001 wt % for a 1-gram sample size. Calcium carbonate (Aldrich, 99.999%) was used as a standard reference material. In all cases analysis of the reference material resulted in values within 5% of the accepted value for CaCO<sub>3</sub> (12.0 wt% C). Results of the inorganic carbon measurements are presented and discussed in Volume 1 of this EPA Report series.

### 5.3.2 Sulfur Analysis

Measurements of total sulfur and sulfur partitioning in the solid phase was carried out using a sulfur coulometer (UIC, Inc.) that measures sulfur as SO<sub>2</sub> or H<sub>2</sub>S gas (Figure 5.8). A gas stream, evolved from a sample by chemical extraction or combustion, is bubbled into a coulometer titration cell, which contains an excess of iodide (I<sup>-</sup>) and a small concentration of free iodine (I<sub>2</sub>). The sulfur gases are oxidized by the iodine as they are swept through the coulometer cell. An amperometric-sensing circuit detects the loss of I<sub>2</sub> in solution and causes more iodine to be electrochemically generated at a rate proportional to the sensed loss of concentration (maximum titration rate is 2000 micrograms S per minute). After all of the SO<sub>2</sub> or H<sub>2</sub>S has been titrated, the iodine is restored to its initial concentration. The total current used to generate the iodine is integrated by the coulometer and digitally displayed in operator-selected units, such as micrograms of S or micrograms of SO<sub>2</sub>.

Concentrations of total sulfur in solid samples are determined by combustion at 1050 °C. Samples are weighed into a ceramic boat, covered with vanadium pentoxide, and introduced to a combustion furnace (Atkin and Sommerfield, 1994). The combustion products are passed over an oxidation catalyst (CuO) to ensure complete decomposition and then over



**Figure 5.8** Schematic diagram of the sulfur coulometer system for core sample characterization.

metallic copper to convert all oxides of sulfur to SO<sub>2</sub>. The SO<sub>2</sub> is measured coulometrically and related to the concentration of sulfur in the sample. The instrument is most effective for samples with total sulfur values that range between 5 and 2500 micrograms. For a 0.10 gram sample, this corresponds to a sulfur concentration range of 0.005 to 2.5 wt% S. Standard reference materials for total sulfur measurements were NIST 1646a (Estuarine sediment, 0.35 wt% S) and barium sulfate (Aldrich, 99.99%, 13.75 wt% S). This combustion method is not able to completely release sulfur present within iron metal. Total sulfur values in Peerless iron obtained by other methods are typically near 0.1 wt%, but with this method total sulfur values in unreacted iron samples are less than 0.03 wt%. The method described here is sensitive, for determining the concentrations of sulfur in precipitates that have formed on the iron surfaces as a consequence of long-term ground-water exposure.

Concentrations of acid-volatile sulfide and chromium-reducible sulfur are measured either sequentially or in single-step extractions (Zhabina and Volkov, 1978; Canfield et al., 1986; Morse and Cornwell, 1987). Sulfur associated with monosulfide minerals is removed by treatment of the sample with hydrochloric acid in an inert atmosphere. Metal monosulfide minerals (e.g., FeS) evolve hydrogen sulfide when treated with hydrochloric acid and are therefore referred to as acid-volatile sulfides (AVS). In other methods for AVS determination, the evolved H<sub>2</sub>S is trapped as silver sulfide (or some other metal sulfide) and the amount of sulfur is determined gravimetrically. Alternatively, the evolved hydrogen sulfide can be trapped in an alkaline solution (NaOH) and the amount of sulfide (as bisulfide, HS<sup>-</sup>) determined using colorimetric methods or by using an ion-selective electrode. In the method described here, evolved hydrogen sulfide is measured with the sulfur coulometer. The advantage of this instrument is that the extraction endpoint is clearly known based on a loss of current detected in the coulometer titration cell.

The chromium-reducible sulfur (CRS) extraction targets elemental sulfur and iron disulfide (pyrite, marcasite) when used in a sequential extraction, i.e., following an AVS extraction (e.g., Canfield et al., 1986). When used in a single-step extraction, hot CRS liberates all reduced sulfur (acid-volatile sulfide + elemental sulfur + pyrite). Like the AVS extraction, the CRS extraction liberates H<sub>2</sub>S from a sample, which is carried to the coulometer cell using an inert gas. The extracting solution is prepared by first dissolving into 0.5 N HCl a quantity of chromic chloride hexahydrate needed to bring a volume of solution to 1 N CrCl<sub>3</sub>. Next the dark-green Cr(III) solution is drawn through a column packed with granulated Zn (a Jones Reductor). Prior to packing the column, the Zn must be amalgamated in acidic 2% mercuric chloride

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solution. As the acidic Cr(III) solution is passed through the Jones Reductor, it is reduced to the chromous oxidation state, Cr(II). A pronounced color change accompanies the change in oxidation state, and the solution turns from green to blue. The Cr(II) solution is unstable and will oxidize in air, so precautions must be taken to minimize air oxidation. Fresh chromous chloride solutions are preferable for CRS determinations; however, if appropriate storage methods are used (glass-stoppered bottles, no head space), acidic Cr(II) solutions can be stored for several months with negligible loss of reactivity.

Results of the total sulfur measurements and sulfur partitioning measurements are presented and discussed in Volume 1 of this EPA Report Series.

### **5.3.3 X-ray Diffraction Analysis**

Powder X-ray diffraction analysis of core samples collected from the Elizabeth City and Denver Federal Center sites in 2000 and 2001 was conducted to determine the mineralogy of precipitates formed in the iron treatment zones. Materials for analysis were prepared by sonicating iron core samples in acetone for 10 minutes followed by filtration of the released particulates through 47 mm diameter, 0.2-micron filter paper (polycarbonate). The separated particles were mounted on a zero-background quartz plate and scanned with Cu K radiation from 3° to 80° 2-theta using a Rigaku Miniflex Diffractometer (0.5° 2 per minute). Results of the X-ray diffraction studies are presented and discussed in Volume 1 of this EPA Report series.

### **5.3.4 Electron Microscopy**

Scanning electron microscopy (SEM) was used to evaluate the morphology and spatial relationships among mineral precipitates on the surfaces of zero-valent iron particles collected at the Elizabeth City and Denver Federal Center sites. In addition, energy dispersive X-ray spectroscopy (EDS) was conducted on polished samples to determine the composition of surface precipitates on a semi-quantitative basis. Samples for SEM and EDS analysis were stored in an anaerobic glove box and then embedded in an epoxy resin. The sample mounts (1" diameter round mounts) were ground and polished using diamond abrasives and coated with a thin layer of carbon prior to being placed within the SEM sample chamber.

Secondary electron and back-scattered electron images were obtained using a JEOL 5300 SEM. The instrument was operated using a 15 to 20 kV accelerating potential and a beam current of about 10 nA. Micrographs were obtained at a range of magnifications from 50x to 5000x. Copper grids obtained from SPI Supplies (West Chester, PA) were used to verify quantitative length scales. EDS spectra were acquired using an Oxford Instruments Model 6587 EDS Unit. Elemental concentrations were calculated using INCA software and cobalt metal as a standard reference material to insure semi-quantitative accuracy. Results of the SEM/EDS studies are presented and discussed in Volume 1 of this EPA Report series.

### **5.3.5 Microbial Characterization**

Sample splits for microbial characterization by phospholipid fatty acid (PLFA) analysis were shipped frozen to Microbial Insights (Rockford, TN) where all analyses were carried out. A total of 198 samples from the Elizabeth City and Denver Federal Center sites were examined by Microbial Insights. Lipids were extracted using buffered chloroform-methanol solvents. Analysis of PLFA was carried using gas chromatography/mass spectrometry (GC/MS). Results of the PLFA measurements are presented and discussed in Volume 1 of this EPA Report series.

## **5.4 Quality Assurance/Quality Control Measures**

For each type of field analysis (i.e., alkalinity, Cr(VI), Fe<sup>2+</sup>, H<sub>2</sub>S), standards of known concentration were analyzed during each sampling event to ensure instrument accuracy and performance. For laboratory analyses, quality control (QC) measures were performed along with the sample analyses. QC included analysis of blanks, duplicates (both field and laboratory), second source standards, and check standards. The relative percent difference (RPD) was calculated for selected organic and cation data for field duplicates. These RPDs are included in Appendices D, E, and F. Relative percent difference was calculated using the following equation:

$$RPD = \frac{|x_1 - x_2|}{[(x_1 + x_2)/2]} \times 100$$

where X<sub>1</sub> is the value of the field sample and X<sub>2</sub> is the value of the duplicate field sample.

Table D shows data for duplicate field samples obtained from the monitoring wells at the Elizabeth City site. Values are generally <10% different for sulfate, chloride, nitrate, and nitrite. Organics, dissolved gases, and cation duplicates also

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showed fairly good agreement. Where greater differences were seen, concentrations were fairly low. Total carbon showed the greatest difference between duplicate samples.

Duplicate data from the monitoring wells from the Denver Federal Center (Table E) show all values (except one pair) for sulfate, chloride, nitrate/nitrite to be <5%. Organics duplicates were very comparable except for July 2001 which showed a 58.8% difference. Duplicates for cations showed good correlation except for iron in July 2000; however, concentrations were very low.

Table F gives duplicate field sample data for Transect 2 multi-level samplers at the Elizabeth City site. Sulfate and chloride differences were <10%. The only significant difference in nitrate/nitrite data was found in June 2000; however, concentrations were <1 mg/L.

Some differences were seen between duplicates for TOC values, notably September 1998 where concentrations were 13.2 and 2.20 mg/L, resulting in a 143% difference. Where large RPDs are seen for the organics and dissolved gases, concentrations are very low. Concentrations of most cation duplicates were very comparable except where concentrations were extremely low.



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## 6.0 Summary

One of the primary concerns of using permeable reactive barriers for treatment of contaminated sites is the potential for plugging or fouling of the barrier. Geochemical changes in the vicinity of the PRB can result in precipitation of native materials along the interface of the iron barrier, resulting in the loss of permeability of the iron filings. Decreased permeability of the iron filings can result in the contaminant plume bypassing the barrier with water flowing either around or beneath the treatment wall. Performance monitoring is crucial to evaluating the performance of permeable reactive barriers. The sampling methods and procedures used to monitor ground water and soil within and around permeable reactive barriers is critical for evaluating the long-term performance of these treatment technologies.

Monitoring well location and installation is a vital first step to obtaining representative ground-water samples. Monitoring wells were installed at the U.S. Coast Guard and Denver Federal Center sites to evaluate upgradient, downgradient, and mid-barrier contaminant concentrations. At the U.S. Coast Guard site, multi-level samplers were installed upgradient, downgradient, and within the wall in order to evaluate vertical and lateral distribution of contaminants and degradation by-products adjacent to the PRB.

For ground water collection, sampling devices and sampling techniques should be selected in order to meet monitoring objectives. Low-flow purging and sampling techniques are recommended for obtaining ground-water samples. It is essential to monitor water quality indicator parameters (WQPs) during purging in order to establish when formation water has been accessed. WQPs include ORP, pH, DO, specific conductance, and turbidity. The electrodes and methods used to monitor these WQPs should be carefully selected, and it is necessary to follow manufacturer's recommendations regarding calibration, use, and storage. Potential interferences using certain field test kits and electrodes must be considered, and proper quality control measures are necessary to ensure representative data are obtained.

Monitoring results show that pH measurements in the multi-level samplers at the U.S. Coast Guard site indicate a significantly higher pH in the wells installed within the wall than in those located/installed immediately upgradient or downgradient of the reactive barrier. Ground water pH in the immediate vicinity of the wall showed a significant increase, which may result in precipitation of naturally occurring metals and carbonates. At both sites, pH returns to near neutral values downgradient of the PRBs.

Oxidation-reduction potential (ORP) is indicative of the oxidation or reduction conditions of a subsurface environment. Significantly decreased ORP and dissolved oxygen (DO) values and the presence of ferrous iron within the iron barrier would be expected in a reducing environment. Monitoring results at both PRBs site show reduced ORP values immediately downgradient of the PRB. Dissolved oxygen values were <1.0 mg/L at all locations at the Denver Federal Center and in all downgradient monitoring wells at the U.S. Coast Guard site.

Total dissolved solids (TDS) values obtained in the laboratory were compared to specific conductance measurements in the monitoring network. Results show good correlation of these two parameters, indicating that measuring specific conductance in the field provides preliminary information regarding TDS values. In general, high levels of TDS (>1,000 mg/L) are expected to result in increased rates of mineral precipitation and iron corrosion. Monitoring relative changes in specific conductance values between upgradient, iron barrier, and downgradient locations is in most cases a reasonable indicator for potential fouling of the iron wall due to mineral precipitation.

Soil cores obtained from within both barriers show some geochemical changes at the upgradient interface. Resultant precipitation of secondary minerals may alter reactivity of the iron barrier by reducing surface area and/or reducing PRB permeability. This may adversely affect ground-water flow direction and velocity, resulting in ground water flowing around or beneath the reactive barrier and reduced effectiveness of the barrier.

Results of geochemical sampling at both PRB sites indicate that iron corrosion is proceeding within the iron barriers. Reduced concentrations below regulatory limits for contaminants of concern indicate the PRB is an effective treatment technology. Chromium and VOC concentrations were decreased to levels below regulatory limits at the Elizabeth City site. Organic contaminant concentrations at the Denver Federal Center site were also significantly decreased following installation of the PRB. Monitoring will need to continue at the U.S. Coast Guard and Denver Federal Center sites in order to adequately evaluate this treatment technology for long term (>5 years) viability at contaminated field sites.



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## 7.0 References

- American Public Health Association, American Water Works Association and Water Pollution Control Federation. (1992) Standard Methods for the Examination of Water and Wastewater, 19<sup>th</sup> edition. Washington, D.C.: APHA, pp. 3-60, 3-66, and 4-126.
- Atkin B.P. and Sommerfield, C. (1994). The determination of total sulphur in geological materials by coulometric titration. *Chemical Geology*, v. 111, pp. 131-134.
- Beck, F.P., Clark, P.J., and Puls, R.W. (2002). Direct push methods for locating and collecting cores of aquifer sediment and zero-valent iron from a permeable reactive barrier. *Ground Water Monitoring and Remediation*, v. 22, pp. 165-168.
- Beck, F.P., Clark, P.J., and Puls, R.W. (2000). Location and characterization of subsurface anomalies using a soil conductivity probe. *Ground Water Monitoring and Remediation*, v. 20, pp. 55-59.
- Canfield, D.E., Raiswell, R., Westrich, J.T., Reaves, C.M., and Berner, R.A. (1986). The use of chromium reduction in the analysis of reduced inorganic sulfur in sediments and shales. *Chemical Geology*, v. 54, pp. 149-155.
- Christy, C.D., Christy, T.M., and Wittig, V. (1994). A percussion probing tool for the direct sensing of soil conductivity. In: Proceedings of NGWA 8th National Outdoor Action Conference, Minneapolis, MN, May 1994, pp. 381-394.
- Engleman, E.E., Jackson, L.L., and Norton, D.R. (1985). Determination of carbonate carbon in geological materials by coulometric titration. *Chemical Geology*, v. 53, pp. 125-128.
- FHWA. (1999). IM#1 Performance evaluation report.
- Gilbert, T.W., Behymer, T.W., and Castaneda, H.B. (1982). Determination of dissolved oxygen in natural and wastewaters. *American Laboratory*, v. 14, pp. 119-134.
- Hitchman, M.L. (1978). Measurement of Dissolved Oxygen. New York: John Wiley & Sons. 211 pp.
- Huffman, E. (1977). Performance of a new automatic carbon dioxide coulometer. *Microchemical Journal*, v. 22, pp. 567-573.
- Kampbell, D. and Vandegrift, S. (1998). Analysis of dissolved methane, ethane and ethylene in ground water by a standard gas chromatographic technique. *Journal of Chromatographic Science*, v. 36, pp. 253-256.
- Kamphake, L., Hannah, S. and Cohen, J. (1967). Automated analysis for nitrate and nitrite by hydrazine reduction. *Water Research*, v. 1, p. 205.
- McMahon, P.B., Dennehy, K.F., and Sandstrom, M.W. (1999). Hydraulic and geochemical performance of a permeable reactive barrier containing zero-valent iron, Denver Federal Center. *Ground Water* 37, no. 3: 396-404.
- Morse, J.W. and Cornwell, J.C. (1987). Analysis and distribution of iron sulfide minerals in recent anoxic marine sediments. *Marine Chemistry*, v. 22, pp. 55-69.
- Pacific Western Technology, Ltd. (2000). 1999 performance evaluation of the interim groundwater remediation measure, Denver Federal Center. Prepared for Federal Highway Administration and General Services Administration, Denver, CO.
- Parsons Engineering Science. (1995). *Interim Measures Baseline Report*, Rev. 1.
- Paul, C.J., Khan, F.A., and Puls, R.W. (2002). *In situ* reduction of chromium-contaminated groundwater, soils, and sediments by sodium dithionite. In "Handbook of Groundwater Remediation Using Permeable Reactive Barriers," eds. D.L. Naftz, S.J. Morrison, J.A. Davis, and C.C. Fuller, Academic Press, New York, pp. 465-493.
- Puls, R.W. and Paul, C.J. (1997). Multi-layer sampling in conventional monitoring wells for improved estimation of vertical contaminant distributions and mass. *Journal of Contaminant Hydrology*, v. 25, pp. 85-111.
- Puls, R.W. and Paul, C.J. (1997). Low-flow purging and sampling of ground water monitoring wells with dedicated systems. *Ground Water Monitoring and Remediation*, Winter, pp 116-123.
- Puls, R.W., Blowes, D.W., and Gillham, R.W. (1999a). Long-term performance monitoring for a permeable reactive barrier at the U.S. Coast Guard Support Center, Elizabeth City, North Carolina. *Journal Hazardous Materials*. v. 68, pp. 109-124.

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- Puls, R.W., Powell, R.M., Paul, C.J., and Blowes, D. (1999b). Groundwater remediation of chromium using zero-valent iron in a permeable reactive barrier. In "Innovative Subsurface remediation: Field Testing of Physical, Chemical and Characterization Technologies", eds, M.L. Brusseau, D.A. Sabatini, J.S. Gierke, and M.D. Annable. Oxford University Press, American Chemical Society, pp. 192-194.
- Puls R.W. and Barcelona, M.J. (1996). Low-flow (minimal drawdown) ground water sampling procedures. U.S. EPA, Ground Water Iss., EPA/540/S-95/504.
- Puls, R.W. and Paul, C.J. (1995). Low-flow purging and sampling of ground-water monitoring wells with dedicated systems. *Ground Water Monitoring and Remediation*, no. 15 v. 1, pp. 116-123.
- Rose, S., and Long, A. (1988). Monitoring dissolved oxygen in groundwater: Some basic considerations. *Ground Water Monitoring Review*, v. 8, pp. 93-97.
- U.S. EPA. (2002). Workshop on monitoring oxidation-reduction processes for ground-water restoration. EPA/600/R-02/002.
- White, A.F., Peterson, M.L., and Solbau, R.D. (1990). Measurement and interpretation of low levels of dissolved oxygen in ground water. *Ground Water*, v. 28(4), pp. 584-590.
- Wilkin, R.T. and Puls, R.W. (2003). Capstone report on the application, monitoring and performance of permeable reactive barriers for ground water remediation: Volume 1 - Performance evaluations at two sites. In publication.
- Wilkin, R.T., Puls, R.W., and Sewell, G.W. (2002). Long-term performance of permeable reactive barriers using zero-valent iron: an evaluation of two sites. U.S. Environmental Protection Agency Research Brief. EPA/600/S-02/001.
- Wilkin, R.T., McNeil, M.S., Adair, C.J., and Wilson, J.T. (2001). Field measurement of dissolved oxygen: a comparison of methods. *Ground Water Monitoring and Remediation*, Fall, pp. 124-132.
- Zhabina, N.N. and Volkov, I.I. (1978). A method of determination of various sulfur compounds in sea sediments and rocks. In "Environmental Biogeochemistry: Methods, Metals and Assessment", v. 3, ed. W.E. Krumbein, pp. 735-745.

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**Appendix A**  
**Selected Parameters Through Time in Elizabeth City Monitoring Wells**

**Table A1. Water Quality Parameters (WQPs) through Time in Elizabeth City Monitoring Wells**

Well ID	Feb-97	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Mar-99	Jun-99	Sep-99	Feb-00	Jun-00	Sep-00	Dec-00	Mar-01	May-01	Aug-01	Feb-02	
<b>pH</b>																			
MW13	6.10	6.32	6.23	6.16	6.20	5.95	6.38	6.22	5.75	6.21	6.16	6.34	6.23	6.94	6.16	6.42	6.45	6.55	
MW18	5.72	5.64	5.79	5.68	6.15	5.97	5.97	5.96	5.85	5.87	6.48	5.98	6.07	6.46	5.93	5.88	6.2	6.33	
MW35D	NA	6.33	NA	6.21	6.47	6.42	6.37	6.16	6.27	6.05	6.84	6.12	6.42	6.08	6.34	6.26	6.56	6.35	
MW38	5.91	5.89	5.95	5.77	6.03	5.68	6.20	6.05	5.68	5.86	6.43	5.95	5.93	6.23	5.98	5.85	6.15	6.02	
MW46	6.12	7.31	7.10	6.16	6.92	6.01	6.37	6.44	6.26	6.27	6.67	6.31	6.93	6.22	6.35	6.31	6.27	6.24	
MW47	6.98	7.05	7.10	7.07	7.69	7.50	7.56	7.53	7.49	7.53	7.99	7.59	7.98	7.39	7.08	7.83	7.50	7.44	
MW48	6.20	5.85	5.77	5.57	5.95	5.98	5.98	5.88	5.14	5.85	6.16	5.96	5.93	5.61	5.73	5.86	6.11	5.99	
MW49	7.00	7.24	6.26	7.06	7.24	7.53	7.44	7.62	6.78	7.36	8.16	7.89	7.76	8.00	7.20	7.37	7.54	7.50	
MW50	NA	6.30	6.26	6.14	6.43	6.44	6.37	6.27	6.05	6.32	6.90	6.45	6.52	6.39	6.25	6.34	6.60	6.54	
MW52	NA	NA	6.53	6.23	7.65	6.75	6.69	6.53	6.70	6.38	6.70	6.42	6.73	6.46	6.32	5.72	6.75	6.72	
<b>Eh (mV)</b>																			
MW13	249.8	389.4	225.3	235.0	380.8	376.4	366.7	378.1	335.6	504.3	423.2	427.4	316.2	301.4	348.5	333.7	275.1	360.0	
MW18	78.5	66.1	106.5	186.9	291.8	195.9	277.3	278.8	222.1	453.6	251.0	350.0	205.3	261.0	320.9	310.5	193.6	-19.0	
MW35D	NA	110.7	NA	98.1	201.5	231.5	154.2	207.9	196.4	279.1	169.8	-141.5	196.0	214.3	135.7	222.7	247.5	259.0	
MW38	279.2	385.6	245.1	236.4	397.4	376.4	385.1	417.8	358.0	404.4	347.4	504.6	204.5	416.6	322.3	348.9	306.4	310.0	
MW46	143.3	82.0	59.4	223.9	317.6	343.6	256.4	331.7	371.9	329.3	298.3	520.5	486.5	212.1	252.7	291.7	261.7	266.0	
MW47	99.9	133.6	59.4	44.6	206.8	-29.1	91.2	93.6	133.9	215.3	349.1	81.1	44.8	216.1	100.8	110.6	-28.8	15.0	
MW48	46.8	351.7	227.5	287.0	203.5	397.3	413.2	389.1	390.5	421.2	366.7	515.5	314.6	211.8	388.6	459.5	272.3	282.0	
MW49	54.6	-2.4	-5.0	-18.1	92.0	25.6	-43.3	32.8	95.8	273.2	8.0	-37.8	-15.2	331.0	12.0	2.3	-88.3	-80.0	
MW50	NA	123.4	18.0	30.5	151.1	182.6	8.2	177.4	240.4	294.7	168.4	166.3	148.4	212.8	408.1	207.8	116.0	113.0	
MW52	NA	NA	70.3	86.0	289.4	203.9	202.7	192.0	310.6	281.7	202.5	328.5	203.1	214.0	370.2	222.4	285.7	298.0	
<b>Specific Conductance (µS/cm)</b>																			
MW13	760	1125	732	830	853	893	801	814	915	820	875	852	825	777	908	905	448	415	
MW18	609	586	569	742	808	687	610	687	629	736	710	627	690	622	703	694	256	408	
MW35D	NA	234	NA	222	553	402	198	195	215	576	233	221	220	209	214	251	119	267	
MW38	160	206	138	185	543	176	157	183	152	168	175	143	162	149	168	180	34	128	
MW46	86	218	198	108	496	246	175	172	192	195	175	136	390	364	174	162	98	218	
MW47	128	262	198	157	509	170	115	156	166	152	170	207	195	153	165	178	135	233	
MW48	72	431	368	430	719	349	328	375	347	290	400	238	231	229	241	241	130	100	
MW49	241	310	201	258	646	284	280	265	273	274	307	296	296	253	306	312	183	223	
MW50	NA	217	146	129	552	198	188	172	226	194	152	126	194	172	111	116	99	240	
MW52	NA	NA	177	164	579	208	167	187	189	209	177	166	236	182	159	121	123	185	

Notes: NA, not analyzed.

continued..

**Table A1. Water Quality Parameters (WQP) through Time in Elizabeth City Monitoring Wells, continued**

Well ID	Feb-97	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Mar-99	Jun-99	Sep-99	Feb-00	Jun-00	Sep-00	Dec-00	Mar-01	May-01	Aug-01	Feb-02	
<b>Dissolved Oxygen - Probe (mg/L)</b>																			
MW13	0.97	2.54	0.71	0.32	1.52	1.29	0.11	0.46	2.05	1.07	0.68	1.37	0.90	3.00	0.80	0.81	0.80	0.81	0.81
MW18	1.00	0.58	1.45	0.18	1.50	0.81	0.10	0.21	1.42	1.29	0.59	0.67	0.73	2.17	0.61	1.08	0.61	1.08	1.08
MW35D	NA	0.93	0.39	0.32	0.68	8.87	0.08	0.13	0.87	0.74	0.55	0.19	0.31	0.81	1.00	1.97	1.00	1.97	1.97
MW38	0.35	0.54	0.59	0.19	2.54	0.90	0.07	0.15	0.85	0.25	0.81	0.38	NA	1.51	0.56	3.80	0.56	3.80	3.80
MW46	0.19	0.19	0.38	3.90	0.45	6.05	0.13	0.11	0.58	0.59	2.37	0.58	0.42	2.67	0.56	2.11	0.56	2.11	2.11
MW47	0.19	0.14	0.38	0.72	0.36	0.43	0.07	0.12	0.69	NA	0.41	0.09	0.12	2.03	0.85	3.31	0.85	3.31	3.31
MW48	0.47	1.51	0.51	0.17	3.12	3.27	5.04	0.12	1.02	0.57	0.40	0.75	0.36	NA	0.30	3.53	0.30	3.53	3.53
MW49	0.24	0.36	0.44	0.42	4.16	2.39	0.09	0.10	0.72	0.24	0.42	4.99	0.06	0.93	0.24	2.10	0.24	2.10	2.10
MW50	0.19	0.17	0.59	0.26	0.89	1.81	0.16	0.11	0.59	1.19	0.34	0.35	0.26	1.17	0.34	3.78	0.34	3.78	3.78
MW52	0.30	0.14	0.43	0.66	0.40	3.37	0.06	0.08	0.65	7.62	3.07	0.05	0.16	1.01	0.29	3.10	0.29	3.10	3.10
<b>Dissolved Oxygen - CHEMmet (mg/L)</b>																			
MW13	0.6	>1.0	1.0	0.2	0.3	0.3	0.4	<0.10	>1.0	2.3	3.5	NA	>1.0	6.0	NA	2.4	3.0	3.0	3.0
MW18	0.3	>1.0	0.8	0.2	0.4	0.3	0.4	0.4	0.2	0.9	2.0	0.1	0.8	1.0	0.5	3.8	1.0	1.0	1.0
MW35D	<0.10	0.8	0.6	0.1	0.2	0.3	0.4	0.1	0.1	0.3	0.2	0.2	>1.0	0.1	0.0	3.2	0.4	0.4	0.4
MW38	0.3	<0.10	1.0	0.2	0.2	0.4	0.4	0.3	0.3	0.3	0.8	0.1	0.3	0.6	0.3	3.6	1.0	1.0	1.0
MW46	0.3	0.9	0.6	0.1	0.3	0.2	0.4	0.6	0.7	0.4	>1	2.0	>1.0	0.4	0.3	0.8	3.0	3.0	3.0
MW47	0.1	>1.0	0.3	0.1	0.2	0.3	0.4	0.6	0.2	0.5	1.0	0.4	0.2	0.1	0.1	1.0	2.0	2.0	2.0
MW48	0.3	>1.0	1.0	0.2	0.2	0.3	0.4	0.8	0.2	0.7	0.4	0.8	1.0	0.8	0.2	0.4	2.0	2.0	2.0
MW49	0.3	0.8	0.3	0.1	0.2	0.2	0.4	0.3	0.0	0.5	0.0	0.2	0.2	0.1	0.1	1.0	1.0	1.0	1.0
MW50	NA	0.2	1.0	0.1	0.2	0.2	<0.10	0.2	0.2	0.7	0.2	0.2	0.4	0.6	0.7	1.0	2.0	2.0	2.0
MW52	NA	0.4	0.8	0.2	0.4	0.2	0.4	0.6	0.4	0.9	0.4	3.0	0.4	0.2	0.2	1.0	4.0	4.0	4.0
<b>Turbidity (NTU)</b>																			
MW13	NA	9.31	16.1	1.90	10.9	0.17	0.82	1.47	3.61	66.4	3.42	4.70	4.90	28.3	2.19	2.15	1.61	7.06	7.06
MW18	NA	6.73	21.1	3.53	24.1	0.99	2.87	1.34	0.62	0.69	0.77	2.20	3.24	3.81	0.82	0.60	0.96	3.74	3.74
MW35D	NA	4.52	NA	1.34	4.49	12.90	2.97	0.82	1.14	7.29	4.99	0.59	2.10	0.90	0.71	0.81	1.66	17.0	17.0
MW38	NA	0.43	0.08	0.12	0.27	0.17	0.77	1.71	0.34	0.23	3.55	2.40	1.94	5.00	0.92	0.74	1.44	1.13	1.13
MW46	NA	26	NA	4.83	2.33	0.52	0.28	0.40	0.24	3.06	1.62	103	8.80	5.00	1.62	1.78	7.50	6.41	6.41
MW47	NA	16.6	10.8	9.10	5.12	2.19	8.47	4.12	3.29	2.45	10.4	128	24.1	11.6	2.25	0.97	1.83	18.2	18.2
MW48	NA	4.99	1.92	0.77	1.00	0.73	2.28	0.66	1.08	3.32	0.66	5.11	5.30	0.90	0.44	1.07	0.64	2.21	2.21
MW49	NA	52.6	2.16	1.27	1.14	N/A	2.45	0.62	1.85	0.61	7.83	7.12	65.4	12.4	6.25	2.72	4.13	8.79	8.79
MW50	NA	558	144	49.1	19.1	73.8	42.2	123	130	144	151	32.5	12.6	8.65	14.50	16.2	2.40	6.08	6.08
MW52	NA	NA	8.87	32.00	0.83	1.20	2.41	2.71	2.92	6.69	46.3	369	127	50.0	54.0	>1000	1.71	132	132

**Table A2. Field Chemical Parameters through Time in Elizabeth City Monitoring Wells**

Well ID	Feb-97	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Mar-99	Jun-99	Sep-99	Feb-00	Jun-00	Sep-00	Dec-00	Mar-01	May-01	Aug-01	Feb-02
<b>Alkalinity (mg/L)</b>																		
MW13	91	137	94	76	98	88	102	93	96	76	119	88	104	67	80	116	NA	113
MW18	60	67	56	52	74	NA	60	75	82	74	77	75	66	69	74	93	NA	74
MW35D	73	87	88	60	76	63	62	74	77	62	84	84	70	65	79	90	NA	81
MW38	36	NA	49	47	41	32	63	43	36	34	48	43	46	39	51	50	NA	42
MW46	40	47	NA	38	74	64	61	76	51	62	57	39	66	51	49	47	NA	46
MW47	NA	66	38	28	53	38	26	40	49	38	45	48	68	47	46	45	NA	38
MW48	47	54	39	42	48	37	63	NA	45	60	53	50	54	32	47	51	NA	43
MW49	57	65	55	47	63	48	51	64	57	68	79	33	78	67	82	89	NA	69
MW50	38	39	41	39	29	33	36	27	46	43	40	32	44	33	39	36	NA	41
MW52	NA	NA	NA	68	29	33	36	29	33	40	37	40	54	54	38	30	NA	50
<b>Hexavalent Chromium (mg/L)</b>																		
MW13	3.5	2.6	5.3	2.5	NA	>0.5	2.50	3.5	0.7	3.0	3.25	3.30	3.8	4.0	4.8	4.3	4.0	2.5
MW18	ND	NA	ND	0.0	NA	ND	ND	ND	ND	ND	ND	0.01	ND	ND	ND	ND	ND	ND
MW35D	ND	ND	ND	0.1	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW38	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW46	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW47	NA	ND	ND	ND	ND	ND	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW48	0.6	0.4	NA	0.8	NA	>0.5	0.34	0.5	0.5	0.3	0.32	0.22	0.1	0.1	0.1	0.1	0.1	0.3
MW49	ND	ND	ND	ND	ND	ND	0.00	<0.1	ND	ND	ND	ND	ND	ND	0.1	ND	ND	ND
MW50	ND	ND	ND	ND	ND	ND	0.08	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW52	NA	NA	ND	ND	ND	ND	0.00	0.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
<b>Chromium-ICP (mg/L)</b>																		
MW13	3.3	3.3	3.7	3.5	2.4	3.8	3.1	4.5	4.3	4.8	2.9	4.2	4.3	4.5	4.1	4.2	4.3	3.3
MW18	0.02	0.003	0.005	0.004	<0.002	0.02	0.003	<0.002	<0.002	0.001	0.002	<0.002	0.004	<0.002	<0.003	<0.003	<0.003	<0.003
MW35D	<0.004	<0.002	<0.004	<0.003	0.004	0.002	0.003	<0.002	<0.002	0.001	0.01	0.002	0.008	<0.002	<0.003	<0.003	0.004	<0.003
MW38	<0.004	<0.002	<0.004	<0.003	0.002	<0.002	0.004	<0.002	<0.002	<0.001	0.003	<0.002	0.003	<0.002	<0.003	<0.003	<0.003	<0.003
MW46	0.004	0.003	<0.004	<0.003	0.003	0.01	<0.002	<0.002	<0.002	0.002	<0.001	<0.002	0.021	0.007	<0.003	<0.003	0.010	<0.003
MW47	<0.004	<0.002	<0.004	<0.003	<0.002	<0.002	0.002	<0.002	<0.002	<0.001	0.002	<0.002	<0.002	<0.002	<0.003	<0.003	<0.003	<0.003
MW48	0.91	0.47	0.73	0.78	1.6	1.1	0.78	0.57	0.59	0.37	0.59	0.21	0.14	0.12	0.11	0.13	0.077	0.29
MW49	<0.004	0.00	<0.004	NA	0.003	<0.002	<0.002	<0.002	0.003	<0.001	0.001	<0.002	0.004	<0.002	<0.003	<0.003	<0.003	<0.003
MW50	<0.004	<0.002	<0.004	<0.003	<0.002	<0.002	0.003	<0.002	<0.002	<0.001	0.002	<0.002	0.003	<0.002	<0.003	<0.003	<0.003	<0.003
MW52	NA	NA	0.03	0.005	<0.002	0.002	<0.002	<0.002	<0.002	<0.001	0.004	<0.002	0.033	<0.002	<0.003	<0.003	0.003	0.019

Notes: NA, not analyzed. ND, not detected.

**Table A3. Organic Values through Time in Elizabeth City Monitoring Wells**

Well ID	Feb-97	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Mar-99	Jun-99	Sep-99	Feb-00	Jun-00	Sep-00	Dec-00	Mar-01	May-01	Aug-01	Feb-02	
<b>Trichloroethene (µg/L)</b>																			
MW13	61.9	24.0	24.9	22.2	17.3	ND	8.24	23.7	22.0	24.8	34.7	27.2	24.4	33.6	ND	20.5	21.3	13.7	
MW18	14.0	7.70	ND	6.7	<1.00	1.00	ND	2.97	252	11.8	4.90	5.64	<1.00	9.37	8.62	2.95	2.46	4.63	
MW35D	0.90	ND	ND	369	ND	ND	ND	<1.00	<0.15	<1.0	ND	ND	ND	ND	ND	ND	1.07	1.61	
MW38	1.32	0.90	ND	2.10	ND	ND	ND	<1.00	<0.15	1.85	1.49	ND	<1.00	2.0	ND	ND	1.51	4.68	
MW46	636	63.3	10.9	226	46.0	36.9	51.9	149	249	270	401	166	2.47	110	328	367	126	106	
MW47	<1.00	1.50	1.90	1.99	ND	1.65	ND	1.12	212	1.53	1.07	2.93	2.55	4.27	2.26	8.18	8.17	2.69	
MW48	471	535	111	650	117	391	347	474	519	1250	1230	1625	1070	1020	1150	791	794	865	
MW49	2.80	NA	5.50	4.12	<1.00	1.33	<1.00	<1.00	<1.00	<1.0	0.86	2.77	<1.00	1.26	12.8	4.27	1.33	9.50	
MW50	3.40	156	548	390	171	360	290	411	200	393	290	111	107	190	66.5	62.3	147	153	
MW52	NA	NA	286	404	470	202	164	367	235	192	527	557	318	656	697	600	266	33.1	
<b>cis-Dichloroethene (µg/L)</b>																			
MW13	2.18	0.70	<1.00	6.49	ND	ND	ND	<1.00	ND	ND	1.29	1.27	<1.00	1.29	ND	ND	<1.00	<1.00	
MW18	7.87	4.50	ND	7.83	ND	ND	ND	1.42	1.26	5.78	2.06	2.13	<1.00	3.32	2.26	1.02	ND	<1.00	
MW35D	ND	ND	ND	43.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.01	
MW38	ND	ND	ND	9.56	ND	ND	ND	<1.00	ND	ND	<1.00	<1.00	<1.00	<1.00	ND	ND	ND	<1.00	
MW46	10.6	6.30	6.40	6.80	33.4	39.1	45.6	30.9	165	179	101	27.4	3.93	12.7	23.3	14.6	11.5	24.1	
MW47	1.00	2.60	2.00	1.31	ND	5.77	1.18	1.22	1.75	2.92	3.63	7.15	6.74	11.2	5.74	11.1	30.0	19.7	
MW48	2.40	4.70	21.4	4.02	3.21	5.90	60.0	3.48	6.08	ND	2.7	<1.00	ND	ND	ND	ND	ND	37.5	
MW49	ND	NA	2.60	<1.00	ND	ND	ND	<1.00	ND	ND	0.90	<1.00	<1.00	1.12	ND	ND	<1.00	1.18	
MW50	ND	3.70	14.7	15.4	16.3	12.1	17.3	18.6	15.2	19.9	10.6	6.40	21.7	34.6	4.51	7.32	6.97	14.6	
MW52	NA	NA	44.7	46.2	28.2	42.0	50.6	56.0	78.6	92.2	73.3	44.1	64.2	96.5	41.4	40.6	63.2	73.8	
<b>Vinyl Chloride (µg/L)</b>																			
MW13	<1.00	ND	<1.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
MW18	1.28	<1.00	ND	<1.00	ND	ND	ND	<1.00	ND	ND	ND	<1.00	ND	ND	ND	ND	ND	ND	
MW35D	ND	ND	ND	4.24	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
MW38	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<1.00	ND	ND	ND	ND	ND	ND	
MW46	1.60	2.00	1.90	2.48	5.17	9.19	8.72	4.40	7.96	11.1	ND	3.27	ND	ND	3.60	3.12	ND	2.18	
MW47	1.82	1.70	ND	4.92	ND	3.57	2.68	10.4	ND	ND	ND	2.05	1.63	30.2	ND	ND	ND	ND	
MW48	<1.00	ND	2.6	ND	ND	<1.00	5.80	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.70	
MW49	<1.00	NA	1.30	4.61	7.03	1.91	2.02	ND	ND	ND	ND	ND	16.7	40.8	ND	20.6	ND	ND	
MW50	ND	<1.00	ND	1.39	1.06	1.82	2.86	ND	ND	ND	ND	ND	4.42	7.89	ND	1.43	ND	3.27	
MW52	NA	NA	5.60	6.98	4.86	2.70	1.42	2.62	4.62	4.84	ND	5.66	17.9	16.2	ND	10.8	12.1	2.24	

Notes: NA, not analyzed. ND, not detected.

**Table A4. Anion Values through Time in Elizabeth City Monitoring Wells**

Well ID	Feb-97	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Mar-99	Jun-99	Sep-99	Feb-00	Jun-00	Sep-00	Dec-00	Mar-01	May-01	Aug-01	Feb-02	
<b>Sulfate (mg/L)</b>																			
MW13	NA	134	128	131	131	113	137	130	136	105	112	116	106	128	124	127	140	191	
MW18	92.7	96.2	91.8	113	108	88	105	117	108	100	115	103	109	119	113	113	89.9	122	
MW35D	<0.5	0.5	1.4	7.5	<0.1	8.0	0.5	<0.1	<0.5	10.8	<0.5	<1.0	3.9	1.1	<1.0	2.3	<1.0	<1.0	
MW38	22.0	24.9	26.9	25.5	28.5	23.9	24.3	25.4	22.7	19.0	20.2	20.4	20.8	20.0	18.8	23.5	22.3	19.4	
MW46	6.0	7.4	3.0	6.6	6.3	11.2	11.4	10.2	NA	15.6	13.0	14.2	26.8	25.2	10.0	10.8	18.5	16.6	
MW47	1.0	2.9	7.9	0.3	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.50	<1.0	<0.50	<0.50	<1.0	<1.0	<1.0	<1.0	
MW48	56.2	46.4	NA	67.4	70.4	8.1	48.8	61.5	49.0	36.5	55.3	<1.0	29.2	27.5	29.9	30.6	29.9	54.8	
MW49	1.8	1.0	2.4	1.2	<0.1	0.3	0.4	<0.1	<0.5	<0.5	<0.50	<1.0	<0.50	<0.50	1.7	<1.0	<1.0	<1.0	
MW50	3.4	12.0	9.4	6.7	4.3	3.8	4.6	3.1	2.7	2.4	3.0	7.0	4.1	2.4	2.4	4.3	1.1	2.3	
MW52	NA	NA	9.4	1.5	5.0	5.4	5.4	5.3	<0.5	3.3	4.0	8.1	6.2	4.6	5.2	6.3	6.4	7.4	
<b>Chloride (mg/L)</b>																			
MW13	145	142	140	124	133	123	129	137	118	118	124	123	110	131	137	134	139	126	
MW18	124	127	119	133	116	104	104	122	106	106	99.2	89.6	83.9	101	91.5	90.1	67.2	85.7	
MW35D	17.0	17.5	19.4	39.1	17.1	75.0	22.0	19.4	110	110	20.4	22.6	24.8	29.9	22.9	23.3	24.3	31.4	
MW38	17.2	10.5	12.3	12.1	11.4	10.9	10.7	9.3	11.3	11.2	8.7	9.4	15.1	8.8	9.2	8.9	9.4	8.9	
MW46	9.5	17.0	55.9	15.0	12.2	17.5	13.2	15.3	19.5	19.5	13.0	12.9	52.2	57.9	19.0	15.0	14.6	27.7	
MW47	19.4	35.9	20.8	21.6	19.7	32.5	25.9	32.0	26.9	26.9	29.8	40.7	30.4	23.5	24.6	21.9	36.5	33.1	
MW48	41.6	44.7	NA	61.2	58.0	7.2	50.0	54.3	30.3	30.3	49.3	23.3	24.5	25.4	21.2	16.9	24.6	48.7	
MW49	57.9	52.1	52.9	53.3	58.2	54.9	56.1	53.6	44.9	49.3	46.5	48.1	45.7	38.9	43.4	42.5	43.2	33.9	
MW50	6.5	33.1	34.7	27.7	36.1	38.2	39.9	36.3	39.1	39.1	21.1	17.1	37.4	29.1	11.5	10.6	37.6	31.2	
MW52	NA	NA	43.3	16.4	36.3	39.1	35.9	39.5	39.6	39.6	29.5	26.3	40.9	31.5	18.7	29.1	37.0	31.7	
<b>Nitrate + Nitrite (mg/L)</b>																			
MW13	4.12	3.87	6.20	2.75	2.79	2.12	2.96	2.53	2.93	2.24	2.47	<0.10	4.27	2.50	2.87	2.59	2.06	2.00	
MW18	<.05	0.15	0.16	<0.10	<0.10	<0.10	<0.10	<0.10	0.14	0.11	<0.10	<0.10	<0.10	<0.10	<0.10	0.22	0.13	<0.10	
MW35D	<.05	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.15	0.11	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	
MW38	0.53	0.56	0.55	0.20	0.48	<0.10	0.83	0.49	0.53	0.56	0.32	<0.10	0.46	0.43	0.43	0.44	<0.10	0.64	
MW46	<.05	0.11	0.14	<0.10	<0.10	<0.10	<0.10	<0.10	NA	0.11	<0.10	0.28	2.30	1.46	<0.10	<0.10	<0.10	<0.10	
MW47	<.05	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.13	0.11	<0.10	2.08	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	
MW48	1.21	1.06	<0.10	1.43	1.23	0.20	1.66	0.92	1.53	0.85	1.34	0.37	0.62	0.55	0.75	0.35	<0.10	1.10	
MW49	<.05	<0.10	0.21	<0.10	<0.10	<0.10	<0.10	<0.10	0.14	0.11	<0.10	0.25	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	
MW50	<.05	<0.10	0.20	<0.10	<0.10	<0.10	<0.10	<0.10	0.12	0.13	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	
MW52	NA	NA	0.14	<0.10	<0.10	<0.10	<0.10	<0.10	0.13	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	

Notes: NA, not analyzed.

**Table A5. Cation Values through Time in Elizabeth City Monitoring Wells**

Well ID	Feb-97	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Mar-99	Jun-99	Sep-99	Feb-00	Jun-00	Sep-00	Dec-00	Mar-01	May-01	Aug-01	Feb-02	
<b>Sodium (mg/L)</b>																			
MW13	160	173	177	158	145	155	168	161	169	149	153	149	143	158	156	163	168	175	
MW18	119	118	130	133	98	115	135	132	134	121	153	111	79	122	118	122	65	131	
MW35D	15.8	15.7	17.0	16.2	15.0	18.5	17.8	17.3	17.7	72.1	17.2	18.0	17.4	17.8	18.3	18.4	15.7	21.8	
MW38	19.4	17.9	18.9	19.1	18.1	18.2	17.6	17.8	19.2	17.2	16.0	15.3	15.8	16.7	16.5	17.4	16.6	17.4	
MW46	11.2	21.6	26.2	19.7	23.6	32.1	24.4	23.1	22.8	23.2	19.6	15.2	48.2	43.8	19.8	18.4	19.5	25.2	
MW47	30.3	35.5	40.3	27.8	25.9	27.5	23.7	33.1	33.1	31.9	34.9	37.2	33.8	27.7	26.2	27.9	29.4	30.7	
MW48	54.1	49.7	69.3	66.6	68.3	54.3	59.5	52.4	55.8	38.6	52.5	30.6	26.8	27.6	26.7	27.2	26.9	48.2	
MW49	56.1	48.0	50.3	NA	51.6	50.1	51.5	51.7	48.9	55.1	55.7	58.5	56.0	53.7	60.0	59.3	57.9	50.8	
MW50	9.32	24.3	28.7	23.0	25.0	28.9	33.6	29.2	31.3	33.9	23.8	28.2	30.1	27.6	16.6	16.0	28.0	26.8	
MW52	NA	NA	43.6	39.6	34.5	40.1	36.8	37.2	35.3	41.2	29.7	19.4	42.4	36.4	21.1	31.0	34.4	35.8	
<b>Potassium (mg/L)</b>																			
MW13	<0.98	2.56	3.04	1.50	3.08	2.79	2.34	1.33	1.59	2.82	3.02	3.24	3.17	3.65	3.19	3.08	3.31	3.71	
MW18	<0.98	0.90	1.34	<0.79	3.82	3.63	1.50	0.57	1.21	2.90	3.02	2.55	3.49	3.23	2.55	2.47	3.32	2.49	
MW35D	<0.98	1.59	1.87	<0.79	2.09	1.77	1.39	0.91	0.93	4.09	1.75	1.94	1.77	1.88	1.88	1.82	1.99	2.21	
MW38	1.69	2.01	2.27	1.44	2.71	2.46	2.08	1.24	0.84	1.74	2.00	1.69	1.80	1.92	1.97	1.99	1.78	1.93	
MW46	<0.98	1.75	0.98	<0.79	1.57	2.03	1.00	1.04	1.13	1.97	1.57	2.02	7.72	6.53	2.37	2.21	3.10	2.78	
MW47	<0.98	1.71	<0.90	<0.79	1.74	0.77	0.25	0.57	<0.48	0.96	0.94	1.82	2.03	2.05	1.95	2.04	2.48	1.86	
MW48	<0.98	1.95	2.79	0.96	2.66	1.21	1.03	0.35	1.18	1.57	1.67	1.47	1.65	1.81	1.43	1.37	1.39	1.77	
MW49	<0.98	1.96	<0.90	NA	1.91	1.26	0.86	0.90	1.09	1.60	1.54	1.49	1.52	1.64	1.54	1.57	1.51	1.40	
MW50	<0.98	2.27	1.01	0.96	2.12	1.68	0.82	0.60	<0.48	0.89	0.82	1.14	0.83	1.09	0.77	0.83	0.81	1.20	
MW52	NA	NA	0.91	<0.79	2.05	<0.30	0.64	0.95	1.30	1.23	1.05	0.85	2.28	1.31	1.04	1.05	1.25	1.74	

Notes: NA, not analyzed. ND, not detected.

continued..

**Table A5. Cation Values through Time in Elizabeth City Monitoring Wells, continued**

Well ID	Feb-97	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Mar-99	Jun-99	Sep-99	Feb-00	Jun-00	Sep-00	Dec-00	Mar-01	May-01	Aug-01	Feb-02	
<b>Calcium (mg/L)</b>																			
MW13	17.9	19.4	18.5	17.7	16.5	15.5	16.4	16.6	17.6	13.3	16.5	15.7	13.9	14.7	15.4	16.0	15.3	21.21	
MW18	14.1	13.6	11.9	13.8	13.8	12.3	11.4	12.8	13.2	12.8	16.5	11.2	9.9	11.9	11.7	11.2	8.5	10.53	
MW35D	14.2	14.9	15.2	15.7	14.9	10.0	15.7	15.4	16.7	15.0	16.3	17.4	17.8	16.7	16.5	16.1	15.8	20.55	
MW38	12.3	10.4	10.5	12.9	10.9	14.5	9.96	10.5	10.0	9.15	10.1	9.15	9.29	9.06	9.84	9.88	8.79	9.46	
MW46	5.53	5.59	5.33	5.66	6.04	10.3	10.2	10.5	12.3	11.7	9.76	9.09	18.9	19.4	9.60	9.53	12.2	13.3	
MW47	5.08	7.74	7.88	6.66	5.31	4.33	2.31	2.87	2.79	2.03	1.98	3.40	4.93	4.83	5.14	5.99	6.23	4.56	
MW48	10.2	11.1	12.1	14.7	10.9	9.1	10.6	13.5	14.2	10.1	12.6	10.9	9.25	10.8	10.3	9.77	9.70	12.6	
MW49	5.04	4.38	4.37	NA	5.18	4.51	4.66	4.54	4.36	4.34	4.31	3.73	3.77	4.83	3.52	3.54	2.69	2.15	
MW50	4.26	5.96	5.93	5.45	4.97	4.54	5.33	4.72	4.38	4.64	3.52	3.70	4.94	4.59	3.27	3.42	5.37	6.00	
MW52	NA	NA	3.86	3.71	3.03	2.88	2.47	3.00	2.86	2.86	2.80	3.85	4.57	4.67	3.27	3.62	6.54	7.48	
<b>Magnesium (mg/L)</b>																			
MW13	12.4	12.2	12.5	10.8	9.94	10.3	10.4	11.0	11.8	9.53	10.8	10.3	8.94	9.91	10.3	11.0	10.3	13.0	
MW18	11.6	11.1	10.1	11.5	7.67	8.79	9.84	11.1	11.0	10.2	10.8	9.12	5.51	9.49	9.70	9.25	4.37	9.31	
MW35D	5.02	5.04	5.55	4.97	4.78	5.42	5.81	5.52	6.02	13.8	5.95	6.33	5.67	6.11	6.16	6.08	5.52	7.72	
MW38	5.41	5.34	5.40	5.66	5.42	7.47	4.96	5.34	5.48	5.00	5.34	4.52	4.61	5.13	4.96	5.29	5.04	5.45	
MW46	3.26	2.95	2.97	3.04	2.72	4.80	5.84	4.73	6.16	6.00	4.85	3.78	4.98	5.62	4.07	3.93	4.88	4.88	
MW47	2.60	3.79	3.85	3.08	2.56	2.22	1.11	1.43	1.27	1.01	1.08	1.60	1.57	1.66	1.89	2.38	2.60	1.89	
MW48	6.63	6.84	7.79	9.57	7.28	6.10	7.03	9.31	9.74	6.79	8.88	7.21	6.11	7.33	6.93	6.91	6.87	9.12	
MW49	2.07	2.25	2.08	NA	2.76	2.50	2.45	2.92	2.74	3.01	3.46	2.72	2.64	2.41	2.30	2.62	1.80	1.38	
MW50	2.63	3.70	3.69	3.29	3.12	2.95	3.11	2.99	2.68	3.01	2.35	2.40	2.97	2.71	2.09	2.25	3.42	3.32	
MW52	NA	NA	2.37	2.23	1.81	1.80	1.48	1.96	1.81	1.98	2.00	2.45	2.75	2.75	2.14	2.44	4.30	5.04	

continued..

**Table A5.** Cation Values through Time in Elizabeth City Monitoring Wells, continued

Well ID	Feb-97	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Mar-99	Jun-99	Sep-99	Feb-00	Jun-00	Sep-00	Dec-00	Mar-01	May-01	Aug-01	Feb-02	
<b>Ferrous Iron (mg/L)</b>																			
MW13	0.02	0.01	ND	ND	0.10	ND	ND	<0.10	<0.10	ND	0.01	ND	ND	<1.0	<0.1	ND	ND	ND	
MW18	0.54	NA	2.69	0.20	1.28	1.25	1.61	0.30	2.00	3.00	0.00	0.63	1.21	2.00	0.10	0.21	1.75	0.30	
MW35D	4.00	5.1	4.95	>1.0	2.97	5.24	6.25	6.25	8.00	1.50	0.63	4.00	2.72	>10.0	8.00	2.73	10.4	7.00	
MW38	0.10	0.04	ND	ND	0.10	NA	ND	0.10	ND	ND	0.80	ND	0.07	<1.0	<0.10	0.00	0.12	ND	
MW46	0.07	0.10	NA	0.10	0.05	0.10	0.20	<0.1	0.30	ND	0.02	ND	0.02	<1.0	<0.10	0.25	0.08	2.00	
MW47	NA	0.03	0.12	0.20	0.40	0.20	0.30	0.20	0.30	0.20	0.01	0.19	0.14	<1.0	0.2	0.14	0.36	0.20	
MW48	0.00	0.02	ND	ND	0.10	ND	ND	<0.01	ND	ND	0.19	ND	0.01	<1.0	<0.10	ND	<0.01	ND	
MW49	0.37	0.62	1.00	1.00	1.00	>0.80	1.00	1.00	1.50	1.00	0.74	1.23	0.84	1.00	1.00	1.13	0.77	0.40	
MW50	0.86	0.69	0.69	1.00	NA	0.40	0.80	1.00	1.50	1.00	0.69	0.80	0.99	1.00	0.80	1.45	1.20	1.00	
MW52	NA	NA	0.03	0.20	0.15	0.10	0.10	0.30	0.20	0.20	0.20	0.12	0.21	1.00	0.30	0.57	0.62	2.00	
<b>Iron-ICP (mg/L)</b>																			
MW13	<0.01	<0.01	0.01	<0.02	0.01	<0.01	0.01	0.02	0.02	0.01	0.04	<0.04	0.05	<0.04	<0.04	0.31	<0.04	0.41	
MW18	0.65	1.7	4.1	0.17	0.92	2.6	2.3	1.2	1.2	2.0	0.04	0.57	0.86	2.3	0.18	0.32	0.75	0.35	
MW35D	6.1	6.6	6.7	7.0	5.9	<0.01	6.3	7.1	7.1	1.3	7.2	6.4	7.2	7.9	7.3	7.4	4.6	9.4	
MW38	0.02	0.08	0.04	0.04	0.08	<0.01	0.07	0.01	0.01	0.06	0.03	<0.04	0.06	<0.04	<0.04	0.04	0.06	0.05	
MW46	0.04	0.01	0.05	<0.02	0.03	0.03	0.07	0.11	0.11	0.11	<0.02	0.06	<0.04	<0.04	<0.04	0.16	0.23	0.94	
MW47	0.08	<0.01	0.2	0.08	0.15	0.26	0.18	0.19	0.19	0.15	0.22	0.12	0.14	0.15	0.18	1.2	0.22	0.69	
MW48	0.03	0.06	0.02	0.03	0.01	0.01	0.04	0.01	0.01	0.01	<0.02	<0.04	0.04	<0.04	<0.04	0.74	<0.04	0.12	
MW49	0.40	0.89	1.01	NA	1.2	1.3	1.4	1.6	1.6	1.2	0.98	1.3	1.1	1.2	0.92	1.70	0.75	0.82	
MW50	1.0	2.5	0.7	1.1	1.6	0.29	0.45	0.82	0.82	0.75	0.64	0.72	1.1	1.2	0.76	1.3	1.11	0.86	
MW52	NA	NA	0.01	0.09	0.04	0.02	0.03	0.05	0.05	0.19	0.34	1.9	0.13	0.91	0.15	0.63	0.54	9.3	
<b>Manganese (mg/L)</b>																			
MW13	0.05	0.03	0.08	<0.01	0.02	0.05	0.09	0.03	0.03	0.06	0.01	0.02	0.04	0.04	0.01	0.01	0.05	0.01	
MW18	0.66	0.95	0.77	0.48	0.57	0.67	0.72	0.42	0.98	0.66	0.01	0.68	0.36	0.63	0.45	0.56	0.28	0.22	
MW35D	0.21	0.25	0.37	0.27	0.25	0.11	0.60	0.33	0.37	0.25	0.31	0.37	0.29	0.31	0.31	0.32	0.32	0.45	
MW38	0.14	0.17	0.18	0.16	0.22	0.28	0.15	0.17	0.19	0.09	0.16	0.10	0.17	0.20	0.06	0.20	0.15	0.07	
MW46	0.04	0.07	0.14	0.13	0.12	0.23	0.31	0.22	0.33	0.33	0.22	0.15	0.00	0.00	0.08	0.16	0.25	0.33	
MW47	0.18	0.21	0.23	0.08	0.07	0.07	0.06	0.07	0.05	0.05	0.06	0.08	0.05	0.06	0.08	0.08	0.07	0.09	
MW48	0.35	0.48	0.48	0.47	0.37	0.29	0.34	0.39	0.40	0.26	0.29	0.21	0.26	0.18	0.16	0.26	0.26	0.17	
MW49	0.16	0.17	0.21	NA	0.23	0.26	0.31	0.24	0.25	0.23	0.21	0.22	0.21	0.21	0.21	0.22	0.16	0.12	
MW50	0.05	0.33	0.27	0.23	0.22	0.18	0.17	0.20	0.20	0.21	0.16	0.14	0.23	0.21	0.14	0.14	0.32	0.30	
MW52	NA	NA	0.05	0.06	0.05	0.04	0.05	0.05	0.05	0.06	0.04	0.07	0.16	0.14	0.08	0.11	0.43	0.54	



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**Appendix B**  
**Selected Parameters Through Time in**  
**Denver Federal Center Monitoring Wells**

**Table B1.** Results of Ground-water Analyses at the Denver Federal Center, May 1999

Well ID	pH	Eh (mV)	Conductivity (µS/cm)	DO - Probe (mg/L)	DO - CHEMet (mg/L)	Turbidity (NTU)	Alkalinity (mg/L)	Sulfide (mg/L)	Fe (II) - CHEMet (mg/L)	NO <sub>2</sub> <sup>-</sup> + NO <sub>3</sub> <sup>-</sup> (mg/L)	NH <sub>3</sub> (N) (mg/L)	Cl <sup>-</sup> (mg/L)	SO <sub>4</sub> <sup>2-</sup> (mg/L)
GSA-21	7.26	367.2	1308	1.41	0.3	1.93	312	0.000	0.1	<0.10	<0.10	62.8	267
C1-GU1	7.21	302.7	1296	0.59	0.2	0.43	305	0.001	0.1	4.22	<0.10	63.7	275
C1-H1 Fe	10.37	-24.7	1017	0.32	0.2	0.74	235	0.355	0.1	<0.10	0.86	68.7	124
C1-USGS6	7.68	21.2	1071	0.20	0.1	2.91	131	0.018	1.5	<0.10	0.18	57.1	244
C1-USGS1	7.78	341.5	1103	0.33	0.1	0.52	229	0.011	2.0	<0.10	0.19	105	400
C1-GD1	8.00	120.1	1034	0.21	0.2	2.54	217	0.020	3.0	<0.10	0.86	63.6	229
GSA-20	7.25	324.3	1443	1.34	0.2	0.50	239	0.003	0.1	<0.10	<0.10	97.1	340
GSA-26	7.09	298.8	1349	0.57	0.3	1.17	210	0.004	0.0	<0.10	<0.10	69.7	292
C2-USGS10	10.00	7.9	1551	0.22	0.3	1.34	215	0.264	0.2	<0.10	0.14	120	487
C2-USGS13	9.60	59.8	1474	0.29	0.3	0.47	215	0.043	0.2	<0.10	0.11	120	449
C2-USGS9 Fe	10.09	22.3	1558	0.26	0.2	0.60	127	0.156	0.1	<0.10	<0.10	123	470
C2-USGS8 Fe	10.52	26.9	1334	0.18	0.2	1.57	NA	0.144	0.2	<0.10	<0.10	144	282
C2-USGS7	9.40	101	1525	0.21	0.3	1.84	NA	0.014	0.1	<0.10	0.24	116	438
C2-USGS1	10.15	97.9	1506	0.36	0.2	0.47	98	0.014	0.1	<0.10	0.18	58.8	249
C2-USGS5	9.49	103.9	1513	0.27	0.1	0.68	187	0.014	0.1	<0.10	0.39	112	425
GSA-25	7.65	321.6	1192	1.70	0.3	1.41	365	0.003	0.2	<0.10	<0.10	131	231

Notes: ND, not detected. NA, not analyzed.

continued..

**Table B1.** Results of Ground-water Analyses at the Denver Federal Center, May 1999, continued

Well ID	B (mg/L)	Ba (mg/L)	Ca (mg/L)	Cr (mg/L)	Fe (mg/L)	K (mg/L)	Mg (mg/L)	Mn (mg/L)	Na (mg/L)	Sr (mg/L)	Si (mg/L)
GSA-21	0.16	0.01	134	<0.024	<0.021	<0.21	18	0.05	199	0.52	NA
C1-GU1	0.25	0.01	110	<0.024	<0.010	<0.21	14	0.05	203	0.43	NA
C1-I1	0.23	<0.39	2.53	<0.024	<0.010	<0.20	6.72	<0.0097	219	0.03	NA
C1-USGS6	0.09	0.00	108	<0.024	1.71	<0.21	7.62	0.19	157	0.34	NA
C1-USGS1	0.09	0.01	111	<0.024	3.53	<0.21	7.66	0.23	154	0.35	NA
C1-GD1	0.09	0.02	87	<0.024	2.59	<0.21	7.28	0.26	161	<0.311	NA
GSA-20	0.28	0.01	111	<0.024	<0.021	<0.21	17.2	<0.0097	208	0.48	NA
GSA-26	0.18	0.02	129	<0.024	<0.010	<0.21	33.8	<0.0097	173	0.79	NA
C2-USGS10	0.25	0.01	2.8	<0.024	<0.010	<0.20	35.5	<0.0097	302	0.01	NA
C2-USGS13	0.27	<0.0015	4.59	<0.024	0.03	<0.20	30	<0.0097	289	0.02	NA
C2-USGS9	0.24	0.01	3.06	<0.024	<0.010	<0.20	34.6	0.01	299	0.01	NA
C2-USGS8	0.27	0.02	4.14	<0.024	0.31	<0.20	11	0.03	282	0.02	NA
C2-USGS7	0.28	0.04	22.5	<0.024	0.02	<0.20	54.2	0.14	272	0.11	NA
C2-USGS1	0.27	0.04	22.9	<0.024	0.03	<0.20	55.1	0.20	268	0.09	NA
C2-USGS5	0.28	0.04	21.7	<0.024	0.02	<0.20	56.1	0.14	271	0.10	NA
GSA-25	0.16	0.01	68.6	<0.024	0.03	<0.21	10	0.04	216	0.29	NA

**Table B1.** Results of Ground-water Analyses at the Denver Federal Center, May 1999, continued

Well ID	TOC (mg/L)	Hydrogen (nM)	Vinyl Chloride (µg/L)	1,1-Dichloroethene (µg/L)	T-1,2-Dichloroethene (µg/L)	1,1-Dichloroethane (µg/L)	C-1,2-Dichloroethene (µg/L)	Chloroform (µg/L)
GSA-21	3.3	4.3	0.16	91	ND	1.3	ND	3.3
C1-GU1	3.3	4.8	0.16	63	ND	4.2	<1.0	2.2
C1-H1	2.3	1030	0.16	<1.0	ND	1.8	ND	ND
C1-USGS6	2.5	26.1	0.16	2.4	ND	1.4	ND	ND
C1-USGS1	2.4	184	0.16	2.8	ND	1.3	ND	ND
C1-GD1	2.6	4.8	0.16	3.0	ND	1.9	ND	ND
GSA-20	3.1	6.0	0.16	1.6	ND	1.3	ND	ND
GSA-26	3.1	11.7	0.16	173	ND	9.0	2.0	5.6
C2-USGS10	4.6	1.9	0.16	8.6	ND	13.5	<1.0	ND
C2-USGS13	2.8	2.8	0.16	16	ND	12.7	1.0	ND
C2-USGS9	4.3	5.3	0.16	8.3	ND	11.0	<1.0	ND
C2-USGS8	2.5	6.5	0.16	3.5	ND	10.2	<1.0	ND
C2-USGS7	5.1	52	0.16	43	ND	13.4	3.6	<1.0
C2-USGS1	4.7	13	0.16	48	ND	15.6	3.2	<1.0
C2-USGS5	4.8	2.5	0.16	45	ND	12.9	3.0	<1.0
GSA-25	1.7	10.7	0.16	24	<1.0	8.8	16	<1.0

Notes: ND, not detected.

continued..

**Table B1.** Results of Ground-water Analyses at the Denver Federal Center, May 1999, continued

Well ID	1,1,1-Trichloroethene (µg/L)	Carbon Tetrachloride (µg/L)	Benzene (µg/L)	1,2-Dichloroethane (µg/L)	Trichloroethene (µg/L)	Toluene (µg/L)	Tetrachloroethene (µg/L)
GSA-21	71	ND	ND	ND	23	ND	ND
C1-GU1	53	ND	ND	<1.0	16	ND	1.0
C1-I1	ND	ND	ND	ND	<0.11	ND	ND
C1-USGS6	ND	ND	ND	ND	<0.11	<1.0	ND
C1-USGS1	ND	ND	ND	ND	<0.11	ND	ND
C1-GD1	<1.0	ND	ND	ND	<0.11	<1.0	ND
GSA-20	<1.0	ND	ND	ND	<0.11	ND	1.4
GSA-26	128	ND	ND	<1.0	62	ND	ND
C2-USGS10	ND	ND	ND	<1.0	<1.0	ND	ND
C2-USGS13	ND	ND	ND	<1.0	<1.0	ND	ND
C2-USGS9	ND	ND	ND	<1.0	<1.0	ND	ND
C2-USGS8	ND	ND	ND	<1.0	ND	ND	ND
C2-USGS7	<1.0	ND	ND	<1.0	5.5	<1.0	ND
C2-USGS1	1.6	ND	<1.0	<1.0	6.6	<1.0	ND
C2-USGS5	1.4	ND	<1.0	<1.0	5.7	<1.0	<1.0
GSA-25	3.0	ND	ND	<1.0	39	ND	2.4

Notes: ND, not detected.

**Table B2.** Results of Ground-water Analyses at the Denver Federal Center, July 1999

Well ID	pH	Eh (mV)	Conductivity (µS/cm)	DO - Probe (mg/L)	DO - CHEM (mg/L)	Turbidity (NTU)	Alkalinity (mg/L)	Sulfide (mg/L)	Fe (II) - CHEM (mg/L)	NO <sub>2</sub> + NO <sub>3</sub> <sup>-</sup> (mg/L)	NH <sub>3</sub> (N) (mg/L)	Cl <sup>-</sup> (mg/L)	SO <sub>4</sub> <sup>2-</sup> (mg/L)
GSA-21	7.24	223.0	1251	0.92	0.8	0.44	376	<0.10	0.4	3.22	<0.10	51.8	234
C1-GU1	7.22	-66.7	1189	0.16	0.2	0.34	336	<0.10	0.0	2.76	<0.10	50.2	229
C1-I1	10.27	-246.8	833	0.13	0.3	0.56	320	<0.10	0.0	<0.10	0.16	59.7	<1.00
C1-I2	10.34	-47.7	775	0.26	0.1	13.7	290	<0.10	0.0	<0.10	0.25	54.9	6.29
C1-GD1	7.97	-130.1	1046	0.09	0.1	5.6	254	0.1	2.0	<0.10	0.14	62.8	229
GSA-20	7.34	137.5	1214	0.38	0.4	2.0	260	<0.10	0.05	<0.10	<0.10	98.1	266
GSA-26	7.28	280.6	1373	0.26	0.2	47.3	388	<0.10	0.0	2.93	<0.10	66.3	286
C2-USGS10	10.07	-53.4	1295	0.17	0.2	3.0	320	<0.10	0.0	0.28	0.49	88.3	211
C2-USGS9	9.93	-34.8	1434	0.09	0.1	3.4	304	<0.10	0.0	1.06	0.30	82.6	359
C2-USGS5	9.69	93.3	1529	0.52	0.3	26.9	390	<0.10	<0.10	1.30	0.30	82.0	406
GSA-25	7.64	-33.2	1302	0.71	2.0	1.7	216	<0.10	0.0	0.27	<0.10	130	223
GSA-31	6.99	-62.0	1296	0.13	<0.10	1.23	600	<0.10	11.3	<0.10	0.93	65.6	<1.00
C3-GU2	8.35	-175.8	1180	0.12	0.4	1.41	290	NA	0.6	<0.10	0.69	189	54.3
C3-I1	9.93	-171.6	970	0.18	0.2	26.8	604	0.03	0.45	<0.10	<0.10	199	<1.00
C3-USGS9	9.31	-208.7	1123	0.10	<0.10	6.06	340	0.11	1.5	<0.10	0.70	130	43.2
C3-I2	9.95	-193.9	1055	0.08	0.1	0.51	180	0.52	0.15	<0.10	0.65	129	2.05
C3-GD2	9.66	-173.0	1114	0.15	0.05	1.23	238	0.47	0.0	<0.10	<0.10	185	58.1
C3-USGS6	9.19	-103.7	1056	0.08	0.1	1.21	344	0.14	0.0	<0.10	<0.10	137	33.4
GSA-30	6.94	123.9	2050	1.31	0.9	1.62	1196	NA	0.2	<0.10	<0.10	172	335

Notes: NID, not detected. NA, not analyzed.

continued..

**Table B2.** Results of Ground-water Analyses at the Denver Federal Center, July 2000, continued

Well ID	TOC (mg/L)	Hydrogen (nM)	Vinyl Chloride (µg/L)	1,1-Dichloroethene (µg/L)	T-1,2-Dichloroethene (µg/L)	1,1-Dichloroethane (µg/L)	C-1,2-Dichloroethene (µg/L)	Chloroform (µg/L)
GSA-21	2.5	0.7	ND	67.6	ND	5.5	1.4	2.9
C1-GU1	2.0	0.6	ND	36.2	ND	3.7	<1.0	2.0
C1-I1	2.1	948	ND	33.6	ND	9.4	<1.0	<1.0
C1-I2	2.3	NA	ND	7.8	ND	6.8	<1.0	ND
C1-GD1	2.0	0.2	ND	3.6	ND	2.8	<1.0	ND
GSA-20	2.1	0.4	ND	2.3	ND	1.8	ND	ND
GSA-26	1.9	2.4	ND	130	ND	8.3	1.4	4.9
C2-USGS10	3.9	1.6	ND	11.4	ND	11.8	<1.0	ND
C2-USGS9	3.6	304	ND	27.4	ND	11.9	1.2	<1.0
C2-USGS5	2.9	1.5	ND	40.3	ND	13.4	1.8	<1.0
GSA-25	2.0	1.1	ND	35.8	<1.0	9.2	23.6	<1.0
GSA-31	10.4	3.68	3.5	2.0	<1.0	2.4	5.4	ND
C3-GU2	4.76	0.89	ND	2.1	ND	1.2	2.2	ND
C3-I1	5.23	NA	ND	ND	ND	ND	ND	ND
C3-USGS9	3.90	NA	6.8	23.7	ND	10.4	17.1	ND
C3-I2	4.72	2740	ND	ND	ND	ND	4.8	ND
C3-GD2	3.89	1.86	ND	<1.0	ND	ND	ND	ND
C3-USGS6	4.22	NA	ND	1.3	ND	4.2	1.0	ND
GSA-30	6.22	0.33	ND	ND	ND	<1.0	<1.0	ND

Notes: ND, not detected.

continued..

**Table B2.** Results of Ground-water Analyses at the Denver Federal Center, July 2000, continued

Well ID	1,1,1-Trichloroethane (µg/L)	Carbon Tetrachloride (µg/L)	Benzene (µg/L)	1,2-Dichloroethane (µg/L)	Trichloroethene (µg/L)	Toluene (µg/L)	Tetrachloroethene (µg/L)
GSA-21	41.4	ND	ND	<1.0	20.4	<1.0	1.0
C1-GU1	23.9	ND	<1.0	<1.0	11.5	<1.0	<1.0
C1-I1	<1.0	ND	<1.0	ND	ND	<1.0	ND
C1-I2	<1.0	ND	<1.0	ND	ND	ND	ND
C1-GD1	ND	ND	ND	ND	ND	<1.0	ND
GSA-20	ND	ND	<1.0	ND	<1.0	ND	ND
GSA-26	72.5	ND	<1.0	<1.0	55.3	<1.0	1.4
C2-USGS10	<1.0	ND	<1.0	<1.0	<1.0	<1.0	ND
C2-USGS9	1.9	ND	<1.0	<1.0	3.50	<1.0	ND
C2-USGS5	3.2	ND	1.3	<1.0	<1.0	ND	ND
GSA-25	2.7	ND	<1.0	<1.0	63.8	<1.0	<1.0
GSA-31	ND	ND	ND	ND	ND	<1.0	ND
C3-GU2	<1.0	ND	<1.0	ND	<1.0	<1.0	ND
C3-I1	ND	ND	<1.0	ND	ND	<1.0	ND
C3-USGS9	1.7	ND	<1.0	<1.0	6.2	<1.0	ND
C3-I2	ND	ND	ND	ND	ND	ND	ND
C3-GD2	ND	ND	<1.0	ND	ND	<1.0	ND
C3-USGS6	ND	ND	<1.0	ND	ND	<1.0	ND
GSA-30	ND	ND	ND	ND	<1.0	ND	ND

Notes: ND, not detected.

continued..

**Table B2.** Results of Ground-water Analyses at the Denver Federal Center, July 2000, continued

Well ID	B (mg/L)	Ba (mg/L)	Ca (mg/L)	Cr (mg/L)	Fe (mg/L)	K (mg/L)	Mg (mg/L)	Mn (mg/L)	Na (mg/L)	Sr (mg/L)	Si (mg/L)
GSA-21	0.29	0.02	100.1	<0.002	0.190	0.39	18.1	<0.001	179.3	0.455	13.2
C1-GU1	0.26	0.02	101.5	<0.002	<0.035	0.69	13.7	0.067	174.2	0.382	10.9
C1-I1	0.32	0.01	1.20	<0.002	<0.035	0.61	3.90	0.005	183.8	0.003	0.36
C1-I2	0.28	0.03	1.61	<0.002	0.313	0.60	2.33	0.005	167.6	0.004	0.33
C1-GD1	0.11	0.02	87.6	<0.002	2.31	0.81	7.94	0.218	155.2	0.315	9.56
GSA-20	0.12	0.01	98.0	<0.002	0.048	0.61	12.5	0.086	163.3	0.350	9.52
GSA-26	0.23	0.02	113.9	<0.002	<0.035	0.27	31.0	0.005	167.2	0.692	14.7
C2-USGS10	0.33	0.00	2.31	<0.002	<0.035	0.76	26.2	0.012	265.1	0.004	0.37
C2-USGS9	0.20	0.01	4.12	<0.002	0.066	0.95	61.3	0.036	248.4	0.008	0.31
C2-USGS5	0.17	0.03	9.00	<0.002	<0.035	0.86	93.2	0.058	231.5	0.041	0.58
GSA-25	0.19	0.01	67.3	<0.002	<0.035	0.77	9.73	0.020	201.1	0.263	9.83
GSA-31	0.16	0.19	116.6	0.010	17.04	0.86	32.5	4.23	140.4	0.918	14.8
C3-GU2	0.19	0.05	35.2	<0.002	0.719	2.48	7.8	0.705	227.7	0.269	4.12
C3-I1	0.20	0.03	2.37	<0.002	<0.035	1.95	0.621	0.014	202.6	0.026	0.33
C3-USGS9	0.17	0.04	27.8	<0.002	0.969	2.19	18.5	0.095	213.3	0.254	2.93
C3-I2	0.19	<0.002	1.97	<0.002	0.227	2.85	13.5	0.026	226.8	0.008	0.70
C3-GD2	0.13	0.01	9.37	<0.002	0.145	2.72	2.16	0.019	234.6	0.075	2.19
C3-USGS6	0.14	0.03	22.3	<0.002	0.254	2.17	7.61	0.096	216.6	0.157	2.30
GSA-30	0.20	0.04	233.3	<0.002	0.255	0.67	41.8	3.73	185.3	1.317	8.97

**Table B3.** Results of Ground-water Analyses at the Denver Federal Center, July 2001

Well ID	pH	Eh (mV)	Conductivity (µS/cm)	DO - Probe (mg/L)	DO - CHEMet (mg/L)	Turbidity (NTU)	Alkalinity (mg/L)	Sulfide (mg/L)	Fe (II) - CHEMet (mg/L)	NO <sub>2</sub> <sup>-</sup> + NO <sub>3</sub> <sup>-</sup> (mg/L)	NH <sub>3</sub> (N) (mg/L)	Cl <sup>-</sup> (mg/L)	SO <sub>4</sub> <sup>2-</sup> (mg/L)
GSA-21	6.93	-267.6	1150	0.53	0.4	10.5	351	NA	0.0	3.71	<0.10	47.8	213
C1-GU1	7.16	-237.1	1119	0.24	0.1	0.99	337	0.004	0.0	3.39	<0.10	47.5	207
C1-I1	10.17	-375.5	736	0.21	0.1	1.58	271	0.28	0.0	<0.10	<0.10	56.9	<1.00
C1-I2	10.48	-239.5	778	0.37	0.0	1.73	267	0.29	0.0	<0.10	<0.10	51.1	6.46
C1-GD1	7.83	-300.0	1004	0.18	0.2	1.34	237	0.16	2.5	<0.10	0.18	241	218
GSA-20	7.24	-110.3	1248	0.44	0.4	16.8	239	NA	0.5	<0.10	<0.10	105.5	286
GSA-26	7.20	-354.2	1353	0.23	0.0	2.04	290	0.002	0.0	1.90	<0.10	67.8	284
USGS10	10.20	-331.9	1250	0.22	0.0	3.29	226	0.23	0.0	<0.10	0.21	94.1	192
USGS11	10.10	-278.7	1264	0.43	0.5	2.40	178	0.15	0.1	<0.10	0.16	98.1	230
USGS13	9.78	-388.9	1156	0.19	0.0	1.73	135	0.08	0.1	<0.10	0.14	105	233
C2-GU2	7.08	-356.2	1683	0.39	0.0	0.53	404	0.00	0.0	1.16	<0.10	82.8	471
C2-I1	9.59	-287.6	928	0.24	0.1	9.04	227	0.88	0.8	<0.10	<0.10	65.8	146
C2-I2	9.32	-382.4	869	0.16	0.1	2.57	232	0.33	0.3	<0.10	<0.10	73.0	105
USGS4	9.40	-380.1	1192	0.15	0.0	3.62	198	0.09	0.0	<0.10	<0.10	103.0	256
USGS5	9.16	-376.6	1190	0.22	0.2	6.33	190	0.05	0.1	<0.10	<0.10	102.0	256
GSA-25	7.55	-194.7	1111	2.20	1.5	1.27	235	NA	0.0	0.22	<0.10	134.0	193
GSA-31	7.13	-347.9	1315	0.14	0.0	2.13	591	NA	17.5	<0.10	1.32	81.0	<1.00
C3-GU2	8.58	-280.3	1137	0.21	0.0	1.47	341	0.024	0.9	<0.10	0.59	165	4.22
C3-I1	9.08	-331.5	890	0.18	0.1	3.44	63	0.01	0.3	<0.10	<0.10	204	22.3
C3-USGS9	9.59	-273.6	1067	0.21	0.0	2.81	359	0.05	1.5	<0.10	0.61	126	3.18
C3-I2	9.58	-394.1	1061	0.13	0.1	1.54	400	0.15	0.3	<0.10	0.68	111	<1.00
C3-GD2	9.08	-391.9	1018	0.11	0.1	1.23	223	0.11	0.0	<0.10	0.34	137	4.76
C3-USGS6	8.99	-390.4	1028	0.1	0.0	1.76	319	0.10	0.1	<0.10	0.31	130	6.72
GSA-30	6.83	-311.6	1607	0.22	0.2	3.02	359	NA	0.8	<0.10	<0.10	184	132

Notes: ND, not detected. NA, not analyzed.

*continued.*

**Table B3.** Results of Ground-water Analyses at the Denver Federal Center, July 2001, continued

Well ID	TOC (mg/L)	Hydrogen (nM)	Vinyl Chloride (µg/L)	1,1-Dichloroethene (µg/L)	T-1,2-Dichloroethene (µg/L)	1,1-Dichloroethane (µg/L)	C-1,2-Dichloroethene (µg/L)	Chloroform (µg/L)
GSA-21	NA	0.21	ND	32.3	ND	4.32	1.06	2.01
C1-GU1	NA	0.18	ND	55.5	ND	5.52	1.39	1.80
C1-I1	NA	657	ND	35.9	ND	7.97	ND	ND
C1-I2	NA	NA	ND	18.7	ND	7.05	ND	ND
C1-GD1	NA	1.11	ND	5.35	ND	2.30	ND	ND
GSA-20	NA	0.65	ND	2.49	ND	1.54	ND	ND
GSA-26	NA	0.41	ND	152	ND	10.3	1.60	4.0
USGS10	NA	0.52	ND	12.0	ND	9.93	ND	ND
USGS11	NA	NA	ND	12.2	ND	9.28	ND	ND
USGS13	NA	NA	ND	22.8	ND	9.51	1.54	ND
C2-GU2	NA	NA	1.81	142	ND	11.7	5.61	2.51
C2-I1	NA	NA	ND	76.8	ND	12.1	2.34	ND
C2-I2	NA	88	ND	108	ND	15.4	2.69	ND
USGS4	NA	NA	ND	51.0	ND	12.2	4.17	ND
USGS5	NA	0.26	ND	48.7	ND	12.1	4.06	ND
GSA-25	NA	0.26	ND	24.4	ND	6.64	12.4	ND
GSA-31	NA	0.49	ND	ND	ND	ND	1.78	ND
C3-GU2	NA	0.64	ND	2.86	ND	2.19	2.33	ND
C3-I1	NA	NA	ND	ND	ND	ND	ND	ND
C3-USGS9	NA	NA	ND	16.1	ND	6.99	11.6	ND
C3-I2	NA	1837	ND	10.8	ND	6.72	6.55	ND
C3-GD2	NA	0.48	ND	1.55	ND	2.32	ND	ND
C3-USGS6	NA	NA	ND	3.30	ND	4.08	1.95	ND
GSA-30	NA	0.61	ND	ND	ND	ND	ND	ND

Notes: ND, not detected. NA, not analyzed.

continued..

**Table B3.** Results of Ground-water Analyses at the Denver Federal Center, July 2001, continued

Well ID	1,1,1-Trichloroethane (µg/L)	Carbon Tetrachloride (µg/L)	Benzene (µg/L)	1,2-Dichloroethane (µg/L)	Trichloroethene (µg/L)	Toluene (µg/L)	Tetrachloroethene (µg/L)
GSA-21	14.6	ND	ND	ND	16.5	ND	ND
C1-GU1	25.0	ND	ND	ND	25.9	ND	1.04
C1-I1	ND	ND	ND	ND	ND	ND	ND
C1-I2	ND	ND	ND	ND	ND	ND	ND
C1-GD1	ND	ND	ND	ND	ND	ND	ND
GSA-20	ND	ND	ND	ND	ND	ND	ND
GSA-26	67.3	ND	ND	ND	69.7	ND	2.36
USGS10	ND	ND	ND	ND	ND	ND	ND
USGS11	ND	ND	ND	ND	ND	ND	ND
USGS13	ND	ND	ND	ND	1.26	ND	ND
C2-GU2	57.5	ND	ND	ND	67.7	ND	1.88
C2-I1	ND	ND	ND	ND	20.6	ND	ND
C2-I2	3.03	ND	ND	ND	38.6	ND	1.36
USGS4	ND	ND	ND	ND	9.06	ND	ND
USGS5	ND	ND	ND	ND	9.90	ND	ND
GSA-25	2.65	ND	ND	ND	42.8	ND	ND
GSA-31	ND	ND	ND	ND	ND	ND	ND
C3-GU2	ND	ND	ND	ND	ND	ND	ND
C3-I1	ND	ND	ND	ND	ND	ND	ND
C3-USGS9	ND	ND	ND	ND	2.60	ND	ND
C3-I2	ND	ND	ND	ND	2.58	ND	ND
C3-GD2	ND	ND	ND	ND	ND	ND	ND
C3-USGS6	ND	ND	ND	ND	ND	ND	ND
GSA-30	ND	ND	ND	ND	ND	ND	ND

Notes: ND, not detected.

continued..

**Table B3.** Results of Ground-water Analyses at the Denver Federal Center, July 2001, continued

Well ID	B (mg/L)	Ba (mg/L)	Ca (mg/L)	Cr (mg/L)	Fe (mg/L)	K (mg/L)	Mg (mg/L)	Mn (mg/L)	Na (mg/L)	Sr (mg/L)	Si (mg/L)
GSA-21	0.30	0.02	88.4	0.025	0.44	0.55	16.6	0.058	166.7	0.47	15.0
C1-GU1	0.27	0.01	86.6	< 0.003	< 0.035	0.93	12.4	0.023	160.5	0.40	11.3
C1-11	0.26	0.01	1.07	< 0.003	< 0.035	1.07	1.94	0.005	158.2	< 0.006	0.353
C1-12	0.32	0.02	2.61	0.005	0.080	0.89	4.30	0.091	154.9	0.014	0.429
C1-GD1	0.12	0.02	79.5	< 0.003	1.33	1.15	7.78	0.244	151.1	0.32	10.4
GSA-20	0.14	0.02	106	< 0.003	0.37	0.67	14.1	1.16	173.0	0.43	10.9
GSA-26	0.25	0.02	110.2	< 0.003	< 0.035	0.45	31.9	0.005	163.9	0.72	15.2
USGS10	0.35	0.003	1.02	< 0.003	< 0.035	1.05	7.94	0.005	252.8	< 0.006	0.379
USGS11	0.32	0.002	1.82	< 0.003	< 0.035	1.04	8.08	0.005	244.9	< 0.006	0.402
USGS13	0.29	0.002	2.10	< 0.003	< 0.035	0.82	14.4	0.006	227.8	0.009	0.476
C2-GU2	0.33	0.03	145.8	< 0.003	< 0.035	0.76	39.7	0.044	214.6	1.01	15.2
C2-11	0.21	< 0.002	3.83	< 0.003	0.077	0.73	25.3	0.040	166.4	0.010	1.24
C2-12	0.19	< 0.002	3.31	0.016	0.19	0.54	23.9	0.030	158.3	0.008	1.46
USGS4	0.23	0.02	4.18	0.004	< 0.035	0.93	28.7	0.031	217.0	0.023	1.35
USGS5	0.21	0.02	3.54	< 0.003	< 0.035	0.81	28.2	0.027	215.2	0.029	1.23
GSA-25	0.19	0.01	67.5	0.003	0.40	0.90	10.1	0.014	187.3	0.32	11.3
GSA-31	0.17	0.19	110.8	< 0.003	19.1	0.98	31.7	4.22	118.4	1.10	13.7
C3-GU2	0.18	0.06	34.3	< 0.003	0.84	3.00	7.53	0.617	197.2	0.33	4.46
C3-11	0.14	0.14	3.91	< 0.003	0.080	2.03	7.18	0.040	157.1	0.07	0.197
C3-USGS9	0.18	0.04	15.9	< 0.003	1.26	2.21	15.7	0.047	198.5	0.25	4.46
C3-12	0.18	< 0.002	2.64	< 0.003	0.17	2.41	22.2	0.035	200.3	0.04	0.997
C3-GD2	0.15	0.03	16.8	< 0.003	< 0.035	2.74	6.58	0.062	193.5	0.18	2.38
C3-USGS6	0.14	0.03	19.5	< 0.003	0.061	2.98	6.87	0.141	191.3	0.19	2.63
GSA-30	0.18	0.04	126.6	< 0.003	0.43	0.82	25.1	2.471	167.9	0.94	8.87



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**Appendix C**  
**Selected Parameters Through Time in Multi-level Samplers**

**Table C1.** Eh Values (mV) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	238.6	233.0	245.4	222.0	199.5	199.9	375.7	333.4	432.1
ML21-6	321.5	294.3	345.8	355.9	257.7	233.7	415.6	526.0	448.6
ML21-5	392.3	425.3	381.4	441.3	409.1	456.0	401.5	529.4	448.7
ML21-4	397.0	416.9	356.8	412.9	393.6	441.3	381.4	525.5	442.2
ML21-3	395.1	398.4	365.1	203.5	385.1	422.2	364.2	495.4	616.2
ML21-2	425.4	394.7	364.7	402.3	387.3	428.5	336.4	506.6	660.2
ML21-1	438.9	352.8	360.6	356.0	344.3	326.5	285.9	523.5	660.2
ML22-7	Dry	154.4	NA	NA	NA	NA	NA	NA	NA
ML22-6	Dry	134.9	NA	NA	NA	NA	NA	NA	NA
ML22-5	168.9	384.6	NA	NA	NA	NA	NA	NA	NA
ML22-4	-486.4	-264.8	NA	NA	NA	NA	NA	NA	NA
ML22-3	22.1	-20.8	NA	NA	NA	NA	NA	NA	NA
ML22-2	34.7	-106.8	NA	NA	NA	NA	NA	NA	NA
ML22-1	359.0	255.7	NA	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	28.0	-144.5	-4.8	17.6	346.2	220.2	183.6
ML22.5-8	NA	NA	163.5	135.6	116.6	70.9	288.2	125.8	138.7
ML22.5-7	NA	NA	Dry	137.1	96.1	65.8	256.4	116.4	133.9
ML22.5-6	NA	NA	160.7	130.3	74.0	63.0	272.7	105.2	116.8
ML22.5-5	NA	NA	139.2	110.0	49.7	62.2	256.5	86.7	76.5
ML22.5-4	NA	NA	99.1	90.5	30.4	48.1	252.5	78.1	77.5
ML22.5-3	NA	NA	94.6	99.0	48.7	68.2	322.6	102.4	90.8
ML22.5-2	NA	NA	353.6	328.5	90.9	284.0	338.3	315.5	387.7
ML22.5-1	NA	NA	313.8	344.3	327.1	316.0	316.7	326.3	182.6
ML23-7	133.3	145.2	NA	NA	NA	NA	NA	NA	NA
ML23-6	-254.2	98.2	NA	NA	NA	NA	NA	NA	NA
ML23-5	-542.3	-184.3	NA	NA	NA	NA	NA	NA	NA
ML23-4	108.2	114.6	NA	NA	NA	NA	NA	NA	NA
ML23-3	-318.8	-25.3	NA	NA	NA	NA	NA	NA	NA
ML23-2	61.2	29.7	NA	NA	NA	NA	NA	NA	NA
ML23-1	-189.9	95.7	57.8	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	170.6	230.2	-66.4	-81.2	297.0	267.9	307.4
ML23.5-8	NA	NA	-13.8	44.0	19.5	-165.3	278.2	35.7	NA
ML23.5-7	NA	NA	10.8	108.7	-45.6	-13.5	218.2	88.0	214.6
ML23.5-6	NA	NA	-45.8	146.4	-67.9	-153.4	233.9	66.4	128.2
ML23.5-5	NA	NA	35.7	-51.1	127.7	-159.7	-11.3	-40.9	-28.3
ML23.5-4	NA	NA	-60.6	-47.3	-55.3	-145.6	-34.1	-38.3	4.3
ML23.5-3	NA	NA	-53.0	-43.5	-8.5	205.9	21.2	-90.2	-63.4
ML23.5-2	NA	NA	72.8	-126.8	-73.9	176.3	-47.5	-2.9	-4.9
ML23.5-1	NA	NA	79.9	73.5	-56.7	25.8	260.0	235.8	343.9
ML24-7	-498.3	-348.7	-91.8	-228.5	-467.6	-448.6	-221.7	-420.3	-379.8
ML24-6	-548.8	-338.5	-86.3	-236.0	-421.0	-554.3	-202.6	-367.3	-271.6
ML24-5	-551.2	-266.8	-63.3	-156.2	-307.6	-538.7	-156.6	-254.4	-39.0
ML24-4	-549.1	-196.9	50.5	-43.6	-206.9	-477.0	-135.3	-107.0	134.3
ML24-3	-324.0	-77.5	-15.2	41.6	-95.3	-150.0	94.1	-8.4	199.6
ML24-2	-122.9	40.6	17.9	73.0	-64.0	-121.3	100.2	10.3	147.2
ML24-1	51.4	-0.1	94.8	120.2	-66.2	-109.0	110.7	175.1	136.6
ML25-7	122.9	130.0	120.6	197.1	123.9	148.1	177.8	184.7	205.5
ML25-6	82.0	74.4	73.0	118.1	101.3	96.1	214.4	144.1	100.4
ML25-5	-46.3	13.1	-13.8	60.5	49.1	-48.5	127.2	335.8	306.0
ML25-4	-55.3	-5.9	-29.0	96.3	-63.9	-33.5	125.7	24.2	281.6
ML25-3	-31.0	14.7	10.5	146.1	-16.6	60.7	148.8	40.4	207.6
ML25-2	60.2	58.5	111.9	131.8	46.3	53.6	199.4	102.8	123.4
ML25-1	67.8	86.5	94.0	159.9	77.7	82.8	80.9	42.9	64.5

Notes: NA, not analyzed. Dry, no water.

**Table C2.** pH Values through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	6.15	6.15	6.24	6.27	6.24	6.36	6.27	6.05	6.01
ML21-6	6.09	6.09	6.15	6.17	6.17	6.25	6.16	5.96	5.79
ML21-5	5.76	5.83	5.89	5.83	5.92	5.96	5.93	5.86	5.78
ML21-4	5.82	5.82	5.83	5.83	5.97	6.06	5.89	5.90	5.62
ML21-3	5.77	5.83	5.88	5.80	5.91	5.99	5.96	5.40	5.71
ML21-2	5.95	5.90	5.92	5.83	5.93	5.98	5.96	5.84	5.67
ML21-1	6.08	5.97	6.02	5.89	5.99	6.04	6.05	5.88	5.75
ML22-7	Dry	6.48	NA	NA	NA	NA	NA	NA	NA
ML22-6	Dry	8.19	NA	NA	NA	NA	NA	NA	NA
ML22-5	7.08	6.86	NA	NA	NA	NA	NA	NA	NA
ML22-4	9.23	9.82	NA	NA	NA	NA	NA	NA	NA
ML22-3	9.76	10.24	NA	NA	NA	NA	NA	NA	NA
ML22-2	9.76	10.01	NA	NA	NA	NA	NA	NA	NA
ML22-1	6.02	5.99	NA	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	9.53	8.44	7.48	7.25	6.73	6.31	6.33
ML22.5-8	NA	NA	6.30	6.44	6.80	6.76	6.73	6.39	6.36
ML22.5-7	NA	NA	Dry	6.46	6.90	6.84	6.76	6.42	5.90
ML22.5-6	NA	NA	6.36	6.56	6.97	6.93	6.79	6.47	6.12
ML22.5-5	NA	NA	6.46	6.67	7.13	7.05	6.87	6.60	6.41
ML22.5-4	NA	NA	6.77	6.81	7.26	7.37	7.00	6.75	6.73
ML22.5-3	NA	NA	6.82	6.75	7.01	6.91	6.86	6.59	6.35
ML22.5-2	NA	NA	5.90	6.00	6.83	6.6	6.10	5.94	5.90
ML22.5-1	NA	NA	5.95	5.94	6.06	6.08	6.01	5.93	5.84
ML23-7	6.39	6.55	NA	NA	NA	NA	NA	NA	NA
ML23-6	8.74	9.32	NA	NA	NA	NA	NA	NA	NA
ML23-5	10.19	9.99	NA	NA	NA	NA	NA	NA	NA
ML23-4	6.98	7.03	NA	NA	NA	NA	NA	NA	NA
ML23-3	9.78	10.05	NA	NA	NA	NA	NA	NA	NA
ML23-2	9.74	10.16	NA	NA	NA	NA	NA	NA	NA
ML23-1	10.25	10.21	9.09	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	9.96	NA	9.81	9.83	9.23	9.11	9.66
ML23.5-8	NA	NA	8.27	NA	8.49	8.69	8.19	7.88	NA
ML23.5-7	NA	NA	7.98	NA	8.49	8.52	7.34	8.01	7.80
ML23.5-6	NA	NA	8.60	NA	8.76	9.05	7.65	8.46	8.17
ML23.5-5	NA	NA	7.82	NA	8.10	8.55	8.19	7.96	7.62
ML23.5-4	NA	NA	8.27	NA	8.14	8.52	8.31	7.66	7.19
ML23.5-3	NA	NA	8.81	NA	9.04	9.08	8.90	8.11	6.78
ML23.5-2	NA	NA	8.49	NA	9.16	9.06	8.64	7.80	7.49
ML23.5-1	NA	NA	8.78	NA	9.85	9.84	9.60	9.47	9.80
ML24-7	9.86	9.96	10.08	9.97	9.71	9.85	9.73	9.31	8.78
ML24-6	9.86	9.97	10.04	9.70	9.51	9.70	9.55	9.23	8.48
ML24-5	9.65	9.83	9.97	9.92	9.73	9.87	9.71	9.86	10.12
ML24-4	9.87	10.16	9.88	9.97	10.06	10.25	9.51	9.68	9.72
ML24-3	10.01	10.70	9.71	9.79	9.97	9.99	9.79	9.49	9.67
ML24-2	10.02	10.65	9.55	9.65	9.78	9.92	9.62	9.27	9.72
ML24-1	9.90	10.65	9.39	9.63	9.84	9.93	9.51	9.48	9.73
ML25-7	6.64	6.65	6.66	6.64	6.52	6.69	6.63	6.38	6.55
ML25-6	7.31	7.32	7.49	7.40	7.03	7.12	6.42	7.37	7.66
ML25-5	8.93	8.80	8.99	8.99	7.66	8.33	8.60	9.13	9.57
ML25-4	9.10	8.73	8.91	9.00	8.91	9.39	9.00	9.21	9.83
ML25-3	9.63	9.30	8.71	9.21	9.31	9.74	9.20	9.23	9.84
ML25-2	7.02	7.34	6.92	7.03	7.58	7.62	6.77	6.95	7.37
ML25-1	6.98	6.99	7.02	7.14	7.06	7.34	7.14	7.31	7.85

Notes: NA, not analyzed. Dry, no water.

**Table C3.** Specific Conductance Values ( $\mu\text{S}/\text{cm}$ ) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	375.0	304.0	378.0	391.0	320.0	296.0	344.0	659.0	663.0
ML21-6	510.0	388.0	103.8	508.0	405.0	381.0	429.0	616.0	530.0
ML21-5	807.0	622.0	104.0	472.0	420.0	484.0	379.0	363.0	283.0
ML21-4	747.0	548.0	93.3	304.0	293.0	313.0	337.0	240.0	249.0
ML21-3	364.0	378.0	46.1	221.0	201.0	212.0	187.0	191.0	207.0
ML21-2	212.0	211.0	42.0	209.0	191.5	184.2	187.9	225.0	234.0
ML21-1	156.9	200.0	42.0	220.0	207.0	203.0	213.0	242.0	260.0
ML22-7	Dry	237.0	NA	NA	NA	NA	NA	NA	NA
ML22-6	Dry	98.5	NA	NA	NA	NA	NA	NA	NA
ML22-5	287.0	215.0	NA	NA	NA	NA	NA	NA	NA
ML22-4	169.1	162.1	NA	NA	NA	NA	NA	NA	NA
ML22-3	239.0	313.0	NA	NA	NA	NA	NA	NA	NA
ML22-2	213.0	261.0	NA	NA	NA	NA	NA	NA	NA
ML22-1	263.0	208.0	NA	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	131.9	291.0	239.0	220.0	138.2	364.0	335.0
ML22.5-8	NA	NA	261.0	249.0	90.2	189.4	95.1	290.0	341.0
ML22.5-7	NA	NA	Dry	250.0	97.6	196.5	100.7	299.0	350.0
ML22.5-6	NA	NA	282.0	286.0	123.8	214.0	122.4	315.0	357.0
ML22.5-5	NA	NA	305.0	330.0	201.0	227.0	155.5	345.0	368.0
ML22.5-4	NA	NA	380.0	378.0	273.0	252.0	219.0	370.0	333.0
ML22.5-3	NA	NA	464.0	433.0	390.0	319.0	259.0	346.0	209.0
ML22.5-2	NA	NA	346.0	373.0	90.1	250.0	213.0	220.0	210.0
ML22.5-1	NA	NA	241.0	268.0	238.0	204.0	192.0	219.0	253.0
ML23-7	285.0	256.0	NA	NA	NA	NA	NA	NA	NA
ML23-6	103.4	100.6	NA	NA	NA	NA	NA	NA	NA
ML23-5	126.7	105.8	NA	NA	NA	NA	NA	NA	NA
ML23-4	239.0	208.0	NA	NA	NA	NA	NA	NA	NA
ML23-3	341.0	306.0	NA	NA	NA	NA	NA	NA	NA
ML23-2	341.0	320.0	NA	NA	NA	NA	NA	NA	NA
ML23-1	270.0	327.0	168.6	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	62.0	261.0	224.0	213.0	171.9	234.0	259.0
ML23.5-8	NA	NA	143.5	170.0	90.8	90.5	64.7	188.0	NA
ML23.5-7	NA	NA	125.7	170.0	95.5	91.2	58.9	171.0	258.0
ML23.5-6	NA	NA	141.8	175.3	98.8	85.7	58.9	140.0	286.0
ML23.5-5	NA	NA	213.0	227.0	149.9	143.0	99.0	257.0	397.0
ML23.5-4	NA	NA	248.0	254.0	177.5	162.9	112.8	256.0	340.0
ML23.5-3	NA	NA	309.0	309.0	235.0	216.0	172.3	296.0	320.0
ML23.5-2	NA	NA	318.0	314.0	255.0	267.0	205.0	282.0	263.0
ML23.5-1	NA	NA	252.0	278.0	272.0	226.0	203.0	259.0	221.0
ML24-7	101.7	97.8	55.8	64.1	56.0	70.5	41.0	64.0	99.0
ML24-6	106.5	99.8	56.4	64.9	56.2	69.1	42.1	77.0	135.0
ML24-5	145.9	139.5	82.8	95.0	106.9	94.8	58.3	152.0	236.0
ML24-4	201.0	163.1	124.5	139.0	131.1	135.1	153.8	188.0	257.0
ML24-3	324.0	312.0	245.0	313.0	258.0	277.0	255.0	277.0	248.0
ML24-2	271.0	243.0	322.0	342.0	251.0	284.0	245.0	305.0	271.0
ML24-1	224.0	303.0	202.0	255.0	236.0	265.0	218.0	290.0	226.0
ML25-7	138.0	110.2	86.5	98.6	93.6	146.7	87.6	218.0	250.0
ML25-6	218.0	132.2	197.6	208.0	103.4	79.5	110.5	181.0	204.0
ML25-5	390.0	154.5	214.0	249.0	235.0	215.0	154.6	206.0	274.0
ML25-4	442.0	242.0	257.0	271.0	275.0	222.0	194.1	249.0	230.0
ML25-3	255.0	221.0	300.0	346.0	226.0	274.0	233.0	281.0	270.0
ML25-2	233.0	221.0	193.7	228.0	197.1	204.0	137.3	196.0	256.0
ML25-1	266.0	231.0	205.0	196.0	195.2	223.0	139.7	184.0	209.0

Notes: NA, not analyzed. Dry, no water.

**Table C4.** Dissolved Oxygen (membrane probe) Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	0.79	0.37	0.92	0.62	0.40	1.22	0.12	0.35	0.61
ML21-6	0.34	0.36	1.11	0.45	2.30	1.04	0.12	1.84	0.54
ML21-5	0.26	0.24	1.19	0.56	0.40	0.99	0.13	3.55	0.55
ML21-4	0.50	0.40	1.41	0.20	0.40	1.11	0.14	2.20	0.53
ML21-3	0.20	0.64	1.47	0.16	0.74	1.03	0.15	1.57	0.69
ML21-2	1.19	0.57	1.60	0.21	0.28	1.12	0.16	0.91	0.70
ML21-1	2.92	0.36	5.50	0.32	0.34	1.05	0.21	1.22	0.81
ML22-7	Dry	NA	NA	NA	NA	NA	NA	NA	NA
ML22-6	Dry	NA	NA	NA	NA	NA	NA	NA	NA
ML22-5	0.83	NA	NA	NA	NA	NA	NA	NA	NA
ML22-4	0.85	0.41	NA	NA	NA	NA	NA	NA	NA
ML22-3	0.65	0.36	NA	NA	NA	NA	NA	NA	NA
ML22-2	0.63	0.25	NA	NA	NA	NA	NA	NA	NA
ML22-1	1.43	0.50	NA	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	7.28	0.34	0.34	0.62	0.23	0.07	1.40
ML22.5-8	NA	NA	5.96	0.36	0.40	1.08	0.19	0.21	1.35
ML22.5-7	NA	NA	Dry	0.73	0.35	1.15	0.15	0.25	1.31
ML22.5-6	NA	NA	2.51	0.40	0.34	0.91	0.14	0.18	1.41
ML22.5-5	NA	NA	5.68	0.44	0.30	1.12	1.65	0.17	0.79
ML22.5-4	NA	NA	2.56	0.24	0.30	1.37	0.14	0.30	0.97
ML22.5-3	NA	NA	2.57	0.43	0.35	0.67	0.14	0.13	1.40
ML22.5-2	NA	NA	3.00	0.50	0.43	1.31	0.30	0.12	1.47
ML22.5-1	NA	NA	2.06	0.38	0.43	1.19	0.18	0.14	1.75
ML23-7	1.13	NA	NA	NA	NA	NA	NA	NA	NA
ML23-6	0.63	NA	NA	NA	NA	NA	NA	NA	NA
ML23-5	0.78	0.42	NA	NA	NA	NA	NA	NA	NA
ML23-4	0.82	1.29	NA	NA	NA	NA	NA	NA	NA
ML23-3	0.99	0.48	NA	NA	NA	NA	NA	NA	NA
ML23-2	0.87	0.64	NA	NA	NA	NA	NA	NA	NA
ML23-1	0.30	0.32	2.38	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	0.85	0.53	0.32	1.39	0.63	1.32	4.74
ML23.5-8	NA	NA	3.65	1.03	1.46	1.36	1.64	NA	NA
ML23.5-7	NA	NA	3.87	1.99	0.48	1.10	5.36	NA	3.80
ML23.5-6	NA	NA	2.01	2.27	0.48	1.02	5.15	NA	3.96
ML23.5-5	NA	NA	2.76	1.11	3.85	0.95	0.20	NA	0.52
ML23.5-4	NA	NA	2.85	0.93	0.39	0.79	0.20	NA	0.90
ML23.5-3	NA	NA	2.48	1.11	0.36	1.80	0.23	0.43	1.19
ML23.5-2	NA	NA	1.87	1.02	0.34	1.66	0.26	0.20	1.00
ML23.5-1	NA	NA	0.90	0.43	0.33	1.36	3.83	0.78	2.43
ML24-7	1.63	0.40	1.87	1.96	0.32	1.98	0.10	NA	1.40
ML24-6	1.60	0.18	2.11	1.70	0.27	0.35	0.10	NA	1.09
ML24-5	1.48	0.31	3.06	2.31	0.27	0.39	0.12	NA	1.20
ML24-4	0.89	0.23	2.04	2.43	0.32	0.33	0.13	NA	2.15
ML24-3	1.20	0.24	1.50	4.64	0.28	0.70	0.16	NA	5.96
ML24-2	1.46	0.36	2.11	2.41	0.82	0.38	0.15	NA	0.80
ML24-1	1.43	0.25	2.69	3.70	0.35	0.44	0.16	NA	0.48
ML25-7	0.45	0.10	2.78	1.91	0.94	0.50	0.14	NA	0.96
ML25-6	0.38	0.51	2.03	2.53	0.36	0.50	0.21	NA	0.72
ML25-5	0.56	0.48	1.48	1.78	0.29	0.60	0.12	NA	1.31
ML25-4	0.50	2.57	2.15	1.69	0.32	5.20	0.11	NA	1.73
ML25-3	0.57	3.01	1.83	1.36	0.32	0.46	0.11	NA	1.57
ML25-2	0.46	0.86	1.89	2.36	0.41	0.65	0.12	NA	1.65
ML25-1	0.38	0.67	2.80	1.52	0.53	1.20	0.15	NA	1.68

Notes: NA, not analyzed. Dry, no water.

**Table C5.** Dissolved Oxygen (CHEMetrics) Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	0.2	0.1	NA	0.3	0.4	0.2	0.1	0.2	0.5
ML21-6	0.3	0.2	NA	1.0	0.1	0.2	1.0	0.6	0.7
ML21-5	0.3	>1.0	NA	0.8	0.2	0.3	0.1	0.8	0.4
ML21-4	0.3	>1.0	NA	0.6	0.2	0.3	0.8	0.2	NA
ML21-3	0.3	0.8	NA	0.4	0.2	0.3	0.6	0.1	0.2
ML21-2	NA	0.8	NA	0.8	0.1	0.3	0.8	0.2	0.3
ML21-1	NA	0.3	NA	0.3	0.1	0.3	0.6	0.1	0.2
ML22-7	Dry	0.1	NA	NA	NA	NA	NA	NA	NA
ML22-6	Dry	0.4	NA	NA	NA	NA	NA	NA	NA
ML22-5	Dry	0.3	NA	NA	NA	NA	NA	NA	NA
ML22-4	0.2	0.2	NA	NA	NA	NA	NA	NA	NA
ML22-3	0.2	0.2	NA	NA	NA	NA	NA	NA	NA
ML22-2	0.3	0.2	NA	NA	NA	NA	NA	NA	NA
ML22-1	NA	0.3	NA	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	NA	0.1	<0.1	<0.1	1.0	<1.0	0.7
ML22.5-8	NA	NA	NA	0.8	0.1	<0.1	0.3	ND	ND
ML22.5-7	NA	NA	NA	ND	0.3	0.1	1.0	ND	ND
ML22.5-6	NA	NA	NA	ND	0.1	0.1	0.6	ND	ND
ML22.5-5	NA	NA	NA	ND	<0.1	<0.1	0.8	ND	ND
ML22.5-4	NA	NA	NA	ND	<0.1	<0.1	1.0	ND	ND
ML22.5-3	NA	NA	NA	ND	<0.1	7.7	0.4	ND	ND
ML22.5-2	NA	NA	NA	0.8	0.3	0.2	0.6	0.1	0.1
ML22.5-1	NA	NA	NA	0.8	0.3	0.3	0.6	0.1	0.7
ML23-7	Dry	0.1	NA	NA	NA	NA	NA	NA	NA
ML23-6	Dry	0.3	NA	NA	NA	NA	NA	NA	NA
ML23-5	Dry	0.2	NA	NA	NA	NA	NA	NA	NA
ML23-4	Dry	0.1	NA	NA	NA	NA	NA	NA	NA
ML23-3	0.3	0.4	NA	NA	NA	NA	NA	NA	NA
ML23-2	0.2	0.2	NA	NA	NA	NA	NA	NA	NA
ML23-1	0.1	0.2	NA	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	NA	0.3	0.3	0.3	0.6	0.1	0.3
ML23.5-8	NA	NA	NA	1.0	0.3	0.3	>1.0	1.0	NA
ML23.5-7	NA	NA	NA	0.6	0.2	0.3	>1.0	1.0	NA
ML23.5-6	NA	NA	NA	1.0	0.3	0.2	>1.0	1.0	NA
ML23.5-5	NA	NA	NA	0.0	0.2	0.3	0.4	ND	ND
ML23.5-4	NA	NA	NA	0.1	0.1	0.1	0.3	ND	ND
ML23.5-3	NA	NA	NA	0.4	0.3	0.3	0.4	ND	ND
ML23.5-2	NA	NA	NA	0.1	0.2	0.1	0.6	ND	0.4
ML23.5-1	NA	NA	NA	0.2	0.3	0.3	0.6	0.6	0.2
ML24-7	0.2	0.2	NA	0.1	0.3	0.3	0.8	0.1	<0.1
ML24-6	0.2	0.2	NA	0.2	0.3	0.2	0.2	0.1	ND
ML24-5	0.2	0.3	NA	0.2	0.3	0.3	0.8	0.1	0.1
ML24-4	0.1	0.2	NA	0.2	0.2	0.3	0.3	0.2	<0.1
ML24-3	0.2	0.2	NA	0.2	0.2	0.3	>1.0	0.2	0.2
ML24-2	0.2	0.2	NA	0.2	0.2	0.3	1.0	0.1	0.1
ML24-1	<0.1	NA	NA	0.2	0.2	0.2	0.8	0.1	0.2
ML25-7	<0.1	0.1	NA	0.1	0.2	0.1	0.6	ND	<0.1
ML25-6	<0.1	0.3	NA	0.2	0.3	0.2	1.0	0.2	0.1
ML25-5	0.1	0.3	NA	0.3	0.3	0.3	0.8	0.1	0.2
ML25-4	0.2	0.3	NA	0.1	0.3	0.2	1.0	0.1	0.1
ML25-3	0.0	0.2	NA	0.1	0.3	0.2	0.8	0.1	<0.1
ML25-2	<0.1	0.2	NA	0.0	0.1	0.2	>1.0	0.1	<0.1
ML25-1	<0.1	0.2	NA	0.1	0.2	<0.1	1.0	0.8	ND

Notes: NA, not analyzed. ND, not detected. Dry, no water.

**Table C6.** Turbidity Values (NTUs) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	2.7	0.8	0.4	0.3	0.3	0.5	0.6	2.5	50.4
ML21-6	1.3	0.6	0.5	0.6	1.4	1.7	0.7	2.2	12.0
ML21-5	0.9	0.5	0.5	0.2	0.2	0.9	0.7	3.5	6.4
ML21-4	0.8	0.6	0.9	4.0	0.4	5.8	1.0	4.6	4.4
ML21-3	1.4	1.5	1.4	14.5	0.5	11.2	10.0	3.9	9.8
ML21-2	12.0	2.1	4.1	6.9	1.0	6.4	4.1	0.5	21.5
ML21-1	14.1	4.9	26.3	2.2	1.0	5.7	5.3	5.9	18.1
ML22-7	Dry	36.4	NA	NA	NA	NA	NA	NA	NA
ML22-6	Dry	21.2	NA	NA	NA	NA	NA	NA	NA
ML22-5	Dry	36.4	NA	NA	NA	NA	NA	NA	NA
ML22-4	1.2	0.6	NA	NA	NA	NA	NA	NA	NA
ML22-3	0.5	0.4	NA	NA	NA	NA	NA	NA	NA
ML22-2	0.8	0.7	NA	NA	NA	NA	NA	NA	NA
ML22-1	NA	2.7	NA	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	24.3	1.6	0.8	0.3	0.6	0.7	1.4
ML22.5-8	NA	NA	13.2	13.4	24.4	13.1	19.5	6.5	3.8
ML22.5-7	NA	NA	Dry	6.5	20.9	6.0	20.6	3.4	0.6
ML22.5-6	NA	NA	12.1	11.2	20.8	8.5	11.3	2.4	3.0
ML22.5-5	NA	NA	32.3	3.2	14.9	5.9	4.2	1.7	0.9
ML22.5-4	NA	NA	7.9	2.7	8.5	3.3	3.3	0.7	0.8
ML22.5-3	NA	NA	5.6	0.7	3.3	1.2	1.2	0.4	0.2
ML22.5-2	NA	NA	9.7	1.3	30.4	4.6	1.0	0.2	0.3
ML22.5-1	NA	NA	3.3	0.8	0.8	0.6	0.5	0.4	0.4
ML23-7	NA	22.4	NA	NA	NA	NA	NA	NA	NA
ML23-6	NA	12.6	NA	NA	NA	NA	NA	NA	NA
ML23-5	0.2	0.5	NA	NA	NA	NA	NA	NA	NA
ML23-4	NA	36.8	NA	NA	NA	NA	NA	NA	NA
ML23-3	0.4	5.2	NA	NA	NA	NA	NA	NA	NA
ML23-2	0.4	0.8	NA	NA	NA	NA	NA	NA	NA
ML23-1	1.2	1.5	NA	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	0.7	0.3	0.6	0.2	1.6	2.0	0.8
ML23.5-8	NA	NA	5.7	2.2	5.4	11.8	9.7	2.9	NA
ML23.5-7	NA	NA	5.1	14.3	6.0	12.8	54.1	7.4	9.8
ML23.5-6	NA	NA	4.1	2.4	5.5	5.1	11.4	3.0	1.8
ML23.5-5	NA	NA	2.1	0.9	0.9	0.8	5.8	1.4	1.7
ML23.5-4	NA	NA	2.3	0.9	0.9	0.8	3.6	0.8	1.6
ML23.5-3	NA	NA	2.1	0.7	0.4	0.2	1.5	1.8	1.0
ML23.5-2	NA	NA	4.0	1.8	0.5	2.3	1.9	1.9	2.9
ML23.5-1	NA	NA	2.4	0.5	0.3	0.3	1.3	1.1	0.9
ML24-7	1.6	0.7	0.7	0.4	0.3	0.5	0.9	1.4	3.1
ML24-6	1.3	0.8	0.6	0.7	0.4	0.7	1.4	1.6	2.1
ML24-5	0.7	1.8	1.0	0.4	0.5	0.6	2.5	0.6	1.0
ML24-4	0.7	0.4	1.1	0.3	0.4	0.2	1.0	0.9	0.7
ML24-3	1.1	0.8	1.1	0.6	0.3	1.2	0.8	1.8	1.0
ML24-2	0.9	0.6	1.6	0.5	0.2	0.2	0.9	0.6	NA
ML24-1	0.3	0.8	0.6	0.3	0.2	0.2	0.8	0.8	0.3
ML25-7	2.6	1.5	0.8	0.1	0.6	0.3	0.2	23.4	27.9
ML25-6	6.4	14.4	0.5	0.3	2.1	2.2	1.3	10.6	2.7
ML25-5	0.5	4.9	1.5	0.4	2.2	6.9	2.0	0.3	1.4
ML25-4	0.5	2.7	2.1	0.3	2.6	3.8	0.5	0.2	0.4
ML25-3	1.1	1.7	9.8	0.6	0.7	2.8	0.9	0.4	1.4
ML25-2	6.7	5.1	0.9	0.4	2.4	1.3	1.8	0.4	1.7
ML25-1	5.3	3.5	2.9	1.5	2.1	0.9	2.6	0.3	2.7

Notes: NA, not analyzed. Dry, no water.

**Table C7.** Alkalinity Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	113	106	81	114	50	96	108	79	67
ML21-6	99	91	74	87	37	80	92	72	62
ML21-5	42	57	37	45	41	51	51	56	57
ML21-4	47	53	41	56	49	42	56	55	56
ML21-3	36	91	31	39	36	55	58	49	55
ML21-2	NA	53	40	45	51	40	55	49	52
ML21-1	NA	51	50	53	41	49	60	51	54
ML22-7	Dry	11	Dry	NA	NA	NA	NA	NA	NA
ML22-6	Dry	20	Dry	NA	NA	NA	NA	NA	NA
ML22-5	Dry	24	Dry	NA	NA	NA	NA	NA	NA
ML22-4	17	19	23	NA	NA	NA	NA	NA	NA
ML22-3	50	45	76	NA	NA	NA	NA	NA	NA
ML22-2	33	29	30	NA	NA	NA	NA	NA	NA
ML22-1	Dry	49	58	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	76	50	64	93	66	71	82
ML22.5-8	NA	NA	160	112	47	44	26	133	119
ML22.5-7	NA	NA	153	119	38	54	47	101	124
ML22.5-6	NA	NA	163	115	63	51	38	143	136
ML22.5-5	NA	NA	67	111	62	56	38	139	130
ML22.5-4	NA	NA	170	116	87	92	90	139	146
ML22.5-3	NA	NA	122	128	107	117	100	111	137
ML22.5-2	NA	NA	61	49	63	72	59	62	54
ML22.5-1	NA	NA	39	48	47	41	60	55	54
ML23-7	Dry	40	Dry	NA	NA	NA	NA	NA	NA
ML23-6	Dry	10	Dry	NA	NA	NA	NA	NA	NA
ML23-5	Dry	19	17	NA	NA	NA	NA	NA	NA
ML23-4	Dry	35	Dry	NA	NA	NA	NA	NA	NA
ML23-3	54	49	87	NA	NA	NA	NA	NA	NA
ML23-2	45	41	57	NA	NA	NA	NA	NA	NA
ML23-1	47	42	66	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	67	61	59	77	58	93	84
ML23.5-8	NA	NA	52	69	36	32	27	106	NA
ML23.5-7	NA	NA	61	56	28	29	32	101	132
ML23.5-6	NA	NA	57	58	29	25	22	101	128
ML23.5-5	NA	NA	70	65	50	36	46	115	156
ML23.5-4	NA	NA	87	75	44	45	33	95	136
ML23.5-3	NA	NA	89	82	72	79	69	122	149
ML23.5-2	NA	NA	77	89	70	78	72	119	128
ML23.5-1	NA	NA	63	78	58	82	75	108	78
ML24-7	11	12	7	9	11	4	8	7	6
ML24-6	13	13	9	6	5	4	7	7	4
ML24-5	15	10	10	42	8	4	10	20	38
ML24-4	12	9	52	15	24	18	15	40	75
ML24-3	49	34	63	72	40	70	64	91	83
ML24-2	49	38	86	92	72	96	88	103	85
ML24-1	43	38	58	77	53	74	80	103	72
ML25-7	31	38	34	31	35	27	27	81	97
ML25-6	22	23	46	38	22	14	45	66	61
ML25-5	64	23	63	66	44	32	41	52	78
ML25-4	77	31	67	52	56	57	76	80	65
ML25-3	74	39	55	89	61	64	67	75	75
ML25-2	36	30	28	44	47	51	35	42	36
ML25-1	49	36	34	29	32	47	45	30	28

Notes: NA, not analyzed. Dry, no water.

**Table C8.** Ferrous Iron (CHEMetrics) Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	>1.0	NA	>1.0	NA	NA	NA	5.0	2.0	NA
ML21-6	0.1	NA	<0.1	0.1	NA	0.8	1.0	<1.0	NA
ML21-5	<0.1	NA	ND	0.0	NA	0.0	0.1	<1.0	NA
ML21-4	<0.1	NA	0.1	0.1	NA	0.0	0.1	<1.0	NA
ML21-3	0.1	NA	ND	0.1	NA	0.0	0.1	<1.0	NA
ML21-2	NA	NA	0.1	0.1	NA	0.0	0.1	<1.0	NA
ML21-1	NA	NA	0.1	0.1	NA	0.0	0.1	<1.0	NA
ML22-7	Dry	NA	Dry	NA	NA	NA	NA	NA	NA
ML22-6	Dry	NA	Dry	NA	NA	NA	NA	NA	NA
ML22-5	Dry	NA	Dry	NA	NA	NA	NA	NA	NA
ML22-4	0.1	NA	0.8	NA	NA	NA	NA	NA	NA
ML22-3	0.1	NA	0.3	NA	NA	NA	NA	NA	NA
ML22-2	0.1	NA	0.0	NA	NA	NA	NA	NA	NA
ML22-1	Dry	NA	0.2	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	0.1	NA	NA	NA	10.0	7.0	NA
ML22.5-8	NA	NA	>1.0	NA	NA	NA	4.0	>10.0	NA
ML22.5-7	NA	NA	>1.0	NA	NA	NA	6.0	>10.0	NA
ML22.5-6	NA	NA	>1.0	NA	NA	NA	6.0	>10.0	NA
ML22.5-5	NA	NA	>1.0	NA	NA	NA	3.0	>10.0	NA
ML22.5-4	NA	NA	>1.0	NA	NA	NA	6.0	>10.0	NA
ML22.5-3	NA	NA	>1.0	NA	NA	NA	0.8	>10.0	NA
ML22.5-2	NA	NA	0.8	0.6	NA	NA	1.0	<1.0	NA
ML22.5-1	NA	NA	0.8	0.6	0.6	NA	0.4	<1.0	NA
ML23-7	Dry	NA	Dry	NA	NA	NA	NA	NA	NA
ML23-6	Dry	NA	Dry	NA	NA	NA	NA	NA	NA
ML23-5	Dry	NA	Dry	NA	NA	NA	NA	NA	NA
ML23-4	Dry	NA	Dry	NA	NA	NA	NA	NA	NA
ML23-3	0.2	NA	Dry	NA	NA	NA	NA	NA	NA
ML23-2	0.1	NA	0.1	NA	NA	NA	NA	NA	NA
ML23-1	0.0	NA	0.2	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	0.4	0.1	0.1	0.1	0.8	<1.0	NA
ML23.5-8	NA	NA	0.6	0.6	0.6	0.3	0.2	<1.0	NA
ML23.5-7	NA	NA	0.8	0.8	0.6	0.3	0.4	<1.0	NA
ML23.5-6	NA	NA	0.6	0.3	0.3	0.2	0.6	<1.0	NA
ML23.5-5	NA	NA	>1.0	>1.0	1.0	0.8	0.6	5.0	NA
ML23.5-4	NA	NA	>1.0	>1.0	NA	0.8	0.6	9.0	NA
ML23.5-3	NA	NA	0.6	0.3	0.3	0.3	0.4	4.0	NA
ML23.5-2	NA	NA	>1.0	0.6	0.4	0.8	0.8	7.0	NA
ML23.5-1	NA	NA	>1.0	0.1	0.1	0.2	0.2	<1.0	NA
ML24-7	0.2	NA	0.1	0.1	0.3	0.2	0.1	<1.0	NA
ML24-6	0.1	NA	ND	0.3	0.2	0.2	0.2	<1.0	NA
ML24-5	ND	NA	0.1	0.1	0.1	0.1	0.1	<1.0	NA
ML24-4	ND	NA	ND	ND	0.1	0.1	0.0	<1.0	NA
ML24-3	0.1	NA	ND	ND	0.2	0.2	0.1	<1.0	NA
ML24-2	0.1	NA	ND	>1.0	0.2	0.1	0.1	2.0	NA
ML24-1	0.1	NA	0.2	ND	0.2	0.1	0.2	<1.0	NA
ML25-7	2.0	NA	>1.0	1.0	NA	>1.0	1.0	3.0	NA
ML25-6	0.9	NA	1.0	>1.0	0.4	0.6	ND	<1.0	NA
ML25-5	ND	NA	ND	ND	0.2	0.6	0.1	<1.0	NA
ML25-4	ND	NA	ND	ND	0.1	0.2	ND	<1.0	NA
ML25-3	ND	NA	0.1	ND	0.1	0.1	ND	<1.0	NA
ML25-2	>1.0	NA	>1.0	>1.0	NA	0.6	0.8	3.0	NA
ML25-1	>1.0	NA	>1.0	>1.0	NA	>1.0	2.0	2.0	NA

Notes: NA, not analyzed. ND, not detected. Dry, no water.

**Table C9.** Hexavalent Chromium (Hach DR100) Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	ND	NA	ND	ND	NA	NA	ND	NA	NA
ML21-6	0.35	NA	0.75	NA	NA	NA	0.12	NA	NA
ML21-5	2.50	NA	>1.0	NA	NA	NA	0.56	NA	NA
ML21-4	1.10	NA	0.45	NA	NA	NA	0.10	NA	NA
ML21-3	0.50	NA	0.25	NA	NA	NA	0.03	NA	NA
ML21-2	NA	NA	0.60	NA	NA	NA	0.16	NA	NA
ML21-1	NA	NA	ND	ND	NA	NA	0.00	NA	NA
ML22-7	Dry	NA	Dry	NA	NA	NA	NA	NA	NA
ML22-6	Dry	NA	Dry	NA	NA	NA	NA	NA	NA
ML22-5	Dry	NA	Dry	NA	NA	NA	NA	NA	NA
ML22-4	ND	NA	ND	NA	NA	NA	NA	NA	NA
ML22-3	ND	NA	ND	NA	NA	NA	NA	NA	NA
ML22-2	ND	NA	0.35	NA	NA	NA	NA	NA	NA
ML22-1	NA	NA	ND	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	NA	ND	ND	NA	ND	NA	NA
ML22.5-8	NA	NA	ND	ND	ND	NA	ND	NA	NA
ML22.5-7	NA	NA	ND	ND	ND	NA	0.02	NA	NA
ML22.5-6	NA	NA	ND	ND	ND	NA	ND	NA	NA
ML22.5-5	NA	NA	ND	ND	ND	NA	ND	NA	NA
ML22.5-4	NA	NA	ND	ND	ND	NA	ND	NA	NA
ML22.5-3	NA	NA	ND	ND	ND	NA	ND	NA	NA
ML22.5-2	NA	NA	0.50	NA	0.04	NA	ND	NA	NA
ML22.5-1	NA	NA	0.33	NA	0.14	NA	0.06	NA	NA
ML23-7	Dry	NA	Dry	NA	NA	NA	NA	NA	NA
ML23-6	Dry	NA	Dry	NA	NA	NA	NA	NA	NA
ML23-5	Dry	NA	Dry	NA	NA	NA	NA	NA	NA
ML23-4	Dry	NA	Dry	NA	NA	NA	NA	NA	NA
ML23-3	ND	NA	ND	NA	NA	NA	NA	NA	NA
ML23-2	ND	NA	ND	NA	NA	NA	NA	NA	NA
ML23-1	ND	NA	ND	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	ND	ND	ND	NA	ND	NA	NA
ML23.5-8	NA	NA	ND	ND	ND	NA	ND	NA	NA
ML23.5-7	NA	NA	ND	ND	ND	NA	ND	NA	NA
ML23.5-6	NA	NA	ND	ND	ND	NA	ND	NA	NA
ML23.5-5	NA	NA	ND	ND	ND	NA	ND	NA	NA
ML23.5-4	NA	NA	ND	ND	ND	NA	ND	NA	NA
ML23.5-3	NA	NA	ND	ND	ND	NA	ND	NA	NA
ML23.5-2	NA	NA	ND	ND	ND	NA	ND	NA	NA
ML23.5-1	NA	NA	ND	ND	ND	NA	ND	NA	NA
ML24-7	ND	NA	ND	ND	NA	NA	ND	NA	NA
ML24-6	ND	NA	ND	ND	NA	NA	ND	NA	NA
ML24-5	ND	NA	ND	ND	NA	NA	ND	NA	NA
ML24-4	ND	NA	ND	ND	ND	NA	ND	NA	NA
ML24-3	ND	NA	0.04	ND	ND	NA	ND	NA	NA
ML24-2	ND	NA	ND	ND	ND	NA	0.02	NA	NA
ML24-1	ND	NA	ND	ND	ND	NA	0.02	NA	NA
ML25-7	ND	NA	ND	ND	ND	ND	ND	NA	NA
ML25-6	ND	NA	ND	ND	ND	ND	ND	NA	NA
ML25-5	ND	NA	ND	ND	ND	ND	ND	NA	NA
ML25-4	ND	NA	ND	ND	ND	ND	0.01	NA	NA
ML25-3	ND	NA	0.04	ND	ND	ND	0.01	NA	NA
ML25-2	ND	NA	ND	ND	ND	ND	ND	NA	NA
ML25-1	ND	NA	ND	ND	ND	NA	ND	NA	NA

Notes: NA, not analyzed. ND, not detected. Dry, no water.

**Table C10.** Ferrous Iron (Hach DR2010) Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	6.00	3.04	3.30	4.54	4.90	2.89	NA	1.29	ND
ML21-6	0.09	0.75	NA	NA	1.79	NA	NA	0.08	ND
ML21-5	0.01	0.01	NA	NA	0.10	NA	NA	<0.01	ND
ML21-4	<0.01	0.01	NA	NA	<0.01	NA	NA	0.01	ND
ML21-3	0.01	0.01	NA	NA	0.10	NA	NA	0.02	ND
ML21-2	NA	0.05	NA	NA	0.10	NA	NA	<0.01	ND
ML21-1	NA	0.16	NA	NA	<0.01	NA	NA	0.03	ND
ML22-7	Dry	<0.01	Dry	NA	NA	NA	NA	NA	NA
ML22-6	Dry	0.01	Dry	NA	NA	NA	NA	NA	NA
ML22-5	Dry	<0.01	Dry	NA	NA	NA	NA	NA	NA
ML22-4	0.01	<0.01	NA	NA	NA	NA	NA	NA	NA
ML22-3	<0.01	<0.01	NA	NA	NA	NA	NA	NA	NA
ML22-2	<0.01	0.01	NA	NA	NA	NA	NA	NA	NA
ML22-1	NA	<0.01	NA	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	NA	0.58	>3.30	1.15	NA	2.31	3.95
ML22.5-8	NA	NA	3.30	5.12	0.66	8.40	NA	7.10	10.9
ML22.5-7	NA	NA	3.30	11.8	0.77	9.90	NA	5.80	8.40
ML22.5-6	NA	NA	3.30	10.6	0.97	9.10	NA	5.75	12.2
ML22.5-5	NA	NA	3.30	12.7	1.54	10.9	NA	0.29	10.8
ML22.5-4	NA	NA	3.30	7.95	1.62	7.80	NA	10.0	7.65
ML22.5-3	NA	NA	3.3	>3.30	1.62	9.50	NA	7.00	5.02
ML22.5-2	NA	NA	NA	NA	1.60	2.66	NA	0.29	0.25
ML22.5-1	NA	NA	NA	NA	NA	0.80	NA	0.06	0.05
ML23-7	Dry	2.53	Dry	NA	NA	NA	NA	NA	NA
ML23-6	Dry	<0.01	Dry	NA	NA	NA	NA	NA	NA
ML23-5	Dry	<0.01	Dry	NA	NA	NA	NA	NA	NA
ML23-4	Dry	1.84	Dry	NA	NA	NA	NA	NA	NA
ML23-3	0.02	0.10	NA	NA	NA	NA	NA	NA	NA
ML23-2	<0.01	<0.01	NA	NA	NA	NA	NA	NA	NA
ML23-1	0.02	<0.01	NA	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	NA	NA	NA	NA	NA	0.09	ND
ML23.5-8	NA	NA	NA	NA	NA	NA	NA	<0.01	NA
ML23.5-7	NA	NA	NA	NA	NA	NA	NA	0.05	0.49
ML23.5-6	NA	NA	NA	NA	NA	NA	NA	0.10	ND
ML23.5-5	NA	NA	2.10	0.71	NA	NA	NA	2.06	5.52
ML23.5-4	NA	NA	1.33	0.67	0.07	NA	NA	3.53	5.74
ML23.5-3	NA	NA	NA	NA	NA	NA	NA	1.16	6.80
ML23.5-2	NA	NA	1.76	NA	NA	NA	NA	2.17	4.24
ML23.5-1	NA	NA	0.98	NA	NA	NA	NA	0.01	0.03
ML24-7	<0.01	<0.01	NA	NA	NA	NA	NA	<0.01	0.85
ML24-6	<0.01	0.01	NA	NA	NA	NA	NA	0.04	0.93
ML24-5	<0.01	<0.01	NA	NA	NA	NA	NA	<0.01	ND
ML24-4	0.01	<0.01	NA	NA	NA	NA	NA	<0.01	ND
ML24-3	0.01	<0.01	NA	NA	NA	NA	NA	<0.01	ND
ML24-2	<0.01	0.01	NA	0.33	NA	NA	NA	NA	ND
ML24-1	<0.01	<0.01	NA	NA	NA	NA	NA	<0.01	ND
ML25-7	1.79	2.29	2.18	1.08	1.74	2.10	NA	2.08	1.97
ML25-6	0.32	0.38	NA	0.40	NA	NA	NA	0.19	0.71
ML25-5	<0.01	0.01	NA	NA	NA	NA	NA	<0.01	ND
ML25-4	<0.01	0.01	NA	NA	NA	NA	NA	<0.01	ND
ML25-3	<0.01	<0.01	NA	NA	NA	NA	NA	0.02	ND
ML25-2	1.20	1.37	1.49	2.60	0.43	NA	NA	1.54	2.04
ML25-1	2.20	1.35	2.49	1.46	1.22	1.65	NA	1.35	1.49

Notes: NA, not analyzed. ND, not detected. Dry, no water.

**Table C11.** Hexavalent Chromium (Hach DR2010) Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	NA	ND	NA	NA	0.22	ND	ND	0.07	1.04
ML21-6	NA	ND	0.66	0.66	ND	0.10	0.12	1.50	1.90
ML21-5	NA	2.50	1.20	0.74	0.66	2.50	0.56	1.55	0.54
ML21-4	NA	1.45	0.39	0.35	0.46	0.90	0.10	0.25	0.09
ML21-3	NA	0.70	0.22	0.21	0.20	0.20	0.03	0.02	0.01
ML21-2	NA	0.38	0.56	0.45	0.40	0.30	0.16	0.12	0.12
ML21-1	NA	ND	NA	NA	ND	ND	ND	ND	ND
ML22-7	Dry	0.00	Dry	NA	NA	NA	NA	NA	NA
ML22-6	Dry	Dry	Dry	NA	NA	NA	NA	NA	NA
ML22-5	Dry	0.00	Dry	NA	NA	NA	NA	NA	NA
ML22-4	NA	0.00	NA	NA	NA	NA	NA	NA	NA
ML22-3	NA	0.00	NA	NA	NA	NA	NA	NA	NA
ML22-2	NA	0.00	NA	NA	NA	NA	NA	NA	NA
ML22-1	NA	0.00	NA	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	NA	NA	NA	ND	ND	0.01	ND
ML22.5-8	NA	NA	NA	NA	NA	ND	ND	ND	ND
ML22.5-7	NA	NA	NA	NA	NA	ND	0.02	ND	ND
ML22.5-6	NA	NA	NA	NA	NA	0.60	ND	ND	ND
ML22.5-5	NA	NA	NA	NA	NA	ND	ND	ND	ND
ML22.5-4	NA	NA	NA	NA	NA	ND	ND	ND	ND
ML22.5-3	NA	NA	NA	NA	NA	0.01	ND	ND	ND
ML22.5-2	NA	NA	0.41	0.21	NA	0.02	ND	0.10	0.01
ML22.5-1	NA	NA	0.30	0.16	NA	0.14	0.06	0.07	0.04
ML23-7	Dry	ND	Dry	NA	NA	NA	NA	NA	NA
ML23-6	Dry	ND	Dry	NA	NA	NA	NA	NA	NA
ML23-5	Dry	ND	NA	NA	NA	NA	NA	NA	NA
ML23-4	Dry	ND	Dry	NA	NA	NA	NA	NA	NA
ML23-3	NA	ND	NA	NA	NA	NA	NA	NA	NA
ML23-2	NA	ND	ND	NA	NA	NA	NA	NA	NA
ML23-1	NA	ND	NA	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	NA	NA	NA	ND	ND	ND	ND
ML23.5-8	NA	NA	NA	NA	NA	ND	ND	ND	NA
ML23.5-7	NA	NA	NA	NA	NA	ND	ND	ND	ND
ML23.5-6	NA	NA	NA	NA	NA	ND	ND	ND	ND
ML23.5-5	NA	NA	NA	NA	NA	ND	ND	ND	ND
ML23.5-4	NA	NA	NA	NA	NA	ND	ND	ND	ND
ML23.5-3	NA	NA	NA	NA	NA	ND	ND	ND	ND
ML23.5-2	NA	NA	NA	NA	NA	ND	ND	ND	ND
ML23.5-1	NA	NA	NA	NA	NA	ND	ND	ND	ND
ML24-7	NA	ND	NA	NA	ND	ND	ND	ND	ND
ML24-6	NA	ND	NA	NA	ND	ND	ND	ND	ND
ML24-5	NA	ND	NA	NA	ND	ND	ND	ND	ND
ML24-4	NA	ND	NA	NA	NA	ND	ND	ND	ND
ML24-3	NA	ND	NA	NA	NA	ND	ND	ND	ND
ML24-2	NA	ND	NA	NA	NA	ND	0.02	ND	ND
ML24-1	NA	ND	NA	NA	NA	ND	0.02	ND	ND
ML25-7	NA	ND	NA	NA	NA	NA	ND	ND	ND
ML25-6	NA	ND	NA	NA	NA	NA	ND	ND	ND
ML25-5	NA	ND	NA	NA	NA	NA	ND	ND	ND
ML25-4	NA	ND	NA	NA	NA	NA	0.01	ND	ND
ML25-3	NA	ND	NA	NA	NA	NA	0.01	ND	ND
ML25-2	NA	ND	NA	NA	NA	NA	ND	ND	ND
ML25-1	NA	ND	NA	NA	NA	ND	ND	ND	ND

Notes: NA, not analyzed. ND, not detected. Dry, no water.

**Table C12.** Sulfate Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	4.52	4.71	15.5	16.7	9.29	9.61	21.8	81.0	91.5
ML21-6	22.6	22.0	45.0	42.0	31.2	30.4	40.5	87.3	67.9
ML21-5	79.1	77.5	80.8	45.6	64.9	86.6	52.1	50.0	32.7
ML21-4	64.3	69.9	59.3	45.2	43.1	64.6	40.1	36.8	31.7
ML21-3	39.5	55.1	29.4	30.1	36.1	43.5	28.0	31.4	29.1
ML21-2	6.66	28.6	26.8	24.1	29.8	29.2	28.0	30.7	26.7
ML21-1	1.58	16.0	16.8	15.0	16.7	18.0	17.6	23.6	23.4
ML22-7	Dry	5.65	Dry	NA	NA	NA	NA	NA	NA
ML22-6	Dry	<1.0	Dry	NA	NA	NA	NA	NA	NA
ML22-5	Dry	1.09	Dry	NA	NA	NA	NA	NA	NA
ML22-4	0.57	2.35	15.90	NA	NA	NA	NA	NA	NA
ML22-3	0.93	1.09	<0.1	NA	NA	NA	NA	NA	NA
ML22-2	<0.1	1.25	28.30	NA	NA	NA	NA	NA	NA
ML22-1	16.10	17.70	18.00	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	0.92	1.38	3.14	2.10	9.90	14.6	17.6
ML22.5-8	NA	NA	0.28	12.3	2.43	7.00	11.0	<1.0	2.64
ML22.5-7	NA	NA	1.01	13.5	2.47	7.14	9.47	NA	4.71
ML22.5-6	NA	NA	1.64	15.4	3.33	6.91	10.4	3.36	4.72
ML22.5-5	NA	NA	9.69	19.1	8.46	5.89	9.38	1.65	5.98
ML22.5-4	NA	NA	0.91	19.1	10.7	10.7	8.51	5.80	9.98
ML22.5-3	NA	NA	33.1	26.2	19.0	15.0	21.6	12.9	19.0
ML22.5-2	NA	NA	39.8	39.3	36.7	32.6	31.4	25.4	26.0
ML22.5-1	NA	NA	30.7	23.8	33.2	29.7	21.5	24.5	26.4
ML23-7	0.68	1.03	Dry	NA	NA	NA	NA	NA	NA
ML23-6	<0.1	1.06	<0.1	NA	NA	NA	NA	NA	NA
ML23-5	<0.1	1.10	9.27	NA	NA	NA	NA	NA	NA
ML23-4	<0.1	1.26	Dry	NA	NA	NA	NA	NA	NA
ML23-3	<0.1	1.06	<0.1	NA	NA	NA	NA	NA	NA
ML23-2	<0.1	1.21	<0.1	NA	NA	NA	NA	NA	NA
ML23-1	<0.1	1.51	<0.1	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	0.84	0.28	5.51	<0.1	0.50	3.98	NA
ML23.5-8	NA	NA	<0.1	<1	0.65	<0.1	0.66	<1.0	<1.0
ML23.5-7	NA	NA	<0.1	<1	0.70	<0.1	0.54	<1.0	<1.0
ML23.5-6	NA	NA	<0.1	<1	0.71	<0.1	0.50	<1.0	<1.0
ML23.5-5	NA	NA	<0.1	0.20	0.35	<0.1	0.65	6.09	<1.0
ML23.5-4	NA	NA	<0.1	<0.1	<0.1	<0.1	0.50	4.73	3.22
ML23.5-3	NA	NA	1.12	0.68	0.83	<0.1	22.3	<1.0	2.04
ML23.5-2	NA	NA	3.08	1.20	2.22	1.02	0.67	4.26	2.14
ML23.5-1	NA	NA	0.51	<0.1	1.79	<0.1	0.50	<1.0	<1.0
ML24-7	<0.1	<0.1	<0.1	<0.1	0.19	<0.1	0.50	<1.0	<1.0
ML24-6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.50	<1.0	<1.0
ML24-5	0.71	9.40	<0.1	<0.1	<0.1	<0.1	1.48	<1.0	<1.0
ML24-4	<0.1	1.02	5.60	<0.1	<0.1	<0.1	0.50	<1.0	<1.0
ML24-3	<0.1	1.09	<0.1	<0.1	<0.1	<0.1	0.50	<1.0	<1.0
ML24-2	<0.1	1.14	<0.1	<0.1	0.50	<0.1	0.50	<1.0	<1.0
ML24-1	<0.1	1.35	<0.1	<0.1	<0.1	<0.1	0.50	<1.0	<1.0
ML25-7	14.3	13.6	8.86	6.93	7.62	7.69	6.94	21.6	17.8
ML25-6	2.54	6.28	0.53	1.39	3.37	1.16	0.50	<1.0	2.30
ML25-5	<0.1	1.29	<0.1	<0.1	8.80	0.38	2.93	<1.0	<1.0
ML25-4	<0.1	1.23	<0.1	<0.1	<0.1	<0.1	0.50	<1.0	<1.0
ML25-3	<0.1	1.50	4.47	<0.1	0.37	<0.1	0.50	<1.0	<1.0
ML25-2	3.74	1.80	1.31	1.12	0.94	0.57	0.50	<1.0	<1.0
ML25-1	1.00	1.93	<0.1	1.33	0.53	<0.1	0.50	<1.0	<1.0

Notes: NA, not analyzed. Dry, no water.

**Table C13.** Chloride Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	24.0	20.9	60.6	51.4	36.7	36.0	47.5	97.1	90.2
ML21-6	51.5	41.9	86.1	75.8	56.8	56.1	64.0	93.0	69.1
ML21-5	115.0	97.6	74.2	69.3	65.0	79.7	61.0	40.6	27.6
ML21-4	99.2	82.8	59.1	28.4	34.5	38.0	57.0	19.9	17.3
ML21-3	42.3	57.1	24.3	15.9	16.3	20.4	15.8	11.1	10.0
ML21-2	5.2	15.9	17.9	17.7	16.9	16.0	15.4	19.7	17.5
ML21-1	1.3	16.9	19.9	22.4	24.9	25.5	25.2	31.1	27.1
ML22-7	Dry	9.2	Dry	NA	NA	NA	NA	NA	NA
ML22-6	Dry	16.2	Dry	NA	NA	NA	NA	NA	NA
ML22-5	Dry	49.5	Dry	NA	NA	NA	NA	NA	NA
ML22-4	27.1	24.4	24.5	NA	NA	NA	NA	NA	NA
ML22-3	61.5	59.8	24.6	NA	NA	NA	NA	NA	NA
ML22-2	39.2	52.6	16.6	NA	NA	NA	NA	NA	NA
ML22-1	16.3	17.0	22.7	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	49.6	32.9	36.1	32.0	21.5	20.7	18.6
ML22.5-8	NA	NA	6.5	5.4	2.4	33.6	12.4	8.5	33.6
ML22.5-7	NA	NA	6.5	5.8	3.3	35.8	12.1	14.0	33.9
ML22.5-6	NA	NA	6.2	11.2	6.3	37.3	12.5	11.9	33.1
ML22.5-5	NA	NA	33.0	21.8	18.0	37.1	12.3	17.3	34.1
ML22.5-4	NA	NA	17.1	31.5	28.2	36.5	22.2	26.9	28.1
ML22.5-3	NA	NA	61.9	46.4	38.7	35.3	24.3	27.1	15.3
ML22.5-2	NA	NA	52.3	36.2	35.1	27.7	20.0	13.1	11.0
ML22.5-1	NA	NA	33.7	21.1	26.3	20.5	20.2	13.2	14.1
ML23-7	9.2	9.5	Dry	NA	NA	NA	NA	NA	NA
ML23-6	15.4	15.8	16.9	NA	NA	NA	NA	NA	NA
ML23-5	12.4	13.4	15.9	NA	NA	NA	NA	NA	NA
ML23-4	41.1	43.9	Dry	NA	NA	NA	NA	NA	NA
ML23-3	76.9	53.1	55.7	NA	NA	NA	NA	NA	NA
ML23-2	40.3	42.3	36.0	NA	NA	NA	NA	NA	NA
ML23-1	28.4	45.3	26.5	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	29.4	33.1	34.8	27.9	25.8	23.9	NA
ML23.5-8	NA	NA	8.6	6.9	9.2	11.8	6.3	6.1	31.1
ML23.5-7	NA	NA	9.1	8.3	10.0	10.5	6.0	6.8	15.9
ML23.5-6	NA	NA	8.4	10.3	10.6	9.0	6.8	6.1	18.9
ML23.5-5	NA	NA	28.7	24.8	22.7	23.6	15.5	23.4	27.9
ML23.5-4	NA	NA	36.1	31.3	26.2	27.9	20.3	31.4	30.8
ML23.5-3	NA	NA	52.1	43.0	35.3	33.5	0.5	26.2	22.7
ML23.5-2	NA	NA	54.9	47.6	37.6	33.1	25.9	23.7	18.9
ML23.5-1	NA	NA	48.9	40.9	30.3	32.9	26.5	29.4	22.5
ML24-7	11.7	14.2	12.4	7.0	9.6	13.1	7.5	10.3	19.7
ML24-6	12.5	15.5	13.7	10.0	12.6	15.0	10.3	15.9	29.8
ML24-5	21.5	25.1	23.4	16.1	26.7	24.3	5.1	26.1	40.2
ML24-4	35.5	34.7	24.6	24.0	21.2	28.2	14.0	29.9	31.0
ML24-3	46.7	45.1	48.6	46.8	42.1	46.0	34.1	29.2	22.6
ML24-2	34.1	40.0	57.9	43.7	32.7	44.2	34.7	33.0	32.5
ML24-1	32.3	40.3	28.5	36.6	28.0	42.6	31.3	32.7	25.5
ML25-7	6.8	5.8	4.1	3.9	4.6	32.4	6.1	8.6	7.4
ML25-6	40.7	20.5	53.1	40.8	21.9	15.2	35.6	24.6	20.3
ML25-5	74.6	27.2	39.2	33.5	78.9	45.1	32.4	25.0	26.8
ML25-4	83.6	47.2	49.2	37.0	60.4	39.3	26.7	30.6	24.5
ML25-3	27.0	38.9	62.7	52.9	37.4	48.1	36.0	38.3	34.1
ML25-2	43.5	43.3	53.5	44.2	35.2	40.0	38.2	34.6	43.3
ML25-1	49.3	45.9	51.1	36.0	40.2	46.6	34.1	31.8	40.5

Notes: NA, not analyzed. Dry, no water.

**Table C14.** Nitrate + Nitrite Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	<0.10	<0.10	0.52	0.38	0.10	0.11	0.36	1.29	1.37
ML21-6	0.54	0.28	1.82	1.45	0.49	0.53	0.85	1.71	1.49
ML21-5	3.49	3.55	1.69	2.04	1.40	2.40	1.61	0.77	0.42
ML21-4	2.78	2.76	1.40	0.59	0.72	0.98	1.64	0.18	0.24
ML21-3	1.07	1.59	0.51	0.31	0.22	0.34	0.31	0.51	<0.10
ML21-2	<0.10	0.42	0.56	0.66	0.51	0.46	0.47	0.66	0.78
ML21-1	<0.10	0.91	1.13	1.28	1.31	1.59	1.48	1.48	1.60
ML22-7	NA	<0.10	Dry	NA	NA	NA	NA	NA	NA
ML22-6	NA	<0.10	Dry	NA	NA	NA	NA	NA	NA
ML22-5	NA	<0.10	Dry	NA	NA	NA	NA	NA	NA
ML22-4	<0.10	<0.10	<0.10	NA	NA	NA	NA	NA	NA
ML22-3	<0.10	<0.10	<0.10	NA	NA	NA	NA	NA	NA
ML22-2	<0.10	NA	0.29	NA	NA	NA	NA	NA	NA
ML22-1	0.93	1.01	1.07	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	0.55	<0.10	<0.10	<0.10	<0.2	0.34	0.30
ML22.5-8	NA	NA	<0.10	<0.10	<0.10	<0.10	<0.2	<0.10	<0.10
ML22.5-7	NA	NA	<0.10	<0.10	<0.10	<0.10	<0.2	<0.10	<0.10
ML22.5-6	NA	NA	<0.10	<0.10	<0.10	<0.10	<0.2	<0.10	<0.10
ML22.5-5	NA	NA	<0.10	0.15	0.10	<0.10	<0.2	<0.10	<0.10
ML22.5-4	NA	NA	<0.10	<0.10	<0.10	<0.10	<0.2	<0.10	<0.10
ML22.5-3	NA	NA	<0.10	<0.10	0.16	<0.10	<0.2	<0.10	<0.10
ML22.5-2	NA	NA	0.33	0.58	0.44	0.27	<0.2	<0.10	0.15
ML22.5-1	NA	NA	0.70	0.29	0.33	0.27	<0.2	0.47	0.39
ML23-7	<0.10	<0.10	Dry	NA	NA	NA	NA	NA	NA
ML23-6	<0.10	<0.10	<0.10	NA	NA	NA	NA	NA	NA
ML23-5	<0.10	<0.10	<0.10	NA	NA	NA	NA	NA	NA
ML23-4	<0.10	<0.10	Dry	NA	NA	NA	NA	NA	NA
ML23-3	<0.10	NA	<0.10	NA	NA	NA	NA	NA	NA
ML23-2	<0.10	<0.10	<0.10	NA	NA	NA	NA	NA	NA
ML23-1	<0.10	<0.10	<0.10	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	<0.10	<0.10	<0.10	<0.10	<0.2	<0.10	NA
ML23.5-8	NA	NA	<0.10	<0.10	<0.10	<0.10	<0.2	0.85	<0.10
ML23.5-7	NA	NA	<0.10	<0.10	<0.10	<0.10	<0.2	1.23	<0.10
ML23.5-6	NA	NA	<0.10	<0.10	<0.10	<0.10	<0.2	0.33	<0.10
ML23.5-5	NA	NA	<0.10	<0.10	<0.10	<0.10	<0.2	<0.10	<0.10
ML23.5-4	NA	NA	<0.10	<0.10	<0.10	<0.10	<0.2	<0.10	<0.10
ML23.5-3	NA	NA	<0.10	<0.10	<0.10	<0.10	<0.2	<0.10	<0.10
ML23.5-2	NA	NA	<0.10	<0.10	<0.10	<0.10	<0.2	<0.10	<0.10
ML23.5-1	NA	NA	<0.10	<0.10	<0.10	<0.10	<0.2	<0.10	<0.10
ML24-7	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.2	1.24	<0.10
ML24-6	<0.10	NA	<0.10	<0.10	<0.10	<0.10	<0.2	0.72	<0.10
ML24-5	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.2	0.25	<0.10
ML24-4	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.2	0.56	<0.10
ML24-3	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.2	0.71	<0.10
ML24-2	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.2	0.87	<0.10
ML24-1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.2	1.50	<0.10
ML25-7	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.14	0.68	<0.10
ML25-6	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.17	<0.10	<0.10
ML25-5	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.12	0.17	<0.10
ML25-4	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.13	<0.10	<0.10
ML25-3	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.14	0.18	<0.10
ML25-2	<0.10	<0.10	<0.10	<0.10	0.14	<0.10	0.13	0.84	<0.10
ML25-1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.14	0.81	<0.10

Notes: NA, not analyzed. Dry, no water.

**Table C15.** Total Organic Carbon Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	1.60	0.83	2.73	NA	2.73	1.93	2.43	2.95	9.17
ML21-6	1.86	1.42	2.84	NA	2.43	2.30	2.49	2.50	8.77
ML21-5	2.43	1.77	2.94	NA	7.75	2.27	1.81	1.51	7.25
ML21-4	2.39	1.87	2.46	NA	1.78	3.38	1.73	1.41	6.91
ML21-3	1.65	1.37	2.04	NA	1.31	1.74	36.90	1.38	7.62
ML21-2	NA	0.94	30.20	NA	4.00	0.98	1.46	<0.40	6.50
ML21-1	NA	1.28	1.52	NA	0.82	0.75	0.99	<0.40	6.91
ML22-7	NA	2.20	NA	NA	NA	NA	NA	NA	NA
ML22-6	NA	7.20	NA	NA	NA	NA	NA	NA	NA
ML22-5	NA	3.93	NA	NA	NA	NA	NA	NA	NA
ML22-4	6.81	3.19	4.35	NA	NA	NA	NA	NA	NA
ML22-3	4.63	4.35	2.35	NA	NA	NA	NA	NA	NA
ML22-2	3.55	1.89	1.48	NA	NA	NA	NA	NA	NA
ML22-1	0.70	<0.40	1.33	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	1.99	NA	1.46	2.10	3.50	0.69	8.58
ML22.5-8	NA	NA	3.43	NA	3.96	1.67	2.24	3.87	14.85
ML22.5-7	NA	NA	2.93	NA	3.64	1.66	2.21	3.84	13.12
ML22.5-6	NA	NA	2.88	NA	3.45	1.75	2.13	3.52	13.45
ML22.5-5	NA	NA	3.19	NA	3.02	1.58	2.11	2.53	12.38
ML22.5-4	NA	NA	2.67	NA	2.57	1.99	2.71	1.56	11.57
ML22.5-3	NA	NA	2.81	NA	2.60	4.23	2.37	1.96	10.62
ML22.5-2	NA	NA	2.21	NA	2.34	1.40	2.17	0.99	7.78
ML22.5-1	NA	NA	2.04	NA	1.68	1.25	2.21	0.74	6.76
ML23-7	2.19	1.94	NA	NA	NA	NA	NA	NA	NA
ML23-6	6.71	5.54	NA	NA	NA	NA	NA	NA	NA
ML23-5	8.68	8.49	1.93	NA	NA	NA	NA	NA	NA
ML23-4	3.75	4.28	NA	NA	NA	NA	NA	NA	NA
ML23-3	4.46	3.81	3.49	NA	NA	NA	NA	NA	NA
ML23-2	7.59	3.34	4.84	NA	NA	NA	NA	NA	NA
ML23-1	4.19	2.05	3.36	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	1.26	NA	1.62	1.60	3.10	<0.40	NA
ML23.5-8	NA	NA	2.39	NA	2.35	1.68	2.42	0.68	12.42
ML23.5-7	NA	NA	2.92	NA	2.14	2.03	2.46	0.71	8.13
ML23.5-6	NA	NA	2.79	NA	1.98	1.85	2.20	1.20	4.43
ML23.5-5	NA	NA	3.22	NA	2.16	2.08	3.34	0.93	13.74
ML23.5-4	NA	NA	2.93	NA	2.20	2.01	3.23	1.27	13.72
ML23.5-3	NA	NA	3.16	NA	2.52	2.16	2.63	1.04	10.22
ML23.5-2	NA	NA	2.96	NA	2.47	2.17	2.75	1.00	8.53
ML23.5-1	NA	NA	2.85	NA	2.20	1.82	2.79	1.01	8.15
ML24-7	7.39	8.52	5.17	NA	3.41	2.93	1.72	1.52	6.88
ML24-6	7.72	8.87	4.88	NA	2.74	2.12	2.55	0.89	7.17
ML24-5	8.42	8.58	4.23	NA	2.31	2.03	2.94	0.96	12.82
ML24-4	5.70	2.69	3.41	NA	1.60	1.70	2.29	0.69	14.69
ML24-3	4.84	4.04	3.79	NA	2.44	2.05	2.39	1.07	11.64
ML24-2	4.81	4.31	3.49	NA	2.02	1.72	NA	1.07	11.39
ML24-1	4.27	2.53	6.75	NA	2.10	1.86	2.19	1.49	10.96
ML25-7	0.86	1.26	1.33	NA	1.27	1.50	NA	0.51	6.23
ML25-6	2.00	1.21	1.92	NA	1.15	0.85	NA	<0.40	6.77
ML25-5	1.69	5.29	3.15	NA	2.79	2.03	NA	0.98	12.08
ML25-4	3.03	3.43	4.22	NA	2.57	2.75	NA	1.13	12.21
ML25-3	3.95	5.87	2.79	NA	2.72	2.08	NA	1.18	12.09
ML25-2	1.70	2.84	1.37	NA	1.56	1.34	NA	<0.40	8.19
ML25-1	0.98	1.93	1.37	NA	1.36	1.17	NA	<0.40	9.86

Notes: NA, not analyzed. Dry, no water.

**Table C16.** Vinyl Chloride Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	19.7	20.0	45.1	35.0	ND	27.1	38.2	51.4	26.8
ML21-6	37.0	28.3	53.2	39.9	ND	42.9	52.1	38.2	11.8
ML21-5	12.7	29.9	NA	<1.0	ND	12.2	5.5	ND	ND
ML21-4	ND	0.9	ND	ND	ND	<1.0	ND	ND	ND
ML21-3	ND	ND	ND	ND	ND	ND	ND	ND	ND
ML21-2	NA	ND	<1.0	ND	ND	<1.0	NA	ND	ND
ML21-3	NA	ND	ND	ND	ND	ND	ND	ND	ND
ML22-7	Dry	2.2	2.2	NA	NA	NA	NA	NA	NA
ML22-6	Dry	ND	1.2	NA	NA	NA	NA	NA	NA
ML22-5	1.4	1.5	<1.0	NA	NA	NA	NA	NA	NA
ML22-4	<1.0	1.1	<1.0	NA	NA	NA	NA	NA	NA
ML22-3	7.3	3.8	3.5	NA	NA	NA	NA	NA	NA
ML22-2	3.5	2.3	ND	NA	NA	NA	NA	NA	NA
ML22-1	ND	ND	1.0	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	21.5	10.1	4.0	12.0	3.1	7.0	38.5
ML22.5-8	NA	NA	45.2	ND	2.9	2.9	ND	16.9	45.6
ML22.5-7	NA	NA	40.0	ND	2.9	2.3	ND	17.5	45.3
ML22.5-6	NA	NA	42.9	ND	2.6	3.0	ND	14.6	41.3
ML22.5-5	NA	NA	24.0	ND	2.2	5.9	ND	10.9	36.9
ML22.5-4	NA	NA	32.9	<1.0	1.8	2.8	ND	3.9	22.6
ML22.5-3	NA	NA	8.9	<1.0	1.6	2.1	ND	ND	10.6
ML22.5-2	NA	NA	3.1	ND	ND	<1.0	ND	ND	ND
ML22.5-1	NA	NA	ND	<1.0	1.0	1.4	ND	ND	ND
ML23-7	10.7	2.8	ND	NA	NA	NA	NA	NA	NA
ML23-6	<1.0	ND	ND	NA	NA	NA	NA	NA	NA
ML23-5	0.9	0.9	1.5	NA	NA	NA	NA	NA	NA
ML23-4	1.0	ND	<1.0	NA	NA	NA	NA	NA	NA
ML23-3	8.6	5.0	4.8	NA	NA	NA	NA	NA	NA
ML23-2	1.8	1.7	3.5	NA	NA	NA	NA	NA	NA
ML23-1	3.0	2.3	3.1	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	4.1	5.0	2.4	4.6	ND	4.4	NA
ML23.5-8	NA	NA	3.3	1.9	1.1	1.6	ND	2.2	14.1
ML23.5-7	NA	NA	3.0	1.4	1.2	2.2	ND	1.8	3.9
ML23.5-6	NA	NA	3.8	1.9	1.0	3.9	ND	1.6	ND
ML23.5-5	NA	NA	6.4	1.7	1.4	<1.0	ND	3.2	12.8
ML23.5-4	NA	NA	6.2	1.2	1.2	<1.0	ND	2.1	13.5
ML23.5-3	NA	NA	6.4	4.1	1.5	1.4	ND	1.4	16.0
ML23.5-2	NA	NA	3.6	3.6	2.2	1.8	ND	NA	23.2
ML23.5-1	NA	NA	3.2	6.6	2.9	4.3	ND	ND	35.3
ML24-7	NA	NA	NA	1.5	NA	<1.0	ND	ND	2.7
ML24-6	<1.0	ND	ND	1.9	<1.0	<1.0	ND	ND	3.2
ML24-5	<1.0	0.9	ND	3.0	1.0	1.3	ND	ND	8.5
ML24-4	1.0	1.1	<1.0	2.6	1.5	2.6	ND	1.2	14.4
ML24-3	1.8	2.1	ND	7.0	3.1	16.9	ND	ND	NA
ML24-2	1.5	1.1	ND	6.2	2.5	13.6	ND	ND	26.3
ML24-1	2.0	1.3	ND	8.2	2.9	1.3	ND	ND	31.1
ML25-7	ND	ND	<1.0	ND	<1.0	1.1	ND	<1.0	ND
ML25-6	1.4	1.2	1.9	6.1	1.7	3.1	ND	ND	ND
ML25-5	8.3	2.6	ND	10.1	4.6	9.5	ND	ND	ND
ML25-4	5.6	2.8	ND	8.7	5.0	5.0	ND	ND	ND
ML25-3	1.6	1.5	5.3	6.7	2.5	4.0	2.8	1.8	ND
ML25-2	1.2	1.4	2.8	5.3	2.0	2.6	6.6	ND	ND
ML25-1	1.4	1.3	27.1	4.6	2.5	3.8	1.8	2.2	ND

Notes: NA, not analyzed. ND, not detected. Dry, no water.

**Table C17.** *cis*-Dichloroethene (*cis*-DCE) Values (µg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	28.2	23.8	201	152	67.3	63.6	164	384	206
ML21-6	152	94.8	299	227	153	173	287	297	90.6
ML21-5	151	190	<1.0	5.4	57.3	136	39.9	1.0	ND
ML21-4	116	8.5	<1.0	ND	ND	21.0	ND	ND	ND
ML21-3	<1.0	ND	5.4	ND	ND	1.8	ND	<1.0	ND
ML21-2	NA	ND	3.4	ND	ND	ND	ND	ND	ND
ML21-1	NA	ND	<1.0	ND	<1.0	ND	ND	ND	ND
ML22-7	Dry	2.7	1.3	NA	NA	NA	NA	NA	NA
ML22-6	Dry	ND	7.8	NA	NA	NA	NA	NA	NA
ML22-5	5.2	4.9	5.0	NA	NA	NA	NA	NA	NA
ML22-4	ND	ND	5.3	NA	NA	NA	NA	NA	NA
ML22-3	27.6	18.7	6.8	NA	NA	NA	NA	NA	NA
ML22-2	41.2	26.2	7.6	NA	NA	NA	NA	NA	NA
ML22-1	1.6	2.3	9.3	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	53.7	47.9	31.0	52.1	40.9	104	87.1
ML22.5-8	NA	NA	3.3	1.0	1.2	3.7	ND	<1.0	3.0
ML22.5-7	NA	NA	2.7	ND	1.2	1.3	ND	<1.0	3.3
ML22.5-6	NA	NA	3.0	ND	1.3	1.0	ND	<1.0	3.6
ML22.5-5	NA	NA	6.3	ND	1.1	1.4	ND	<1.0	3.7
ML22.5-4	NA	NA	3.3	1.1	1.3	1.7	1.4	<1.0	2.0
ML22.5-3	NA	NA	14.6	2.0	1.4	3.3	ND	<1.0	<1.0
ML22.5-2	NA	NA	6.2	1.1	ND	2.5	ND	<1.0	ND
ML22.5-1	NA	NA	3.5	3.8	1.3	4.6	7.8	6.1	13.0
ML23-7	8.9	5.9	5.5	NA	NA	NA	NA	NA	NA
ML23-6	ND	ND	6.7	NA	NA	NA	NA	NA	NA
ML23-5	ND	ND	5.8	NA	NA	NA	NA	NA	NA
ML23-4	2.0	1.2	7.0	NA	NA	NA	NA	NA	NA
ML23-3	52.2	38.4	19.2	NA	NA	NA	NA	NA	NA
ML23-2	5.7	4.5	9.3	NA	NA	NA	NA	NA	NA
ML23-1	25.9	12.7	5.2	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	30.6	21.3	12.8	20.2	56.3	113.0	NA
ML23.5-8	NA	NA	<1.0	ND	1.2	1.7	ND	<1.0	298.0
ML23.5-7	NA	NA	<1.0	ND	1.1	1.1	ND	<1.0	ND
ML23.5-6	NA	NA	<1.0	ND	ND	ND	ND	<1.0	<1.0
ML23.5-5	NA	NA	3.1	<1.0	ND	1.0	ND	<1.0	1.4
ML23.5-4	NA	NA	4.1	1.4	ND	<1.0	1.3	<1.0	3.9
ML23.5-3	NA	NA	8.3	3.0	3.0	3.8	3.9	4.9	18.0
ML23.5-2	NA	NA	8.6	3.5	4.2	5.4	8.2	NA	34.3
ML23.5-1	NA	NA	3.7	2.8	4.7	7.3	6.7	7.7	51.4
ML24-7	ND	ND	1.8	ND	ND	ND	ND	ND	ND
ML24-6	ND	ND	ND	ND	ND	ND	ND	ND	ND
ML24-5	ND	ND	3.3	ND	ND	ND	ND	<1.0	<1.0
ML24-4	ND	ND	8.1	ND	ND	ND	6.9	<1.0	ND
ML24-3	5.5	9.0	12.0	6.0	6.2	7.3	570	<1.0	NA
ML24-2	2.4	<1.0	20.9	10.9	8.0	8.2	18.9	3.2	20.4
ML24-1	8.9	4.7	ND	2.5	4.4	8.1	7.8	18.0	5.8
ML25-7	ND	<1.0	<1.0	ND	ND	1.0	ND	<1.0	ND
ML25-6	3.9	1.8	21.9	6.7	2.7	1.8	7.2	13.0	38.1
ML25-5	28.0	12.8	15.9	13.2	14.4	25.9	16.0	10.5	74.6
ML25-4	8.1	11.4	15.4	6.3	13.1	20.2	13.9	18.3	16.4
ML25-3	6.0	3.2	23.6	14.0	8.1	8.0	22.1	24.3	18.8
ML25-2	1.9	1.7	2.7	7.7	5.4	5.9	12.1	2.3	2.9
ML25-1	14.8	6.5	39.5	6.4	3.2	3.9	5.5	2.5	2.9

Notes: NA, not analyzed. ND, not detected. Dry, no water.

**Table C18.** Trichloroethene Values (µg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	21.1	16.8	201	133	57.7	40.3	170	487	257
ML21-6	157	103	330	231	140	132	316	413	123
ML21-5	155	305	26.7	18.1	90.5	154	64.9	11.2	ND
ML21-4	206	30.3	14.1	3.6	25.7	50.2	14.6	5.0	1.8
ML21-3	21.1	10.9	10.4	18.1	47.1	44.4	10.0	8.7	1.9
ML21-2	NA	314	833	840	495	438	523	1710	2050
ML21-1	NA	4110	3570	4815	4439	3790	6007	9040	4740
ML22-7	NA	1.9	1.2	NA	NA	NA	NA	NA	NA
ML22-6	NA	1.0	1.6	NA	NA	NA	NA	NA	NA
ML22-5	72.9	2.4	1.3	NA	NA	NA	NA	NA	NA
ML22-4	ND	1.0	5.7	NA	NA	NA	NA	NA	NA
ML22-3	0.9	3.5	10.3	NA	NA	NA	NA	NA	NA
ML22-2	ND	1.0	54.8	NA	NA	NA	NA	NA	NA
ML22-1	4320	501	3674	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	4.3	55.2	216	242	510	1250	1510
ML22.5-8	NA	NA	ND	ND	1.2	ND	ND	5.2	1.6
ML22.5-7	NA	NA	ND	ND	1.3	1.2	ND	6.5	6.2
ML22.5-6	NA	NA	ND	ND	1.3	1.4	ND	9.2	12.0
ML22.5-5	NA	NA	6.6	3.0	3.7	1.2	ND	15.6	22.0
ML22.5-4	NA	NA	<1.0	5.8	4.5	4.2	1.6	20.3	37.4
ML22.5-3	NA	NA	13.7	15.7	9.5	7.3	24.2	28.6	47.2
ML22.5-2	NA	NA	23.7	29.4	17.6	14.4	765	74.8	127
ML22.5-1	NA	NA	747	321	122	159	563	1205	1090
ML23-7	8.5	ND	ND	NA	NA	NA	NA	NA	NA
ML23-6	9.2	ND	ND	NA	NA	NA	NA	NA	NA
ML23-5	12.7	ND	ND	NA	NA	NA	NA	NA	NA
ML23-4	ND	ND	ND	NA	NA	NA	NA	NA	NA
ML23-3	3.3	2.5	14.6	NA	NA	NA	NA	NA	NA
ML23-2	ND	ND	<1.0	NA	NA	NA	NA	NA	NA
ML23-1	ND	2.1	3.8	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	1.4	ND	ND	1.3	11.3	8.9	NA
ML23.5-8	NA	NA	ND	ND	ND	ND	ND	ND	3.5
ML23.5-7	NA	NA	ND	ND	ND	ND	ND	ND	ND
ML23.5-6	NA	NA	ND	ND	ND	ND	ND	ND	ND
ML23.5-5	NA	NA	1.1	ND	ND	ND	ND	<1.0	1.6
ML23.5-4	NA	NA	1.4	1.6	ND	ND	ND	4.5	4.5
ML23.5-3	NA	NA	3.4	1.1	ND	ND	2.1	13.7	23.3
ML23.5-2	NA	NA	5.5	1.7	1.3	1.5	4.1	16.7	48.0
ML23.5-1	NA	NA	6.1	2.7	3.0	3.0	9.8	40.5	66.2
ML24-7	ND	ND	<1.0	ND	ND	ND	ND	ND	1.1
ML24-6	ND	ND	ND	ND	ND	ND	ND	ND	ND
ML24-5	ND	ND	ND	ND	ND	ND	ND	ND	ND
ML24-4	ND	ND	ND	ND	ND	ND	1.8	ND	ND
ML24-3	ND	ND	6.2	1.8	1.2	1.0	559	<1.0	NA
ML24-2	ND	ND	2.4	ND	ND	ND	1.3	8.1	11.4
ML24-1	ND	ND	ND	ND	ND	ND	1.8	<1.0	3.0
ML25-7	1.1	1.3	1.7	ND	ND	ND	ND	<1.0	65.6
ML25-6	ND	ND	<1.0	ND	ND	ND	ND	ND	34.7
ML25-5	ND	ND	1.0	ND	ND	ND	ND	1.7	4.3
ML25-4	ND	ND	1.9	ND	ND	ND	ND	1.5	2.9
ML25-3	ND	ND	NA	ND	ND	ND	ND	6.4	20.3
ML25-2	ND	ND	2.7	ND	ND	NA	0.2	ND	1.3
ML25-1	81.6	17.3	105	12.4	4.3	3.6	3.4	3.7	3.9

Notes: NA, not analyzed. ND, not detected.

**Table C19.** Ethane Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Sample ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	NA	ND	ND	ND	ND	ND	<0.002	ND	ND
ML21-6	ND	ND	ND	ND	ND	ND	<0.002	ND	ND
ML21-5	ND	ND	ND	ND	ND	ND	<0.002	ND	ND
ML21-4	ND	ND	ND	ND	ND	ND	<0.002	NA	ND
ML21-3	ND	ND	ND	ND	ND	ND	<0.002	ND	ND
ML21-2	NA	ND	ND	ND	ND	ND	<0.002	ND	ND
ML21-1	ND	ND	ND	ND	ND	ND	<0.002	ND	ND
ML22-7	NA	ND	ND	NA	NA	NA	NA	NA	NA
ML22-6	NA	0.005	0.004	NA	NA	NA	NA	NA	NA
ML22-5	NA	0.011	0.007	NA	NA	NA	NA	NA	NA
ML22-4	0.008	0.007	0.007	NA	NA	NA	NA	NA	NA
ML22-3	0.021	0.045	NA	NA	NA	NA	NA	NA	NA
ML22-2	0.037	0.052	ND	NA	NA	NA	NA	NA	NA
ML22-1	ND	ND	ND	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	0.025	0.036	0.015	0.010	0.018	NA	0.0138
ML22.5-8	NA	NA	ND	ND	ND	ND	<0.002	ND	ND
ML22.5-7	NA	NA	ND	ND	ND	ND	<0.002	ND	ND
ML22.5-6	NA	NA	ND	ND	ND	ND	<0.002	0.001	0.0000
ML22.5-5	NA	NA	ND	<0.002	<0.002	ND	<0.002	0.001	0.0011
ML22.5-4	NA	NA	<0.002	0.003	0.003	0.002	<0.002	0.003	0.0027
ML22.5-3	NA	NA	0.003	0.004	0.003	0.002	<0.002	0.001	0.0029
ML22.5-2	NA	NA	<0.002	ND	ND	ND	<0.002	ND	ND
ML22.5-1	NA	NA	ND	0.003	ND	ND	0.006	0.000	<0.002
ML23-7	ND	ND	ND	NA	NA	NA	NA	NA	NA
ML23-6	0.005	0.005	0.002	NA	NA	NA	NA	NA	NA
ML23-5	0.007	0.007	0.004	NA	NA	NA	NA	NA	NA
ML23-4	0.006	0.004	0.002	NA	NA	NA	NA	NA	NA
ML23-3	0.031	0.042	0.012	NA	NA	NA	NA	NA	NA
ML23-2	0.034	0.044	0.010	NA	NA	NA	NA	NA	NA
ML23-1	0.038	0.048	0.011	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	0.016	0.018	0.014	ND	0.029	0.016	NA
ML23.5-8	NA	NA	0.004	0.003	ND	ND	<0.002	0.001	0.0350
ML23.5-7	NA	NA	0.003	ND	0.003	<0.002	<0.002	0.001	0.0023
ML23.5-6	NA	NA	0.004	0.002	0.002	ND	<0.002	0.001	<0.002
ML23.5-5	NA	NA	0.008	0.006	0.005	0.003	0.004	0.004	0.0060
ML23.5-4	NA	NA	0.008	0.006	0.005	0.003	0.006	0.005	0.0072
ML23.5-3	NA	NA	0.010	0.009	0.007	0.005	0.008	0.006	0.0070
ML23.5-2	NA	NA	0.007	0.009	0.009	0.008	0.009	0.007	0.009
ML23.5-1	NA	NA	0.007	0.012	0.015	0.008	0.016	0.007	0.0111
ML24-7	0.004	0.005	0.004	0.003	0.002	0.002	0.002	0.004	<0.002
ML24-6	ND	0.006	NA	0.004	0.002	0.002	<0.002	0.005	0.0092
ML24-5	ND	0.009	0.005	0.004	0.003	0.003	<0.002	0.008	0.0126
ML24-4	0.010	0.014	0.009	0.008	0.005	0.005	0.004	0.008	NA
ML24-3	0.022	0.037	0.010	0.010	0.013	0.009	0.015	0.008	0.0129
ML24-2	0.026	0.041	ND	0.011	0.009	0.008	0.014	0.009	0.0126
ML24-1	0.039	0.038	0.012	0.012	0.017	0.011	0.015	0.006	0.0120
ML25-7	0.004	<0.002	ND	ND	ND	ND	<0.002	0.001	ND
ML25-6	0.029	0.030	0.013	0.011	0.011	0.012	0.009	0.011	0.0117
ML25-5	0.015	0.050	0.010	0.018	0.012	0.012	0.013	0.013	0.0169
ML25-4	0.017	0.053	0.009	0.012	0.013	0.013	0.014	0.013	0.0133
ML25-3	0.030	0.048	0.009	0.011	0.010	0.010	0.013	0.012	0.0163
ML25-2	0.014	0.049	0.014	0.010	0.010	0.009	0.012	0.009	0.0140
ML25-1	0.015	0.037	0.013	0.010	0.010	0.011	0.008	0.009	0.0131

Notes: NA, not analyzed. ND, not detected.

**Table C20.** Ethene Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	ND	ND	ND	ND	ND	ND	<0.001	ND	ND
ML21-6	ND	<0.003	ND	ND	ND	ND	<0.001	ND	ND
ML21-5	ND	ND	ND	ND	ND	ND	<0.001	ND	ND
ML21-4	ND	ND	ND	ND	ND	ND	<0.001	NA	ND
ML21-3	ND	ND	ND	ND	ND	ND	<0.001	ND	ND
ML21-2	NA	ND	ND	ND	ND	ND	<0.001	ND	ND
ML21-1	ND	ND	ND	ND	ND	ND	<0.001	ND	ND
ML22-7	NA	ND	ND	NA	NA	NA	NA	NA	NA
ML22-6	NA	<0.003	<0.003	NA	NA	NA	NA	NA	NA
ML22-5	NA	0.008	0.005	NA	NA	NA	NA	NA	NA
ML22-4	<0.003	<0.003	0.003	NA	NA	NA	NA	NA	NA
ML22-3	0.026	0.024	NA	NA	NA	NA	NA	NA	NA
ML22-2	0.035	0.030	ND	NA	NA	NA	NA	NA	NA
ML22-1	ND	<0.003	ND	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	0.043	0.057	0.027	0.023	0.019	NA	0.0403
ML22.5-8	NA	NA	0.004	ND	ND	ND	<0.001	0.006	0.0142
ML22.5-7	NA	NA	0.003	ND	ND	ND	<0.001	0.006	0.0141
ML22.5-6	NA	NA	0.003	<0.003	<0.003	<0.003	<0.001	0.005	0.013
ML22.5-5	NA	NA	0.006	<0.003	<0.003	<0.003	<0.001	0.005	0.0122
ML22.5-4	NA	NA	0.005	0.003	0.004	<0.003	0.002	0.003	0.0085
ML22.5-3	NA	NA	0.007	0.005	0.003	0.003	<0.001	0.001	0.0047
ML22.5-2	NA	NA	ND	ND	ND	ND	<0.001	ND	<0.003
ML22.5-1	NA	NA	ND	0.004	ND	ND	0.005	ND	<0.003
ML23-7	ND	ND	ND	NA	NA	NA	NA	NA	NA
ML23-6	ND	ND	ND	NA	NA	NA	NA	NA	NA
ML23-5	ND	<0.003	<0.003	NA	NA	NA	NA	NA	NA
ML23-4	0.003	ND	NA	NA	NA	NA	NA	NA	NA
ML23-3	0.031	0.029	0.007	NA	NA	NA	NA	NA	NA
ML23-2	0.029	0.024	0.007	NA	NA	NA	NA	NA	NA
ML23-1	0.048	0.036	0.012	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	0.027	0.025	0.019	0.014	0.029	0.018	NA
ML23.5-8	NA	NA	<0.003	<0.003	<0.003	<0.003	<0.001	0.002	0.0435
ML23.5-7	NA	NA	<0.003	ND	<0.003	<0.003	<0.001	0.001	0.0039
ML23.5-6	NA	NA	<0.003	<0.003	<0.003	ND	0.044	0.001	<0.003
ML23.5-5	NA	NA	0.006	0.004	0.004	0.003	0.002	0.004	0.0098
ML23.5-4	NA	NA	0.008	0.005	0.006	0.003	0.003	0.004	0.0107
ML23.5-3	NA	NA	0.008	0.008	0.008	0.005	0.005	0.005	0.0084
ML23.5-2	NA	NA	0.006	0.006	0.009	0.005	0.007	0.005	0.0077
ML23.5-1	NA	NA	0.006	0.008	0.013	0.006	0.008	0.005	0.0092
ML24-7	ND	<0.003	ND	ND	ND	ND	NA	0.001	<0.003
ML24-6	ND	<0.003	ND	ND	ND	ND	NA	0.001	0.0036
ML24-5	0.011	<0.003	ND	<0.003	ND	ND	NA	0.004	0.0089
ML24-4	<0.003	<0.003	0.004	0.004	0.003	<0.003	NA	0.004	NA
ML24-3	0.019	0.020	0.007	0.008	0.010	0.007	NA	0.006	0.0107
ML24-2	0.033	0.017	ND	0.010	0.009	0.008	NA	0.007	0.0100
ML24-1	0.040	0.023	0.009	0.009	0.010	0.009	NA	0.003	0.0079
ML25-7	<0.003	ND	ND	ND	ND	ND	<0.001	ND	ND
ML25-6	0.029	0.018	0.012	0.010	0.010	0.008	1.068	0.006	0.0082
ML25-5	0.038	0.037	0.010	0.016	0.015	0.014	0.002	0.009	0.0135
ML25-4	0.017	0.030	0.008	0.010	0.013	0.014	0.008	0.008	0.0097
ML25-3	0.038	0.027	0.011	0.011	0.011	0.009	0.010	0.008	0.0136
ML25-2	0.016	0.027	0.010	0.007	0.009	0.008	0.009	0.005	0.0074
ML25-1	0.010	0.024	0.010	0.006	0.007	0.008	<0.001	0.004	0.0059

Notes: NA, not analyzed. ND, not detected. Dry, no water.

**Table C21. Sodium Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells**

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	14.0	14.3	29.0	28.6	21.9	21.7	32.8	72.5	82.2
ML21-6	35.0	31.2	53.1	52.5	41.9	39.4	49.8	82.7	75.4
ML21-5	123.0	96.0	87.1	72.8	78.4	81.3	72.4	61.0	43.1
ML21-4	130.0	89.6	55.6	44.0	49.1	63.9	51.1	37.0	28.1
ML21-3	49.4	58.6	25.6	24.2	27.9	33.1	24.5	21.7	19.4
ML21-2	NA	27.3	26.0	24.0	25.1	23.3	23.2	NA	22.0
ML21-1	NA	18.9	20.3	21.2	25.1	22.3	23.0	24.6	23.2
ML22-7	Dry	9.4	Dry	NA	NA	NA	NA	NA	NA
ML22-6	Dry	13.6	Dry	NA	NA	NA	NA	NA	NA
ML22-5	Dry	26.3	Dry	NA	NA	NA	NA	NA	NA
ML22-4	19.8	17.3	18.0	NA	NA	NA	NA	NA	NA
ML22-3	56.8	61.5	34.7	NA	NA	NA	NA	NA	NA
ML22-2	34.1	48.7	24.0	NA	NA	NA	NA	NA	NA
ML22-1	21.2	20.9	22.6	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	51.3	34.5	40.2	38.0	22.8	27.0	24.3
ML22.5-8	NA	NA	11.9	10.2	4.2	10.0	5.2	11.8	17.2
ML22.5-7	NA	NA	12.7	10.5	5.1	9.9	5.2	11.7	17.5
ML22.5-6	NA	NA	12.0	15.4	7.5	10.2	5.5	12.6	19.0
ML22.5-5	NA	NA	37.1	22.8	21.0	8.2	5.4	21.3	22.1
ML22.5-4	NA	NA	24.5	34.3	31.7	28.1	23.9	32.6	23.1
ML22.5-3	NA	NA	64.0	52.5	47.2	41.8	35.0	34.8	21.9
ML22.5-2	NA	NA	56.3	45.8	47.8	41.1	30.6	24.5	19.9
ML22.5-1	NA	NA	37.1	28.5	37.1	30.1	25.4	23.7	21.0
ML23-7	Dry	11.7	Dry	NA	NA	NA	NA	NA	NA
ML23-6	12.2	13.7	Dry	NA	NA	NA	NA	NA	NA
ML23-5	16.0	15.1	Dry	NA	NA	NA	NA	NA	NA
ML23-4	Dry	24.2	Dry	NA	NA	NA	NA	NA	NA
ML23-3	61.9	61.7	67.1	NA	NA	NA	NA	NA	NA
ML23-2	43.0	53.4	45.3	NA	NA	NA	NA	NA	NA
ML23-1	35.4	54.8	39.6	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	31.2	37.7	44.9	36.1	29.4	26.2	NA
ML23.5-8	NA	NA	18.3	16.0	12.3	14.4	6.0	16.1	32.6
ML23.5-7	NA	NA	18.6	16.3	13.5	14.1	5.7	17.8	39.0
ML23.5-6	NA	NA	19.4	16.7	14.5	12.8	6.3	17.8	20.8
ML23.5-5	NA	NA	29.3	25.3	21.1	21.2	11.5	28.9	22.1
ML23.5-4	NA	NA	32.8	28.2	24.0	24.6	17.6	30.4	26.6
ML23.5-3	NA	NA	47.6	44.8	41.5	42.7	29.4	39.1	25.7
ML23.5-2	NA	NA	55.4	55.1	52.4	52.7	38.9	41.4	29.9
ML23.5-1	NA	NA	50.2	51.3	44.0	49.7	39.7	49.8	31.9
ML24-7	11.4	12.5	10.1	7.4	6.8	8.0	5.0	8.2	9.8
ML24-6	11.3	12.5	10.0	7.8	7.4	8.0	4.9	8.3	11.6
ML24-5	16.3	16.8	15.8	10.9	16.1	13.3	3.0	14.1	23.9
ML24-4	24.0	18.9	19.6	18.8	14.7	19.5	9.4	20.4	27.1
ML24-3	49.3	52.2	54.4	58.1	45.0	59.2	43.9	48.0	35.0
ML24-2	38.8	43.9	55.2	58.1	44.9	68.8	44.5	46.1	40.4
ML24-1	35.8	51.9	40.5	52.0	33.4	58.7	41.1	56.2	32.4
ML25-7	7.9	8.3	7.5	6.8	7.7	12.1	6.2	16.2	12.6
ML25-6	33.6	22.3	51.8	38.6	19.5	12.4	31.4	29.3	26.9
ML25-5	67.4	29.1	51.0	44.6	61.3	44.2	44.4	37.2	32.9
ML25-4	77.7	44.8	52.7	45.7	59.4	52.7	39.0	46.5	36.0
ML25-3	44.8	43.1	58.6	65.0	48.9	62.5	48.4	44.4	38.0
ML25-2	38.9	44.7	42.7	43.1	42.0	45.3	37.1	32.5	28.9
ML25-1	49.6	45.8	45.3	38.7	40.1	49.6	34.6	23.1	24.4

Notes: NA, not analyzed. Dry, no water.

**Table C22.** Potassium Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	3.92	6.31	7.02	6.84	5.25	5.48	6.09	7.39	5.53
ML21-6	4.94	6.94	6.15	6.48	5.24	5.16	5.14	5.22	3.22
ML21-5	<0.53	3.04	1.70	2.25	<0.30	1.55	1.27	1.56	2.79
ML21-4	<0.53	2.30	1.41	1.65	<0.30	0.74	1.58	1.32	4.43
ML21-3	<0.53	2.24	1.04	1.76	<0.30	0.60	1.22	1.30	2.14
ML21-2	NA	2.01	1.00	1.78	<0.30	0.40	1.00	NA	1.40
ML21-1	NA	NA	1.26	0.44	<0.30	0.77	1.33	1.53	1.30
ML22-7	Dry	5.51	Dry	NA	NA	NA	NA	NA	NA
ML22-6	Dry	1.97	Dry	NA	NA	NA	NA	NA	NA
ML22-5	Dry	1.94	Dry	NA	NA	NA	NA	NA	NA
ML22-4	1.12	2.33	1.89	NA	NA	NA	NA	NA	NA
ML22-3	2.92	2.72	1.31	NA	NA	NA	NA	NA	NA
ML22-2	<0.53	1.79	<0.79	NA	NA	NA	NA	NA	NA
ML22-1	<0.53	1.82	1.20	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	11.9	2.06	0.68	1.19	1.15	1.54	2.33
ML22.5-8	NA	NA	12.7	6.34	2.51	4.30	3.30	5.69	6.12
ML22.5-7	NA	NA	12.0	6.13	2.73	4.50	3.48	5.52	5.83
ML22.5-6	NA	NA	37.1	4.73	3.05	4.42	3.36	5.56	5.82
ML22.5-5	NA	NA	24.5	4.72	2.98	4.29	3.27	4.70	5.32
ML22.5-4	NA	NA	64.0	3.99	2.34	3.27	2.28	3.14	4.36
ML22.5-3	NA	NA	56.3	2.82	1.68	2.42	1.58	1.98	3.68
ML22.5-2	NA	NA	37.1	1.75	0.70	0.82	0.81	1.42	0.53
ML22.5-1	NA	NA	51.3	1.78	0.63	0.89	1.13	1.39	3.55
ML23-7	Dry	5.66	Dry	NA	NA	NA	NA	NA	NA
ML23-6	<0.53	1.62	Dry	NA	NA	NA	NA	NA	NA
ML23-5	Dry	2.87	Dry	NA	NA	NA	NA	NA	NA
ML23-4	NA	5.38	Dry	NA	NA	NA	NA	NA	NA
ML23-3	2.93	4.62	1.69	NA	NA	NA	NA	NA	NA
ML23-2	0.57	1.48	1.01	NA	NA	NA	NA	NA	NA
ML23-1	<0.53	2.49	0.94	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	31.2	1.65	1.64	1.41	1.81	1.77	NA
ML23.5-8	NA	NA	18.3	0.95	1.42	1.23	1.19	2.52	1.88
ML23.5-7	NA	NA	18.6	<0.92	1.03	0.91	0.99	2.29	2.74
ML23.5-6	NA	NA	19.4	0.98	0.88	0.96	1.16	2.23	3.63
ML23.5-5	NA	NA	29.3	1.13	1.30	1.22	1.05	2.73	3.76
ML23.5-4	NA	NA	32.8	1.52	1.52	1.74	1.20	2.47	3.64
ML23.5-3	NA	NA	47.6	2.20	1.11	1.80	1.46	2.48	3.05
ML23.5-2	NA	NA	55.4	2.72	1.27	2.33	1.83	2.56	3.27
ML23.5-1	NA	NA	50.2	2.39	1.90	2.72	1.95	3.62	2.35
ML24-7	1.21	1.52	10.1	2.06	1.76	1.90	1.28	1.53	1.84
ML24-6	1.24	2.33	10.0	2.00	1.57	1.92	1.45	2.00	2.42
ML24-5	1.31	2.03	15.8	2.39	1.86	1.65	0.91	3.15	3.96
ML24-4	0.90	1.99	19.6	2.66	2.11	1.94	1.36	3.15	3.46
ML24-3	0.79	1.93	54.4	2.29	2.13	2.09	1.72	3.52	3.14
ML24-2	0.78	1.93	55.2	2.91	3.37	4.56	3.37	4.39	3.46
ML24-1	<0.53	2.10	40.5	2.20	2.39	3.14	2.89	4.31	2.27
ML25-7	3.07	3.65	7.53	4.16	3.38	4.77	3.77	5.89	5.45
ML25-6	2.34	2.50	51.8	3.04	1.42	1.77	2.74	2.08	2.35
ML25-5	1.15	1.02	51.0	2.39	2.47	1.49	2.11	2.07	3.47
ML25-4	0.99	1.02	52.7	3.24	1.93	0.95	2.9	2.81	2.69
ML25-3	1.89	1.84	58.6	4.98	2.44	2.96	3.3	4.47	3.17
ML25-2	<0.53	1.23	42.7	1.71	1.80	2.19	2.19	0.76	0.85
ML25-1	<0.53	<0.90	45.3	0.95	1.08	0.75	0.5	0.84	1.07

Notes: NA, not analyzed. Dry, no water.

**Table C23.** Calcium Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	24.8	23.3	32.2	30.1	27.2	26.4	28.7	32.1	23.3
ML21-6	26.7	24.6	3.10	29.3	26.3	25.3	29.2	27.2	14.2
ML21-5	10.7	17.6	10.5	9.77	9.70	15.0	9.59	6.92	6.73
ML21-4	4.26	8.87	14.5	9.38	8.55	8.21	13.3	7.72	8.05
ML21-3	10.8	10.8	11.2	9.84	9.43	9.12	9.93	9.90	9.70
ML21-2	NA	9.22	9.88	10.6	10.4	10.2	11.1	NA	11.4
ML21-1	NA	12.1	12.3	13.2	11.8	12.8	13.7	14.8	12.7
ML22-7	Dry	19.3	Dry	NA	NA	NA	NA	NA	NA
ML22-6	Dry	4.56	Dry	NA	NA	NA	NA	NA	NA
ML22-5	Dry	8.83	Dry	NA	NA	NA	NA	NA	NA
ML22-4	7.97	8.48	9.08	NA	NA	NA	NA	NA	NA
ML22-3	2.97	2.04	7.93	NA	NA	NA	NA	NA	NA
ML22-2	3.64	2.67	9.88	NA	NA	NA	NA	NA	NA
ML22-1	11.0	10.8	12.1	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	DRY	7.94	6.72	7.30	9.70	13.3	12.1
ML22.5-8	NA	NA	41.0	30.4	11.4	21.9	13.9	30.2	30.0
ML22.5-7	NA	NA	45.0	30.2	12.1	22.8	12.2	30.3	28.2
ML22.5-6	NA	NA	44.0	29.3	14.4	23.6	13.8	32.7	27.8
ML22.5-5	NA	NA	44.9	30.6	19.1	22.8	13.0	29.3	25.3
ML22.5-4	NA	NA	45.3	28.4	22.4	23.8	20.6	24.6	22.7
ML22.5-3	NA	NA	26.1	22.2	19.6	18.1	13.5	15.4	13.2
ML22.5-2	NA	NA	14.0	12.7	11.0	10.3	10.3	10.6	9.01
ML22.5-1	NA	NA	11.4	9.14	9.10	9.14	9.47	10.5	9.96
ML23-7	Dry	29.90	Dry	NA	NA	NA	NA	NA	NA
ML23-6	5.19	4.22	Dry	NA	NA	NA	NA	NA	NA
ML23-5	1.87	3.17	Dry	NA	NA	NA	NA	NA	NA
ML23-4	Dry	8.64	Dry	NA	NA	NA	NA	NA	NA
ML23-3	3.54	1.67	5.26	NA	NA	NA	NA	NA	NA
ML23-2	NA	NA	4.43	NA	NA	NA	NA	NA	NA
ML23-1	2.50	2.86	6.42	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	9.34	4.71	2.99	3.25	5.72	10.4	NA
ML23.5-8	NA	NA	12.9	11.3	5.16	4.72	5.14	23.0	6.19
ML23.5-7	NA	NA	11.5	9.73	4.89	4.25	4.73	20.4	24.6
ML23.5-6	NA	NA	11.9	10.4	5.38	4.02	4.32	20.7	26.5
ML23.5-5	NA	NA	17.8	12.7	7.88	6.74	6.89	21.0	24.0
ML23.5-4	NA	NA	20.7	14.4	9.98	9.02	7.93	14.6	22.7
ML23.5-3	NA	NA	20.8	13.2	10.0	9.85	10.1	17.2	13.0
ML23.5-2	NA	NA	12.5	7.44	4.65	6.05	5.38	12.0	6.24
ML23.5-1	NA	NA	8.33	3.65	2.52	3.24	3.97	5.61	5.37
ML24-7	4.45	5.65	2.86	1.90	2.71	3.84	1.82	2.24	3.39
ML24-6	4.88	5.41	3.16	1.68	2.37	3.50	2.28	3.69	4.70
ML24-5	6.01	7.24	2.88	3.53	2.84	4.24	3.13	7.32	8.90
ML24-4	7.44	8.09	6.86	4.97	4.26	4.79	4.17	8.12	9.19
ML24-3	3.10	2.06	6.06	3.76	2.71	3.22	2.71	6.40	6.70
ML24-2	3.80	2.45	4.99	4.02	1.77	3.25	3.48	6.28	4.65
ML24-1	3.75	2.08	4.63	3.30	2.09	2.15	2.51	3.09	3.99
ML25-7	6.16	5.78	5.97	5.89	5.45	10.6	6.69	19.9	19.2
ML25-6	2.86	2.47	5.69	4.24	1.91	2.45	5.62	4.63	5.48
ML25-5	6.09	2.92	6.56	4.81	2.84	1.15	5.22	2.94	5.12
ML25-4	8.19	3.90	7.74	4.94	4.95	1.57	3.49	3.31	3.35
ML25-3	5.24	3.91	9.32	4.14	1.97	1.31	4.26	7.83	5.86
ML25-2	3.59	2.01	2.91	2.43	1.36	2.84	2.76	3.32	5.83
ML25-1	2.59	1.93	2.43	1.46	1.47	2.47	3.83	6.23	6.22

Notes: NA, not analyzed. Dry, no water.

**Table C24.** Magnesium Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	9.52	9.07	12.0	11.0	9.50	9.07	10.8	14.3	11.9
ML21-6	12.4	10.5	15.9	14.2	11.5	11.1	13.5	14.2	8.12
ML21-5	7.89	12.5	7.92	7.16	7.34	11.1	7.14	5.22	5.34
ML21-4	2.91	6.17	9.73	6.17	5.94	5.59	9.35	5.54	6.38
ML21-3	6.89	7.00	6.40	6.02	6.14	5.86	6.41	6.47	6.63
ML21-2	NA	4.67	5.69	6.09	6.28	6.12	6.71	NA	6.99
ML21-1	NA	6.37	6.96	7.43	7.78	7.62	8.17	8.86	7.89
ML22-7	Dry	4.25	Dry	NA	NA	NA	NA	NA	NA
ML22-6	Dry	0.89	Dry	NA	NA	NA	NA	NA	NA
ML22-5	Dry	3.30	Dry	NA	NA	NA	NA	NA	NA
ML22-4	0.33	0.26	2.14	NA	NA	NA	NA	NA	NA
ML22-3	3.42	0.29	6.86	NA	NA	NA	NA	NA	NA
ML22-2	0.93	0.19	5.97	NA	NA	NA	NA	NA	NA
ML22-1	6.63	6.61	7.26	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	8.71	4.05	5.20	5.57	4.93	8.04	7.56
ML22.5-8	NA	NA	4.58	3.56	1.44	2.69	1.78	3.89	4.21
ML22.5-7	NA	NA	4.37	3.59	1.78	2.93	1.66	3.97	3.90
ML22.5-6	NA	NA	4.60	3.72	2.08	3.11	1.85	4.48	3.98
ML22.5-5	NA	NA	6.07	4.43	3.51	3.09	1.73	4.61	3.69
ML22.5-4	NA	NA	7.83	7.01	5.72	5.62	4.36	7.69	6.12
ML22.5-3	NA	NA	9.50	8.78	7.17	6.84	6.24	7.36	7.30
ML22.5-2	NA	NA	7.94	7.75	6.51	6.03	6.57	7.04	6.07
ML22.5-1	NA	NA	7.21	5.68	5.98	5.98	6.16	6.83	6.65
ML23-7	Dry	4.96	Dry	NA	NA	NA	NA	NA	NA
ML23-6	0.75	0.95	Dry	NA	NA	NA	NA	NA	NA
ML23-5	<0.039	0.07	Dry	NA	NA	NA	NA	NA	NA
ML23-4	Dry	3.58	Dry	NA	NA	NA	NA	NA	NA
ML23-3	4.65	0.53	7.21	NA	NA	NA	NA	NA	NA
ML23-2	1.60	0.07	6.69	NA	NA	NA	NA	NA	NA
ML23-1	1.31	1.18	4.76	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	6.62	6.09	4.23	8.80	3.48	11.89	NA
ML23.5-8	NA	NA	4.65	4.10	1.60	1.52	1.40	7.11	6.28
ML23.5-7	NA	NA	4.17	3.53	1.78	1.43	1.02	6.10	7.73
ML23.5-6	NA	NA	4.20	3.77	1.68	1.21	1.00	6.16	7.86
ML23.5-5	NA	NA	7.12	5.02	3.30	2.68	1.91	6.55	7.94
ML23.5-4	NA	NA	8.14	4.99	3.39	2.79	1.27	4.62	6.01
ML23.5-3	NA	NA	7.38	4.88	3.18	2.98	2.66	6.29	5.69
ML23.5-2	NA	NA	5.55	4.04	1.70	2.69	2.12	5.98	3.99
ML23.5-1	NA	NA	8.22	3.95	2.82	4.74	2.47	5.74	5.81
ML24-7	<0.039	0.10	0.11	0.10	0.11	0.13	0.09	0.14	0.57
ML24-6	<0.039	0.19	0.12	0.12	0.15	0.15	0.24	0.22	1.33
ML24-5	0.14	NA	0.28	0.38	0.21	0.33	0.26	2.54	4.02
ML24-4	0.28	0.24	1.61	0.70	0.34	0.28	0.47	2.54	5.98
ML24-3	1.38	0.10	4.81	2.90	1.46	3.46	1.58	3.53	4.20
ML24-2	2.12	0.27	7.58	5.84	1.89	3.37	3.08	4.07	5.39
ML24-1	1.77	0.19	4.19	2.62	2.46	3.55	3.07	5.93	5.04
ML25-7	2.63	2.61	2.84	2.44	2.84	4.85	2.68	6.83	6.62
ML25-6	1.27	1.20	1.47	1.39	1.79	1.13	2.07	2.50	3.84
ML25-5	0.85	0.48	2.03	2.51	4.24	1.50	3.95	3.24	6.18
ML25-4	2.41	0.94	3.21	3.90	3.97	1.07	4.05	4.02	3.89
ML25-3	0.26	0.20	2.45	1.97	1.12	0.45	3.37	5.45	5.11
ML25-2	1.82	1.00	1.43	1.30	0.61	0.90	1.44	1.87	3.38
ML25-1	1.38	0.98	1.35	0.81	1.06	1.34	2.10	3.62	3.48

Notes: NA, not analyzed. Dry, no water.

**Table C25.** Total Iron Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	5.57	4.03	5.45	5.02	5.88	6.29	7.05	2.54	0.097
ML21-6	0.098	0.51	<0.57	0.04	1.77	3.29	1.14	0.16	< 0.035
ML21-5	<0.012	<0.007	<0.57	0.01	<0.008	<0.003	<0.006	< 0.035	< 0.035
ML21-4	<0.012	<0.007	<0.012	<0.003	<0.008	<0.003	<0.006	< 0.035	< 0.035
ML21-3	0.02	<0.007	0.03	<0.003	<0.008	<0.003	0.008	< 0.035	< 0.035
ML21-2	NA	0.02	<0.019	0.00	<0.008	<0.003	<0.006	NA	0.10
ML21-1	NA	<0.007	<0.012	0.01	<0.008	<0.003	0.011	< 0.035	< 0.035
ML22-7	Dry	10.4	Dry	NA	NA	NA	NA	NA	NA
ML22-6	Dry	0.02	Dry	NA	NA	NA	NA	NA	NA
ML22-5	Dry	2.62	Dry	NA	NA	NA	NA	NA	NA
ML22-4	<0.012	0.02	0.54	NA	NA	NA	NA	NA	NA
ML22-3	<0.012	<0.007	0.16	NA	NA	NA	NA	NA	NA
ML22-2	<0.012	0.01	0.03	NA	NA	NA	NA	NA	NA
ML22-1	<0.012	0.15	0.05	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	0.098	1.28	7.05	7.79	6.51	7.68	4.86
ML22.5-8	NA	NA	13.1	13.0	4.52	10.9	2.52	17.2	21.1
ML22.5-7	NA	NA	10.8	13.0	5.55	12.3	3.58	19.3	24.8
ML22.5-6	NA	NA	16.9	13.7	7.05	12.2	3.57	22.3	25.6
ML22.5-5	NA	NA	23.6	15.6	9.89	12.1	3.57	22.2	25.9
ML22.5-4	NA	NA	27.7	14.9	9.63	10.3	6.18	21.7	25.1
ML22.5-3	NA	NA	15.8	15.8	11.50	11.1	12.0	18.0	15.7
ML22.5-2	NA	NA	1.15	0.82	2.26	2.98	1.31	0.45	0.32
ML22.5-1	NA	NA	1.01	0.54	0.57	0.54	0.33	0.05	0.05
ML23-7	Dry	7.18	Dry	NA	NA	NA	NA	NA	NA
ML23-6	<0.012	0.07	Dry	NA	NA	NA	NA	NA	NA
ML23-5	<0.012	0.02	Dry	NA	NA	NA	NA	NA	NA
ML23-4	Dry	7.61	Dry	NA	NA	NA	NA	NA	NA
ML23-3	<0.012	0.27	0.17	NA	NA	NA	NA	NA	NA
ML23-2	<0.012	0.15	0.05	NA	NA	NA	NA	NA	NA
ML23-1	<0.012	0.01	0.10	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	0.06	0.03	0.03	0.03	0.02	0.35	NA
ML23.5-8	NA	NA	0.49	0.28	0.08	<0.003	0.05	0.27	0.15
ML23.5-7	NA	NA	0.59	0.51	0.18	0.06	0.30	0.32	0.73
ML23.5-6	NA	NA	0.32	0.08	0.05	<0.003	0.15	0.47	0.13
ML23.5-5	NA	NA	2.74	1.75	0.62	0.49	0.35	5.11	18.2
ML23.5-4	NA	NA	2.07	1.63	0.85	0.74	0.50	7.50	21.1
ML23.5-3	NA	NA	0.39	0.19	0.08	0.11	0.11	3.66	15.6
ML23.5-2	NA	NA	2.46	0.43	0.30	0.66	0.34	6.03	6.44
ML23.5-1	NA	NA	1.16	0.03	0.02	0.03	0.02	0.11	0.62
ML24-7	<0.012	<0.007	<0.019	0.00	0.01	0.02	0.01	0.27	0.81
ML24-6	<0.012	0.04	0.02	<0.003	0.05	0.07	0.07	0.07	1.09
ML24-5	<0.012	0.01	<0.019	<0.003	0.02	0.02	0.01	< 0.035	0.05
ML24-4	0.05	0.01	<0.019	0.02	0.02	<0.003	<0.007	0.07	0.17
ML24-3	<0.012	<0.007	<0.019	0.00	0.02	0.03	0.02	0.05	4.74
ML24-2	<0.012	<0.007	<0.019	0.02	0.02	0.03	0.04	0.19	0.13
ML24-1	0.14	<0.007	<0.019	0.01	0.04	0.03	0.06	< 0.035	0.07
ML25-7	2.18	2.70	2.45	1.04	1.81	2.43	1.20	3.28	2.70
ML25-6	0.58	0.66	1.02	0.51	0.27	0.47	0.63	0.30	1.00
ML25-5	0.014	0.009	<0.019	0.005	0.64	0.21	0.02	<0.035	< 0.035
ML25-4	0.063	0.028	<0.019	0.014	0.015	<0.003	0.02	<0.035	< 0.035
ML25-3	<0.012	<0.007	0.04	0.011	0.019	0.02	0.01	<0.035	< 0.035
ML25-2	1.02	1.19	3.67	2.99	0.56	0.70	3.01	3.25	4.19
ML25-1	2.52	1.89	2.74	1.57	1.19	1.85	1.98	2.33	2.57

Notes: NA, not analyzed. Dry, no water.

**Table C26.** Manganese Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	2.96	3.06	4.54	4.05	3.54	3.44	3.82	4.13	2.99
ML21-6	2.52	1.97	3.08	2.75	2.20	2.08	2.67	2.27	1.20
ML21-5	0.201	0.336	0.187	0.165	0.191	0.266	0.181	0.111	0.105
ML21-4	0.099	0.203	0.353	0.215	0.209	0.202	0.330	0.184	0.228
ML21-3	0.240	0.240	0.238	0.209	0.216	0.210	0.220	0.208	0.225
ML21-2	NA	0.102	0.129	0.134	0.136	0.135	0.152	NA	0.159
ML21-1	NA	0.090	0.096	0.104	0.116	0.097	0.106	0.112	0.110
ML22-7	Dry	0.132	Dry	NA	NA	NA	NA	NA	NA
ML22-6	Dry	0.044	Dry	NA	NA	NA	NA	NA	NA
ML22-5	Dry	0.344	Dry	NA	NA	NA	NA	NA	NA
ML22-4	0.015	0.003	0.023	NA	NA	NA	NA	NA	NA
ML22-3	0.019	0.002	0.110	NA	NA	NA	NA	NA	NA
ML22-2	0.010	<0.0004	0.215	NA	NA	NA	NA	NA	NA
ML22-1	0.051	0.053	0.067	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	0.046	0.099	0.166	0.150	0.147	0.283	0.224
ML22.5-8	NA	NA	0.379	0.314	0.136	0.321	0.198	0.310	0.175
ML22.5-7	NA	NA	0.390	0.418	0.245	0.425	0.234	0.391	0.210
ML22.5-6	NA	NA	0.527	0.507	0.293	0.489	0.261	0.522	0.240
ML22.5-5	NA	NA	0.905	0.682	0.543	0.487	0.259	0.584	0.295
ML22.5-4	NA	NA	1.380	1.090	0.773	0.788	0.514	0.942	0.860
ML22.5-3	NA	NA	1.900	1.400	1.180	1.090	0.814	0.916	0.969
ML22.5-2	NA	NA	0.711	0.471	0.549	0.502	0.395	0.305	0.238
ML22.5-1	NA	NA	0.236	0.180	0.244	0.232	0.193	0.197	0.199
ML23-7	Dry	0.095	Dry	NA	NA	NA	NA	NA	NA
ML23-6	0.037	0.062	Dry	NA	NA	NA	NA	NA	NA
ML23-5	<0.003	0.016	Dry	NA	NA	NA	NA	NA	NA
ML23-4	Dry	0.421	Dry	NA	NA	NA	NA	NA	NA
ML23-3	0.009	0.011	0.047	NA	NA	NA	NA	NA	NA
ML23-2	0.010	0.002	0.024	NA	NA	NA	NA	NA	NA
ML23-1	0.009	0.002	0.135	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	0.076	0.010	0.008	0.018	0.009	0.046	NA
ML23.5-8	NA	NA	0.211	0.165	0.050	0.040	0.050	0.212	0.023
ML23.5-7	NA	NA	0.274	0.209	0.087	0.064	0.101	0.182	0.261
ML23.5-6	NA	NA	0.175	0.157	0.056	0.036	0.061	0.197	0.176
ML23.5-5	NA	NA	0.855	0.580	0.285	0.243	0.213	0.923	1.002
ML23.5-4	NA	NA	0.817	0.542	0.320	0.261	0.081	0.572	0.743
ML23.5-3	NA	NA	0.162	0.109	0.051	0.057	0.081	0.671	0.871
ML23.5-2	NA	NA	0.407	0.147	0.108	0.187	0.111	0.691	0.424
ML23.5-1	NA	NA	0.078	0.010	0.011	0.013	0.008	0.041	0.032
ML24-7	0.010	0.016	0.015	0.005	0.012	0.036	0.249	0.108	0.196
ML24-6	0.009	0.016	0.030	0.029	0.044	0.064	0.081	0.132	0.302
ML24-5	0.015	0.033	0.040	0.010	0.012	0.036	<0.002	0.023	0.030
ML24-4	0.009	0.011	0.011	0.005	<0.003	0.012	<0.002	0.051	0.056
ML24-3	0.009	<0.001	0.030	0.013	<0.003	0.014	0.010	0.037	0.033
ML24-2	0.012	0.002	0.049	0.039	0.010	0.024	0.035	0.081	0.043
ML24-1	0.028	0.004	0.085	0.041	0.014	0.044	0.040	0.054	0.066
ML25-7	0.601	0.648	0.761	0.554	0.583	1.170	0.629	1.57	1.488
ML25-6	0.273	0.308	0.502	0.441	0.181	0.324	0.543	0.36	0.477
ML25-5	0.025	0.011	0.011	<0.003	0.068	0.023	<0.001	0.002	0.004
ML25-4	0.025	0.011	<0.010	0.010	0.012	0.012	0.004	0.005	0.004
ML25-3	0.004	<0.001	<0.010	<0.003	<0.003	0.004	<0.001	0.002	< 0.003
ML25-2	0.183	0.072	0.170	0.109	0.021	0.042	0.111	0.21	0.389
ML25-1	0.084	0.106	0.098	0.060	0.074	0.129	0.234	0.48	0.453

Notes: NA, not analyzed. Dry, no water.

**Table C27.** Strontium Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	0.277	0.337	0.397	0.374	0.308	0.301	0.353	0.473	0.393
ML21-6	0.390	0.299	0.272	0.462	0.367	0.358	0.429	0.443	0.257
ML21-5	0.212	0.145	0.186	0.168	0.169	0.255	0.164	0.117	0.108
ML21-4	0.086	0.159	0.233	0.147	0.135	0.131	0.209	0.119	0.120
ML21-3	0.157	0.105	0.162	0.140	0.135	0.132	0.139	0.136	0.128
ML21-2	NA	0.132	0.139	0.146	0.143	0.140	0.154	NA	0.163
ML21-1	NA	0.128	0.158	0.170	0.157	0.165	0.179	0.194	0.180
ML22-7	Dry	0.025	Dry	NA	NA	NA	NA	NA	NA
ML22-6	Dry	0.057	Dry	NA	NA	NA	NA	NA	NA
ML22-5	Dry	0.081	Dry	NA	NA	NA	NA	NA	NA
ML22-4	0.061	0.029	0.135	NA	NA	NA	NA	NA	NA
ML22-3	0.035	0.026	0.106	NA	NA	NA	NA	NA	NA
ML22-2	0.046	0.132	0.139	NA	NA	NA	NA	NA	NA
ML22-1	0.136	0.250	0.156	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	0.140	0.075	0.076	0.087	0.114	0.177	0.172
ML22.5-8	NA	NA	0.505	0.364	0.118	0.244	0.156	0.395	0.364
ML22.5-7	NA	NA	0.499	0.358	0.117	0.248	0.131	0.393	0.352
ML22.5-6	NA	NA	0.478	0.347	0.140	0.248	0.144	0.402	0.348
ML22.5-5	NA	NA	0.465	0.335	0.179	0.234	0.128	0.357	0.320
ML22.5-4	NA	NA	0.431	0.274	0.194	0.206	0.158	0.251	0.279
ML22.5-3	NA	NA	0.266	0.233	0.185	0.168	0.149	0.167	0.173
ML22.5-2	NA	NA	0.207	0.188	0.157	0.147	0.145	0.145	0.148
ML22.5-1	NA	NA	0.167	0.130	0.133	0.132	0.129	0.142	0.149
ML23-7	Dry	0.023	NA	NA	NA	NA	NA	NA	NA
ML23-6	0.022	0.042	NA	NA	NA	NA	NA	NA	NA
ML23-5	0.028	0.058	NA	NA	NA	NA	NA	NA	NA
ML23-4	Dry	0.018	NA	NA	NA	NA	NA	NA	NA
ML23-3	0.034	0.029	0.068	NA	NA	NA	NA	NA	NA
ML23-2	0.053	0.037	0.049	NA	NA	NA	NA	NA	NA
ML23-1	0.029	0.042	0.088	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	0.091	0.040	0.029	0.024	0.067	0.104	NA
ML23.5-8	NA	NA	0.081	0.066	0.030	0.029	0.032	0.120	0.063
ML23.5-7	NA	NA	0.074	0.058	0.029	0.026	0.032	0.110	0.155
ML23.5-6	NA	NA	0.071	0.062	0.031	0.022	0.027	0.111	0.172
ML23.5-5	NA	NA	0.128	0.086	0.052	0.046	0.045	0.157	0.235
ML23.5-4	NA	NA	0.154	0.107	0.076	0.071	0.058	0.142	0.213
ML23.5-3	NA	NA	0.173	0.101	0.070	0.071	0.076	0.130	0.150
ML23.5-2	NA	NA	0.120	0.081	0.042	0.059	0.048	0.107	0.082
ML23.5-1	NA	NA	0.123	0.044	0.033	0.046	0.047	0.063	0.060
ML24-7	0.028	0.055	0.023	0.014	0.024	0.041	0.021	0.033	0.052
ML24-6	0.040	0.072	0.038	0.022	0.033	0.053	0.027	0.048	0.053
ML24-5	0.053	0.069	0.035	0.033	0.030	0.049	0.024	0.065	0.085
ML24-4	0.059	0.016	0.102	0.059	0.050	0.058	0.037	0.111	0.155
ML24-3	0.029	0.034	0.051	0.030	0.020	0.025	0.021	0.049	0.060
ML24-2	0.047	0.029	0.073	0.054	0.024	0.039	0.041	0.070	0.053
ML24-1	0.049	0.075	0.061	0.037	0.023	0.024	0.025	0.028	0.039
ML25-7	0.075	0.033	0.083	0.073	0.072	0.143	0.082	0.236	0.239
ML25-6	0.037	0.014	0.055	0.040	0.022	0.027	0.046	0.035	0.049
ML25-5	0.028	0.038	0.050	0.039	0.037	0.013	0.043	0.029	0.050
ML25-4	0.093	0.038	0.081	0.053	0.057	0.020	0.040	0.035	0.032
ML25-3	0.052	0.023	0.129	0.053	0.027	0.017	0.050	0.088	0.075
ML25-2	0.045	0.024	0.039	0.035	0.015	0.026	0.036	0.037	0.061
ML25-1	0.032	0.278	0.031	0.019	0.018	0.029	0.038	0.055	0.059

Notes: NA, not analyzed. Dry, no water.

**Table C28.** Total Chromium Values (mg/L) through Time in Elizabeth City Transect 2 Multi-level Wells

Well ID	Jun-97	Sep-97	Mar-98	Jun-98	Sep-98	Dec-98	Jun-99	Jun-00	May-01
ML21-7	<0.004	<0.004	<0.003	<0.002	<0.002	<0.002	<0.002	0.512	1.404
ML21-6	0.246	0.059	0.716	0.845	0.116	0.002	0.426	1.794	1.959
ML21-5	3.430	3.080	2.380	1.540	2.440	3.240	2.080	1.720	0.739
ML21-4	1.110	1.550	0.423	0.382	0.566	1.370	0.291	0.265	0.106
ML21-3	0.503	0.583	0.234	0.220	0.227	0.276	0.095	0.024	0.019
ML21-2	NA	0.523	0.551	0.465	0.446	0.365	0.275	NA	0.138
ML21-1	NA	<0.004	<0.002	<0.002	0.229	0.002	<0.002	<0.002	0.004
ML22-7	Dry	<0.004	Dry	NA	NA	NA	NA	NA	NA
ML22-6	Dry	<0.004	Dry	NA	NA	NA	NA	NA	NA
ML22-5	Dry	0.004	Dry	NA	NA	NA	NA	NA	NA
ML22-4	<0.004	<0.004	<0.003	NA	NA	NA	NA	NA	NA
ML22-3	<0.004	<0.004	<0.003	NA	NA	NA	NA	NA	NA
ML22-2	<0.004	<0.004	0.392	NA	NA	NA	NA	NA	NA
ML22-1	<0.004	<0.004	0.009	NA	NA	NA	NA	NA	NA
ML22.5-0	NA	NA	<0.003	<0.002	0.003	<0.002	<0.002	<0.002	0.011
ML22.5-8	NA	NA	<0.003	<0.002	<0.002	<0.002	<0.002	0.019	<0.003
ML22.5-7	NA	NA	<0.003	<0.002	<0.002	<0.002	<0.002	0.022	<0.003
ML22.5-6	NA	NA	<0.003	<0.002	0.002	0.002	<0.002	0.025	<0.003
ML22.5-5	NA	NA	<0.003	<0.002	<0.002	<0.002	<0.002	0.024	<0.003
ML22.5-4	NA	NA	<0.003	<0.002	<0.002	<0.002	<0.002	0.023	<0.003
ML22.5-3	NA	NA	<0.003	<0.002	<0.002	<0.002	<0.002	0.019	<0.003
ML22.5-2	NA	NA	0.613	0.314	0.225	0.160	0.123	0.056	0.049
ML22.5-1	NA	NA	0.389	0.213	0.191	0.212	0.089	0.083	0.068
ML23-7	<0.004	<0.004	Dry	NA	NA	NA	NA	NA	NA
ML23-6	<0.004	<0.004	Dry	NA	NA	NA	NA	NA	NA
ML23-5	<0.004	<0.004	Dry	NA	NA	NA	NA	NA	NA
ML23-4	Dry	0.004	Dry	NA	NA	NA	NA	NA	NA
ML23-3	<0.004	<0.004	<0.003	NA	NA	NA	NA	NA	NA
ML23-2	<0.004	<0.004	<0.003	NA	NA	NA	NA	NA	NA
ML23-1	<0.004	<0.004	<0.003	NA	NA	NA	NA	NA	NA
ML23.5-0	NA	NA	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	NA
ML23.5-8	NA	NA	<0.003	<0.002	<0.003	<0.002	<0.002	<0.002	<0.003
ML23.5-7	NA	NA	<0.003	<0.002	<0.003	<0.002	<0.002	<0.002	<0.003
ML23.5-6	NA	NA	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003
ML23.5-5	NA	NA	<0.003	<0.002	<0.002	<0.002	<0.002	0.003	<0.003
ML23.5-4	NA	NA	<0.003	<0.002	<0.002	<0.002	<0.002	0.006	<0.003
ML23.5-3	NA	NA	<0.003	<0.002	0.002	<0.002	<0.002	<0.002	<0.003
ML23.5-2	NA	NA	<0.003	<0.002	<0.002	0.004	<0.002	0.003	<0.003
ML23.5-1	NA	NA	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003
ML24-7	<0.004	<0.004	<0.003	0.002	<0.003	<0.002	<0.002	<0.002	<0.003
ML24-6	<0.004	<0.004	<0.003	<0.002	<0.003	<0.002	<0.002	<0.002	<0.003
ML24-5	<0.004	<0.004	<0.003	<0.002	<0.003	<0.002	<0.002	<0.002	<0.003
ML24-4	<0.004	<0.004	<0.003	<0.002	<0.003	<0.002	<0.002	<0.002	<0.003
ML24-3	<0.004	<0.004	<0.003	<0.002	<0.003	<0.002	<0.002	<0.002	<0.003
ML24-2	<0.004	<0.004	<0.003	<0.002	<0.003	0.000	<0.002	<0.002	<0.003
ML24-1	<0.004	<0.004	<0.003	<0.002	<0.003	<0.002	<0.002	<0.002	<0.003
ML25-7	<0.004	<0.004	<0.003	<0.002	<0.003	<0.002	<0.002	<0.002	<0.003
ML25-6	<0.004	<0.004	<0.003	<0.002	<0.003	<0.002	<0.002	<0.002	<0.003
ML25-5	<0.004	<0.004	<0.003	<0.002	<0.003	<0.002	<0.002	<0.002	<0.003
ML25-4	<0.004	<0.004	<0.003	<0.002	<0.003	0.003	<0.002	<0.002	<0.003
ML25-3	<0.004	<0.004	<0.003	<0.002	<0.003	<0.002	<0.002	<0.002	<0.003
ML25-2	<0.004	<0.004	<0.003	<0.002	<0.003	<0.002	<0.002	<0.002	<0.003
ML25-1	<0.004	<0.004	<0.003	<0.002	<0.003	<0.002	<0.002	<0.002	<0.003

Notes: NA, not analyzed. Dry, no water.



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**Appendix D**  
**Quality Control Data for Field Duplicates from**  
**Monitoring Wells at the Elizabeth City Site**

**Table D1.** RPD in Sulfate Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Monitoring Wells

<b>Sample</b>	MW46	MW49	MW47	MW50	MW18	MW46	MW38
<b>Date</b>	Mar-98	Jun-98	Sep-98	Sep-98	Dec-98	Dec-98	Mar-99
<b>Concentration</b>	6.37	<0.1	<0.1	3.69	98.9	11.4	25.6
<b>Concentration F. Dup</b>	6.85	<0.1	<0.1	3.99	111	11.4	25.1
<b>% Difference</b>	7.26	NA	NA	7.81	11.5	0.00	1.97
<b>Sample</b>	MW50	MW18	MW52	MW48	MW38	MW48	MW18
<b>Date</b>	Mar-99	Jun-99	Sep-99	Feb-00	Jun-00	Jun-00	Dec-00
<b>Concentration</b>	3.16	112	2.98	54.7	20.8	<1.00	120
<b>Concentration F. Dup</b>	2.98	103	3.57	55.9	19.9	<1.00	117
<b>% Difference</b>	5.86	8.37	18.0	2.17	4.42	NA	2.53
<b>Sample</b>	MW46	MW38	MW48	MW52	MW46		
<b>Date</b>	Dec-00	Mar-01	Mar-01	May-01	Aug-01		
<b>Concentration</b>	25.1	19.1	29.9	8.07	18.5		
<b>Concentration F. Dup</b>	25.3	18.5	30.0	4.59	18.5		
<b>% Difference</b>	0.79	3.19	0.33	55.0	0.00		

Notes: NA, not applicable due to one or both duplicates being below limit of detection.

**Table D2.** RPD in Chloride Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Monitoring Wells

<b>Sample</b>	MW46	MW49	MW13	MW47	MW50	MW18	MW46
<b>Date</b>	Mar-98	Jun-98	Sep-98	Sep-98	Sep-98	Dec-98	Dec-98
<b>Concentration</b>	14.9	58.5	123	32.5	38	98.2	13.2
<b>Concentration F. Dup</b>	15.1	57.9	122	32.4	38.3	110	13.3
<b>% Difference</b>	1.33	1.03	0.816	0.308	0.786	11.3	0.755
<b>Sample</b>	MW38	MW50	MW52	MW49	MW48	MW38	MW18
<b>Date</b>	Mar-99	Mar-99	Jun-99	Sep-99	Jun-00	Sep-00	Dec-00
<b>Concentration</b>	9.29	36.5	38.8	49.3	23.6	15.7	102
<b>Concentration F. Dup</b>	9.30	36.0	40.4	49.3	23.0	14.4	100
<b>% Difference</b>	0.108	1.38	4.04	0.00	2.58	8.64	1.98
<b>Sample</b>	MW46	MW18	MW38	MW52	MW46		
<b>Date</b>	Dec-00	Mar-01	Mar-01	May-01	Aug-01		
<b>Concentration</b>	56.9	91.7	9.04	28.9	14.5		
<b>Concentration F. Dup</b>	58.8	91.3	9.28	29.3	14.6		
<b>% Difference</b>	3.28	0.437	2.62	1.55	0.687		

**Table D3.** RPD in Nitrate + Nitrite Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Monitoring Wells

<b>Sample</b>	MW46	MW49	MW13	MW50	MW18	MW46	MW38
<b>Date</b>	Mar-98	Jun-98	Sep-98	Sep-98	Dec-98	Dec-98	Mar-99
<b>Concentration</b>	<0.10	<0.10	2.12	<0.10	<0.10	<0.10	0.49
<b>Concentration F. Dup</b>	<0.10	<0.10	2.11	<0.10	<0.10	<0.10	0.50
<b>% Difference</b>	NA	NA	0.473	NA	NA	NA	2.02
<b>Sample</b>	MW50	MW18	MW50	MW48	MW48	MW38	MW18
<b>Date</b>	Mar-99	Jun-99	Sep-99	Feb-00	Jun-00	Sep-00	Dec-00
<b>Concentration</b>	<0.10	0.14	0.10	1.36	0.39	0.47	<0.10
<b>Concentration F. Dup</b>	<0.10	0.15	0.10	1.31	0.35	0.44	<0.10
<b>% Difference</b>	NA	6.90	0.00	3.75	10.8	6.59	NA
<b>Sample</b>	MW46	MW38	MW48	MW52	MW46		
<b>Date</b>	Dec-00	Mar-01	Mar-01	May-01	Aug-01		
<b>Concentration</b>	1.46	0.39	0.75	<0.10	<0.10		
<b>Concentration F. Dup</b>	1.46	0.46	0.74	<0.10	<0.10		
<b>% Difference</b>	0.00	16.47	1.34	NA	NA		

Notes: NA, not applicable due to one or both duplicates being below limit of detection.

**Table D4.** RPD in Total Organic Carbon Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Monitoring Wells

<b>Sample</b>	MW50	MW35D	MW49	MW13	MW48	MW18	MW46
<b>Date</b>	Jun-97	Mar-98	Jun-98	Mar-99	Jun-00	Dec-00	Dec-00
<b>Concentration</b>	1.14	1.32	1.43	4.96	1.12	14.8	0.68
<b>Concentration F. Dup</b>	0.97	1.39	1.39	5.33	0.89	4.37	0.92
<b>% Difference</b>	16.32	5.17	2.84	7.19	22.9	109	30.0
<b>Sample</b>	MW38	MW48					
<b>Date</b>	Mar-01	Mar-01					
<b>Concentration</b>	1.12	1.65					
<b>Concentration F. Dup</b>	1.23	1.59					
<b>% Difference</b>	8.96	3.58					

**Table D5.** RPD in Vinyl Chloride Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Monitoring Wells

<b>Vinyl Chloride</b>							
<b>Sample</b>	MW46	MW46	MW35D	MW49	MW52	MW38	MW18
<b>Date</b>	Mar-98	Mar-99	Sep-99	Jun-00	Jun-00	Sept-00	Dec-00
<b>Concentration</b>	2.50	4.40	ND	ND	ND	<0.5	9.42
<b>Concentration F. Dup</b>	2.50	4.00	ND	ND	ND	<0.5	9.32
<b>% Difference</b>	0.00	9.52	NA	NA	NA	NA	1.07

<b>Vinyl Chloride</b>	
<b>Sample</b>	MW52
<b>Date</b>	Aug-01
<b>Concentration</b>	10.8
<b>Concentration F. Dup</b>	11.5
<b>% Difference</b>	6.28

<b>cis-DCE</b>							
<b>Sample</b>	MW46	MW46	MW35D	MW49	MW52	MW48	MW38
<b>Date</b>	Mar-98	Mar-99	Sep-99	Feb-00	Feb-00	Jun-00	Sept-00
<b>Concentration</b>	6.80	30.6	<0.08	0.91	74.9	<1.0	<0.5
<b>Concentration F. Dup</b>	7.70	31.2	<0.08	0.88	71.6	<1.0	<0.5
<b>% Difference</b>	12.4	2.09	NA	3.35	4.51	NA	NA

<b>cis-DCE</b>			
<b>Sample</b>	MW18	MW38	MW46
<b>Date</b>	Dec-00	May-01	Aug-01
<b>Concentration</b>	3.27	ND	11.2
<b>Concentration F. Dup</b>	3.27	ND	11.8
<b>% Difference</b>	0.00	NA	5.22

<b>TCE</b>							
<b>Sample</b>	MW46	MW18	MW46	MW49	MW48	MW38	MW18
<b>Date</b>	Mar-98	Dec-98	Mar-99	Feb-00	Jun-00	Sept-00	Dec-00
<b>Concentration</b>	212	ND	146	1.07	1625	ND	ND
<b>Concentration F. Dup</b>	240	ND	152	0.64	1625	ND	ND
<b>% Difference</b>	12.13	NA	3.58	50.3	0.00	NA	NA

<b>TCE</b>			
<b>Sample</b>	MW38	MW52	MW46
<b>Date</b>	Mar-01	May-01	Aug-01
<b>Concentration</b>	ND	597	128
<b>Concentration F. Dup</b>	ND	603	124
<b>% Difference</b>	NA	1.00	3.17

Notes: ND, not detected. BLQ, below limit of quantitation. NA, not applicable due to one or both duplicates being below limit of detection or not detected.

**Table D6.** RPD in Sodium Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Monitoring Wells

<b>Sample</b>	MW50	MW46	MW46	MW50	MW38	MW18	MW35D
<b>Date</b>	Sep-97	Mar-98	Jun-98	Jun-98	Sep-98	Dec-98	Dec-98
<b>Concentration</b>	28.5	20.0	22.9	25.9	49.2	135	17.6
<b>Concentration F. Dup</b>	28.5	19.3	23.8	24.0	18.2	135	17.8
<b>% Difference</b>	0.00	3.56	3.85	7.62	92.0	0.00	1.13
<b>Sample</b>	MW52	MW48	MW18	MW46	MW38	MW48	MW52
<b>Date</b>	Sep-99	Jun-00	Dec-00	Dec-00	Mar-01	Mar-01	May-01
<b>Concentration</b>	41.2	30.6	122	43.6	16.5	26.6	31.1
<b>Concentration F. Dup</b>	41.3	30.6	122	44.0	16.5	26.8	30.8
<b>% Difference</b>	0.291	0.261	0.705	0.891	0.0608	0.785	0.969
<b>Sample</b>	MW46						
<b>Date</b>	Aug-01						
<b>Concentration</b>	19.4						
<b>Concentration F. Dup</b>	19.5						
<b>% Difference</b>	0.565						

**Table D7.** RPD in Potassium Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Monitoring Wells

<b>Sample</b>	MW48	MW46	MW46	MW50	MW38	MW18	MW35D
<b>Date</b>	Sep-97	Mar-98	Jun-98	Jun-98	Sep-98	Dec-98	Dec-98
<b>Concentration</b>	2.03	<0.79	1.52	1.85	3.12	1.79	1.54
<b>Concentration F. Dup</b>	1.52	<0.79	1.62	2.39	1.8	1.20	1.24
<b>% Difference</b>	28.7	NA	6.37	25.5	53.7	39.5	21.6
<b>Sample</b>	MW52	MW48	MW18	MW46	MW38	MW48	MW52
<b>Date</b>	Sep-99	Jun-00	Dec-00	Dec-00	Mar-01	Mar-01	May-01
<b>Concentration</b>	1.33	1.47	3.23	3.39	1.97	1.42	1.04
<b>Concentration F. Dup</b>	1.22	1.47	3.24	3.68	1.95	1.44	1.05
<b>% Difference</b>	8.63	0.00	0.31	8.20	1.02	1.40	0.96
	8.63	0.00	0.309	8.20	1.02	1.40	0.957
<b>Sample</b>	MW46						
<b>Date</b>	Aug-01						
<b>Concentration</b>	3.11						
<b>Concentration F. Dup</b>	3.09						
<b>% Difference</b>	0.645						

Notes: NA, not applicable due to one or both duplicates being below limit of detection.

**Table D8.** RPD in Calcium Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Monitoring Wells

<b>Sample</b>	MW48	MW46	MW46	MW50	MW38	MW18	MW35D
<b>Date</b>	Sep-97	Mar-98	Jun-98	Jun-98	Sep-98	Dec-98	Dec-98
<b>Concentration</b>	12.1	5.74	6.17	5.04	15	11.4	15.6
<b>Concentration F. Dup</b>	12.1	5.58	5.9	4.9	9.97	11.4	15.7
<b>% Difference</b>	0.00	2.83	4.47	2.82	40.3	0.00	0.639
<b>Sample</b>	MW52	MW48	MW18	MW46	MW38	MW48	MW52
<b>Date</b>	Sep-99	Jun-00	Dec-00	Dec-00	Mar-01	Mar-01	May-01
<b>Concentration</b>	2.90	10.9	12.0	19.4	9.85	10.3	3.67
<b>Concentration F. Dup</b>	2.82	10.8	11.9	19.4	9.82	10.2	3.57
<b>% Difference</b>	3.08	1.01	1.42	0.207	0.305	0.488	2.76

**Table D9.** RPD in Magnesium Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Monitoring Wells

<b>Sample</b>	MW48	MW50	MW46	MW46	MW50	MW38	MW18
<b>Date</b>	Sep-97	Sep-97	Mar-98	Jun-98	Jun-98	Sep-98	Dec-98
<b>Concentration</b>	7.79	3.66	3.07	2.80	3.14	9.48	9.83
<b>Concentration F. Dup</b>	7.78	3.71	3.00	2.63	3.09	9.46	9.84
<b>% Difference</b>	0.128	1.36	2.31	6.26	1.61	0.211	0.102
<b>Sample</b>	MW35D	MW52	MW48	MW18	MW46	MW38	MW48
<b>Date</b>	Dec-98	Sep-99	Jun-00	Dec-00	Dec-00	Mar-01	Mar-01
<b>Concentration</b>	5.8	1.979	7.26	9.45	5.66	4.96	6.95
<b>Concentration F. Dup</b>	5.83	1.971	7.16	9.52	5.58	4.94	6.92
<b>% Difference</b>	0.516	0.405	1.35	0.685	1.42	0.444	0.389
<b>Sample</b>	MW52	MW46					
<b>Date</b>	May-01	Aug-01					
<b>Concentration</b>	2.46	4.86					
<b>Concentration F. Dup</b>	2.41	4.89					
<b>% Difference</b>	1.85	0.615					

**Table D10.** RPD in Total Iron Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Monitoring Wells

Sample	MW48	MW50	MW46	MW46	MW50	MW38	MW18
Date	Sep-97	Sep-97	Mar-98	Jun-98	Jun-98	Sep-98	Dec-98
Concentration	0.018	0.745	<0.019	0.02	1.60	<0.0083	2.27
Concentration F. Dup	0.031	0.775	<0.019	0.039	1.53	<0.0083	2.31
% Difference	53.7	3.95	NA	63.9	4.47	NA	1.75

Sample	MW35D	MW52	MW48	MW18	MW46	MW38	MW48
Date	Dec-98	Sep-99	Jun-00	Dec-00	Dec-00	Mar-01	Mar-01
Concentration	6.33	0.19	<0.035	2.33	<0.035	<0.035	<0.035
Concentration F. Dup	6.33	0.18	<0.035	2.37	<0.035	<0.035	<0.035
% Difference	0.00	5.41	NA	1.61	NA	NA	NA

Sample	MW52	MW46
Date	May-01	Aug-01
Concentration	0.636	0.230
Concentration F. Dup	0.631	0.342
% Difference	0.789	38.9

Notes: NA, not applicable due to one or both duplicates being below limit of detection.

**Table D11.** RPD in Manganese Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Monitoring Wells

Sample	MW48	MW50	MW46	MW46	MW50	MW38	MW18
Date	Sep-97	Sep-97	Mar-98	Jun-98	Jun-98	Sep-98	Dec-98
Concentration	0.480	0.267	0.133	0.125	0.229	0.450	0.723
Concentration F. Dup	0.480	0.271	0.129	0.107	0.216	0.108	0.709
% Difference	0.00	1.49	3.05	15.5	5.84	123	1.96

Sample	MW35D	MW52	MW48	MW18	MW38	MW48	MW52
Date	Dec-98	Sep-99	Jun-00	Dec-00	Mar-01	Mar-01	May-01
Concentration	0.588	0.064	0.210	0.625	0.063	0.162	0.107
Concentration F. Dup	0.613	0.064	0.211	0.628	0.063	0.163	0.108
% Difference	4.16	0.00	0.475	0.479	0.00	0.615	0.930

Sample	MW46
Date	Aug-01
Concentration	0.240
Concentration F. Dup	0.261
% Difference	8.38

**Table D12.** RPD Difference in Strontium Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Monitoring Wells

Sample	MW48	MW50	MW46	MW46	MW50	MW38	MW18
Date	Sep-97	Sep-97	Mar-98	Jun-98	Jun-98	Sep-98	Dec-98
Concentration	0.184	0.074	0.0749	0.083	0.064	0.141	0.314
Concentration F. Dup	0.185	0.076	0.073	0.080	0.061	0.130	0.320
% Difference	0.542	2.55	2.57	3.81	4.31	8.12	1.89

Sample	MW35D	MW52	MW48	MW18	MW46	MW38	MW48
Date	Dec-98	Sep-99	Jun-00	Dec-00	Dec-00	Mar-01	Mar-01
Concentration	0.13	0.42	0.155	0.309	0.289	0.126	0.156
Concentration F. Dup	0.13	0.42	0.153	0.316	0.291	0.127	0.157
% Difference	0.00	0.00	1.30	2.43	0.622	0.791	0.639

Sample	MW46
Date	Aug-01
Concentration	0.174
Concentration F. Dup	0.176
% Difference	1.14

**Table D13.** RPD in Total Chromium Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Monitoring Wells

Sample	MW48	MW50	MW46	MW46	MW50	MW38	MW18
Date	Sep-97	Sep-97	Mar-98	Jun-98	Jun-98	Sep-98	Dec-98
Concentration	0.724	<0.0041	<0.0034	0.003	<0.0016	<0.0021	0.004
Concentration F. Dup	0.728	<0.0041	<0.0034	<0.0016	0.0002	<0.0021	0.002
% Difference	0.55	NA	0.00	NA	NA	NA	66.7

Sample	MW35D	MW52	MW48	MW18	MW38	MW48	MW52
Date	Dec-98	Sep-99	Jun-00	Dec-00	Mar-01	Mar-01	May-01
Concentration	0.004	<0.001	0.21	<0.002	<0.003	0.11	<0.001
Concentration F. Dup	0.002	<0.001	0.2	<0.002	<0.003	0.11	<0.001
% Difference	66.7	NA	0.00	NA	NA	0.00	NA

Sample	MW46
Date	Aug-01
Concentration	0.01
Concentration F. Dup	0.01
% Difference	0.00

Notes: NA, not applicable due to one or both duplicates being below limit of detection.

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**Appendix E**  
**Quality Control Data for Field Duplicates from**  
**Monitoring Wells at the Denver Federal Site**

**Table E1.** RPD in Sulfate, Chloride, and Nitrite + Nitrate Concentrations (mg/L) for Field Duplicates Collected through Time in Denver Federal Center, Lakewood, CO

<b>Sulfate</b>							
<b>Sample</b>	C1-USGS-6	GSA-26	C1-I2	C2-USGS-5	C3-I1	GSA-21	C3-I2
<b>Date</b>	May-99	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	242	292	4.30	409	<1.00	213	<1.00
<b>Concentration F. Dup</b>	245	287	3.98	403	<1.00	212	<1.00
<b>% Difference</b>	1.23	1.73	7.73	1.48	NA	0.47	NA

<b>Sample</b>	GSA-31
<b>Date</b>	Jul-01
<b>Concentration</b>	<1.00
<b>Concentration F. Dup</b>	<1.00
<b>% Difference</b>	0.00

<b>Chloride</b>							
<b>Sample</b>	C1-USGS-6	GSA-26	C1-I2	C2-USGS-5	C3-I1	GSA-21	C3-I2
<b>Date</b>	May-99	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	57.1	69.7	54.4	83.0	195	47.8	111
<b>Concentration F. Dup</b>	57.0	68.2	55.5	80.9	203	45.8	111
<b>% Difference</b>	0.18	2.18	2.00	2.56	4.02	4.27	0.00

<b>Sample</b>	GSA-31
<b>Date</b>	Jul-01
<b>Concentration</b>	81.0
<b>Concentration F. Dup</b>	81.1
<b>% Difference</b>	0.12

<b>Nitrate + Nitrite</b>							
<b>Sample</b>	C1-USGS-6	GSA-26	C1-I2	C2-USGS-5	C3-I1	GSA-21	C3-I2
<b>Date</b>	May-99	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	<0.10	3.21	<0.10	1.29	<0.10	3.71	<0.10
<b>Concentration F. Dup</b>	<0.10	3.22	<0.10	1.30	<0.10	3.70	<0.10
<b>% Difference</b>	0.00	0.31	0.00	0.77	0.00	0.27	0.00

<b>Sample</b>	GSA-31
<b>Date</b>	Jul-01
<b>Concentration</b>	<0.10
<b>Concentration F. Dup</b>	<0.10
<b>% Difference</b>	0.00

**Note:** NA, not applicable due to one or both duplicates being below limit of detection.

**Table E2.** RPD in Organic Concentrations ( $\mu\text{g/L}$ ) for Field Duplicates Collected through Time in Denver Federal Center, Lakewood, CO

<b>Vinyl Chloride</b>							
<b>Sample</b>	C1-USGS-6	GSA-26	C1-I2	C2-USGS-5	C3-I1	GSA-21	C3-I2
<b>Date</b>	May-99	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	ND	ND	ND	ND	ND	ND	ND
<b>Concentration F. Dup</b>	ND	ND	ND	ND	ND	ND	ND
<b>% Difference</b>	NA	NA	NA	NA	NA	NA	NA

<b>Sample</b>	GSA-31
<b>Date</b>	Jul-01
<b>Concentration</b>	ND
<b>Concentration F. Dup</b>	ND
<b>% Difference</b>	NA

<b>cis-Dichloroethene</b>							
<b>Sample</b>	C1-USGS-6	GSA-26	C1-I2	C2-USGS-5	C3-I1	GSA-21	C3-I2
<b>Date</b>	May-99	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	ND	<1.0	8.40	40.9	ND	22.8	6.55
<b>Concentration F. Dup</b>	ND	<1.0	7.20	39.6	ND	41.8	6.96
<b>% Difference</b>	NA	NA	15.4	3.23	NA	58.8	6.07

<b>Sample</b>	GSA-31
<b>Date</b>	Jul-01
<b>Concentration</b>	ND
<b>Concentration F. Dup</b>	ND
<b>% Difference</b>	NA

<b>Trichloroethene</b>							
<b>Sample</b>	C1-USGS-6	GSA-26	C1-I2	C2-USGS-5	C3-I1	GSA-21	C3-I2
<b>Date</b>	May-99	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	ND	<1.0	ND	ND	ND	16.5	2.58
<b>Concentration F. Dup</b>	ND	<1.0	<1.0	ND	ND	19.8	2.80
<b>% Difference</b>	NA	NA	NA	NA	NA	18.2	8.18

<b>Sample</b>	GSA-31
<b>Date</b>	Jul-01
<b>Concentration</b>	ND
<b>Concentration F. Dup</b>	ND
<b>% Difference</b>	NA

**Note:** NA, not applicable due to one or both duplicates being below limit of detection. ND, not detected.

*Continued*

**Table E2.** RPD in Organic Concentrations ( $\mu\text{g/L}$ ) for Field Duplicates Collected through Time in Denver Federal Center, Lakewood, CO, continued

<b>1,1,1-Trichloroethane</b>							
<b>Sample</b>	<b>C1-USGS-6</b>	<b>GSA-26</b>	<b>C1-I2</b>	<b>C2-USGS-5</b>	<b>C3-I1</b>	<b>GSA-21</b>	<b>C3-I2</b>
<b>Date</b>	May-99	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	<1.0	ND	BLQ	3.20	ND	ND	ND
<b>Concentration F. Dup</b>	<1.0	ND	BLQ	3.10	ND	ND	ND
<b>% Difference</b>	NA	NA	NA	3.17	NA	NA	NA
<b>Sample</b> GSA-31							
<b>Date</b>	Jul-01						
<b>Concentration</b>	ND						
<b>Concentration F. Dup</b>	ND						
<b>% Difference</b>	NA						
<b>Carbon Tetrachloride</b>							
<b>Sample</b>	<b>C1-USGS-6</b>	<b>GSA-26</b>	<b>C1-I2</b>	<b>C2-USGS-5</b>	<b>C3-I1</b>	<b>GSA-21</b>	<b>C3-I2</b>
<b>Date</b>	May-99	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	ND	ND	ND	ND	ND	ND	ND
<b>Concentration F. Dup</b>	ND	ND	ND	ND	ND	ND	ND
<b>% Difference</b>	NA	NA	NA	NA	NA	NA	NA
<b>Sample</b> GSA-31							
<b>Date</b>	Jul-01						
<b>Concentration</b>	ND						
<b>Concentration F. Dup</b>	ND						
<b>% Difference</b>	NA						
<b>1,1-Dichloroethane</b>							
<b>Sample</b>	<b>C1-USGS-6</b>	<b>GSA-26</b>	<b>C1-I2</b>	<b>C2-USGS-5</b>	<b>C3-I1</b>	<b>GSA-21</b>	<b>C3-I2</b>
<b>Date</b>	May-99	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	NA	NA	7.30	13.2	ND	3.97	6.72
<b>Concentration F. Dup</b>	NA	NA	6.20	13.6	ND	4.67	6.97
<b>% Difference</b>	NA	NA	16.3	2.99	NA	16.2	3.65
<b>Sample</b> GSA-31							
<b>Date</b>	Jul-01						
<b>Concentration</b>	ND						
<b>Concentration F. Dup</b>	ND						
<b>% Difference</b>	NA						

*Continued*

**Table E2.** RPD in Organic Concentrations ( $\mu\text{g/L}$ ) for Field Duplicates Collected through Time in Denver Federal Center, Lakewood, CO, continued

**trans-1,2-Dichloroethene**

Sample	C1-USGS-6	GSA-26	C1-I2	C2-USGS-5	C3-I1	GSA-21	C3-I2
<b>Date</b>	May-99	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	ND	ND	ND	ND	ND	ND	ND
<b>Concentration F. Dup</b>	ND	ND	ND	ND	ND	ND	ND
<b>% Difference</b>	NA	NA	NA	NA	NA	NA	NA

Sample	GSA-31
<b>Date</b>	Jul-01
<b>Concentration</b>	ND
<b>Concentration F. Dup</b>	ND
<b>% Difference</b>	NA

**Benzene**

Sample	C1-USGS-6	GSA-26	C1-I2	C2-USGS-5	C3-I1	GSA-21	C3-I2
<b>Date</b>	May-99	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	ND	ND	<1.0	1.10	<1.0	ND	ND
<b>Concentration F. Dup</b>	ND	ND	<1.0	1.40	<1.0	ND	ND
<b>% Difference</b>	NA	NA	NA	24.0	NA	NA	NA

Sample	GSA-31
<b>Date</b>	Jul-01
<b>Concentration</b>	ND
<b>Concentration F. Dup</b>	ND
<b>% Difference</b>	NA

**Toluene**

Sample	C1-USGS-6	GSA-26	C1-I2	C2-USGS-5	C3-I1	GSA-21	C3-I2
<b>Date</b>	May-99	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	ND	ND	<1.0	ND	<1.0	ND	ND
<b>Concentration F. Dup</b>	<1.0	ND	ND	<1.0	<1.0	ND	ND
<b>% Difference</b>	NA	NA	NA	NA	NA	NA	NA

Sample	GSA-31
<b>Date</b>	Jul-01
<b>Concentration</b>	ND
<b>Concentration F. Dup</b>	ND
<b>% Difference</b>	NA

**Table E3.** RPD in Cation Concentrations (mg/L) for Field Duplicates Collected through Time in Denver Federal Center, Lakewood, CO

<b>Barium</b>						
<b>Sample</b>	C1-USGS-6	C1-I2	C2-USGS-5	C3-I1	GSA-21	C2-USGS-13
<b>Date</b>	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	0.0038	0.033	ND	0.032	0.022	0.002
<b>Concentration F. Dup</b>	0.0036	0.033	ND	0.033	0.018	0.003
<b>% Difference</b>	5.41	0.00	NA	3.08	20.00	40.00

<b>Sample</b>	C3-I2	GSA-31
<b>Date</b>	Jul-01	Jul-01
<b>Concentration</b>	<0.002	0.185
<b>Concentration F. Dup</b>	<0.002	0.184
<b>% Difference</b>	NA	0.542

<b>Calcium</b>						
<b>Sample</b>	C1-USGS-6	C1-I2	C2-USGS-5	C3-I1	GSA-21	C2-USGS-13
<b>Date</b>	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	108	1.65	9.00	2.16	89.3	2.10
<b>Concentration F. Dup</b>	109	1.56	8.97	2.57	87.5	2.29
<b>% Difference</b>	0.922	5.61	0.334	17.3	1.96	8.66

<b>Sample</b>	C3-I2	GSA-31
<b>Date</b>	Jul-01	Jul-01
<b>Concentration</b>	2.75	111
<b>Concentration F. Dup</b>	2.53	111
<b>% Difference</b>	8.33	0.450

<b>Chromium</b>						
<b>Sample</b>	C1-USGS-6	C1-I2	C2-USGS-5	C3-I1	GSA-21	C2-USGS-13
<b>Date</b>	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	<0.0024	<0.002	<0.002	<0.002	0.025	<0.003
<b>Concentration F. Dup</b>	<0.0024	<0.002	<0.002	<0.002	<0.003	<0.003
<b>% Difference</b>	NA	NA	NA	NA	NA	NA

<b>Sample</b>	C3-I2	GSA-31
<b>Date</b>	Jul-01	Jul-01
<b>Concentration</b>	<0.003	<0.003
<b>Concentration F. Dup</b>	<0.003	<0.003
<b>% Difference</b>	NA	NA

**Note:** NA, not applicable due to one or both duplicates being below limit of detection.

*Continued*

**Table E3.** RPD in Cation Concentrations (mg/L) for Field Duplicates Collected through Time in Denver Federal Center, Lakewood, CO, continued

<b>Iron</b>						
<b>Sample</b>	C1-USGS-6	C1-I2	C2-USGS-5	C3-I1	GSA-21	C2-USGS-13
<b>Date</b>	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	1.71	0.313	<0.035	<0.035	0.437	<0.035
<b>Concentration F. Dup</b>	1.59	0.062	<0.035	<0.035	<0.035	<0.035
<b>% Difference</b>	7.27	134	NA	NA	NA	NA

<b>Sample</b>	C3-I2	GSA-31
<b>Date</b>	Jul-01	Jul-01
<b>Concentration</b>	0.177	19.1
<b>Concentration F. Dup</b>	0.171	19.2
<b>% Difference</b>	3.45	0.52

<b>Potassium</b>						
<b>Sample</b>	C1-USGS-6	C1-I2	C2-USGS-5	C3-I1	GSA-21	C2-USGS-13
<b>Date</b>	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	<0.21	0.567	0.861	1.89	0.653	0.822
<b>Concentration F. Dup</b>	<0.21	0.628	0.855	2.02	0.444	0.783
<b>% Difference</b>	0.00	10.21	0.70	6.76	38.1	4.86

<b>Sample</b>	C3-I2	GSA-31
<b>Date</b>	Jul-01	Jul-01
<b>Concentration</b>	2.42	0.98
<b>Concentration F. Dup</b>	2.40	1.00
<b>% Difference</b>	0.70	1.82

<b>Magnesium</b>						
<b>Sample</b>	C1-USGS-6	C1-I2	C2-USGS-5	C3-I1	GSA-21	C2-USGS-13
<b>Date</b>	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	7.57	2.37	93.2	0.575	17.0	14.4
<b>Concentration F. Dup</b>	7.65	2.30	92.8	0.666	16.1	14.1
<b>% Difference</b>	1.05	3.00	0.43	14.7	5.44	2.11

<b>Sample</b>	C3-I2	GSA-31
<b>Date</b>	Jul-01	Jul-01
<b>Concentration</b>	22.9	31.7
<b>Concentration F. Dup</b>	21.5	31.6
<b>% Difference</b>	6.31	0.32

*Continued*

**Table E3.** RPD in Cation Concentrations (mg/L) for Field Duplicates Collected through Time in Denver Federal Center, Lakewood, CO, continued

<b>Manganese</b>						
<b>Sample</b>	<b>C1-USGS-6</b>	<b>C1-I2</b>	<b>C2-USGS-5</b>	<b>C3-I1</b>	<b>GSA-21</b>	<b>C2-USGS-13</b>
<b>Date</b>	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	0.186	0.007	0.058	0.013	0.109	0.006
<b>Concentration F. Dup</b>	0.194	0.004	0.058	0.015	0.006	0.005
<b>% Difference</b>	4.21	54.5	0.00	14.3	179	18.2

<b>Sample</b>	<b>C3-I2</b>	<b>GSA-31</b>
<b>Date</b>	Jul-01	Jul-01
<b>Concentration</b>	0.036	4.23
<b>Concentration F. Dup</b>	0.034	4.21
<b>% Difference</b>	5.71	0.47

<b>Sodium</b>						
<b>Sample</b>	<b>C1-USGS-6</b>	<b>C1-I2</b>	<b>C2-USGS-5</b>	<b>C3-I1</b>	<b>GSA-21</b>	<b>C2-USGS-13</b>
<b>Date</b>	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	156	167	232	202	167	228
<b>Concentration F. Dup</b>	158	168	231	204	166	223
<b>% Difference</b>	1.27	0.477	0.475	0.938	0.480	2.35

<b>Sample</b>	<b>C3-I2</b>	<b>GSA-31</b>
<b>Date</b>	Jul-01	Jul-01
<b>Concentration</b>	201	118
<b>Concentration F. Dup</b>	200	119
<b>% Difference</b>	0.799	0.084

<b>Strontium</b>						
<b>Sample</b>	<b>C1-USGS-6</b>	<b>C1-I2</b>	<b>C2-USGS-5</b>	<b>C3-I1</b>	<b>GSA-21</b>	<b>C2-USGS-13</b>
<b>Date</b>	May-99	Jul-00	Jul-00	Jul-00	Jul-01	Jul-01
<b>Concentration</b>	0.337	0.00	0.041	0.025	0.461	0.009
<b>Concentration F. Dup</b>	0.339	0.00	0.040	0.026	0.473	0.009
<b>% Difference</b>	0.592	0.00	2.47	3.92	2.57	0.00

<b>Sample</b>	<b>C3-I2</b>	<b>GSA-31</b>
<b>Date</b>	Jul-01	Jul-01
<b>Concentration</b>	0.040	1.10
<b>Concentration F. Dup</b>	0.038	1.11
<b>% Difference</b>	5.13	0.905

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**Appendix F**  
**Quality Control Data for Field Duplicates from**  
**Multi-level Samples at the Elizabeth City Site**

**Table F1.** RPD in Sulfate Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Transect 2 Multi-level Wells

Sample	ML21-7	ML21-3	ML22-2	ML23-3	ML24-6	ML25-4	ML22-2
Date	Mar-97	Jun-97	Jun-97	Jun-97	Jun-97	Jun-97	Sep-97
Concentration	15.3	39.30	0.10	0.10	0.10	0.10	1.25
Concentration F. Dup	15.6	39.70	0.10	0.10	0.10	0.10	1.25
% Difference	1.94	1.01	0.00	0.00	0.00	0.00	0.00

Sample	ML23-3	ML24-6	ML21-7	ML22.5-4	ML23-5	ML23.5-4	ML24-5
Date	Sep-97	Sep-97	Mar-98	Mar-98	Mar-98	Mar-98	Mar-98
Concentration	1.05	1.00	15.3	0.89	8.26	0.10	0.10
Concentration F. Dup	1.06	1.00	15.6	0.92	8.27	0.10	0.10
% Difference	0.95	0.00	1.94	3.31	0.12	0.00	0.00

Sample	ML25-2	ML22.5-1	ML23.5-1	ML25-2	ML21-3	ML24-3	ML25-2
Date	Mar-98	Sep-98	Sep-98	Sep-98	Dec-98	Dec-98	Dec-98
Concentration	1.31	33.4	1.80	0.54	43.5	0.10	0.54
Concentration F. Dup	1.31	33.0	1.77	0.59	43.4	0.10	0.59
% Difference	0.00	1.20	1.68	8.85	0.23	0.00	8.85

Sample	ML21-2	ML22.5-5	ML23.5-4	ML24-6	ML25-6	ML22.5-1	ML23.5-4
Date	Jun-99	Jun-99	Jun-99	Jun-99	Jun-99	Jun-00	Jun-00
Concentration	28.0	9.41	0.50	0.50	0.50	24.30	4.30
Concentration F. Dup	27.9	9.34	0.50	0.50	0.50	24.60	5.16
% Difference	0.36	0.75	0.00	0.00	0.00	1.23	18.2

Sample	ML24-5	ML25-4	ML22.5-6	ML23.5-2	ML24-7
Date	Jun-00	Jun-00	May-01	May-01	May-01
Concentration	1.00	1.00	4.67	2.12	1.00
Concentration F. Dup	1.00	1.00	4.76	2.15	1.00
% Difference	0.00	0.00	1.91	1.41	0.00

**Table F2.** RPD in Chloride Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Transect 2 Multi-level Wells

Sample	ML21-3	ML22-2	ML23-3	ML24-4	ML25-4	ML22-2	ML23-3
Date	Jun-97	Jun-97	Jun-97	Jun-97	Jun-97	Sep-97	Sep-97
Concentration	42.4	39.1	76.5	12.4	83.7	52.6	53.0
Concentration F. Dup	42.2	39.2	77.2	12.5	83.4	52.6	53.1
% Difference	0.47	0.26	0.91	0.80	0.36	0.00	0.19

Sample	ML24-6	ML21-7	ML22.5-4	ML23-6	ML23-5	ML23.5-4	ML25-2
Date	Sep-97	Mar-98	Mar-98	Mar-98	Mar-98	Mar-98	Mar-98
Concentration	15.5	60.3	17.0	16.9	15.9	36.1	53.5
Concentration F. Dup	15.5	60.9	17.2	16.9	15.9	36.0	53.4
% Difference	0.00	0.99	1.17	0.00	0.00	0.28	0.19

Sample	ML22.5-1	ML23.5-1	ML25-2	ML21-3	ML24-3	ML25-2	ML21-2
Date	Sep-98	Sep-98	Sep-98	Dec-98	Dec-98	Dec-98	Jun-99
Concentration	26.2	30.3	35.3	20.4	47.3	44.1	15.5
Concentration F. Dup	26.3	30.3	35.1	20.4	47.7	43.9	15.3
% Difference	0.38	0.00	0.57	0.00	0.84	0.45	1.30

Sample	ML22.5-5	ML23.5-4	ML24-6	ML25-6	ML22.5-1	ML23.5-4	ML24-2
Date	Jun-99	Jun-99	Jun-99	Jun-99	Jun-00	Jun-00	Jun-00
Concentration	12.2	20.3	10.3	35.5	13.0	31.3	29.9
Concentration F. Dup	12.3	20.0	10.2	36.2	13.3	31.4	29.2
% Difference	0.82	1.49	0.98	1.95	2.28	0.32	2.37

Sample	ML22.5-6	ML23.5-2	ML24-7	ML25-6	ML25-4	ML22.5-6	ML23.5-2
Date	Jun-00	Jun-00	Jun-00	Jun-00	Jun-00	May-01	May-01
Concentration	32.5	19.0	19.7	20.3	30.6	33.7	19.0
Concentration F. Dup	33.7	18.7	19.7	20.3	31.7	32.5	18.7
% Difference	3.63	1.59	0.00	0.00	3.37	3.63	1.59

Sample	ML24-7	ML25-6
Date	May-01	May-01
Concentration	19.7	20.3
Concentration F. Dup	19.7	20.3
% Difference	0.00	0.00

**Table F3.** RPD in Nitrate + Nitrite Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Transect 2 Multi-level Wells

Sample	ML21-3	ML22-2	ML23-3	ML24-6	ML25-4	ML21-7	ML23-5
Date	Jun-97	Jun-97	Jun-97	Jun-97	Jun-97	Mar-98	Mar-98
Concentration	1.07	0.10	0.10	0.10	0.10	0.52	0.10
Concentration F. Dup	1.06	0.10	0.10	0.10	0.10	0.51	0.10
% Difference	0.94	0.00	0.00	0.00	0.00	1.94	0.00

Sample	ML23.5-4	ML24-5	ML25-2	ML22.5-1	ML23.5-1	ML25-2	ML21-3
Date	Mar-98	Mar-98	Mar-98	Sep-98	Sep-98	Sep-98	Dec-98
Concentration	0.10	0.10	0.10	0.32	0.10	0.12	0.33
Concentration F. Dup	0.10	0.10	0.10	0.34	0.10	0.17	0.35
% Difference	0.00	0.00	0.00	6.06	0.00	34.5	5.88

Sample	ML24-3	ML25-2	ML21-2	ML23.5-4	ML24-6	ML25-6	ML22.5-1
Date	Dec-98	Dec-98	Jun-99	Jun-99	Jun-99	Jun-99	Jun-00
Concentration	0.10	0.10	0.47	0.20	0.20	0.15	0.81
Concentration F. Dup	0.10	0.10	0.47	0.20	0.20	0.19	0.13
% Difference	0.00	0.00	0.00	0.00	0.00	23.5	145

Sample	ML23.5-4	ML24-5	ML25-4	ML22.5-6	ML23.5-2	ML24-7	ML25-6
Date	Jun-00	Jun-00	Jun-00	May-01	May-01	May-01	May-01
Concentration	0.10	0.39	0.10	0.10	0.10	0.10	0.10
Concentration F. Dup	0.10	0.10	0.10	0.10	0.10	0.10	0.10
% Difference	0.00	118	0.00	0.00	0.00	0.00	0.00

**Table F4.** RPD in Total Organic Carbon Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Transect 2 Multi-level Wells

<b>Total Carbon Sample</b>	ML21-3	ML24-7	ML21-6	ML25-7	ML22.5-0	ML22.5-8	ML24-1
<b>Date</b>	Jun-97	Jun-97	Sep-97	Sep-97	Mar-98	Mar-98	Mar-98
<b>Concentration</b>	1.61	7.41	1.39	1.27	1.99	3.26	6.62
<b>Concentration F. Dup</b>	1.68	7.37	1.45	1.25	1.98	3.60	6.88
<b>% Difference</b>	4.26	0.54	4.23	1.59	0.50	9.91	3.85

<b>Sample</b>	ML25-5	ML25-2	ML21-5	ML22.5-4	ML23.5-4	ML22.5-4	ML23.5-7
<b>Date</b>	Mar-98	Mar-98	Sep-98	Sep-98	Sep-98	Dec-98	Dec-98
<b>Concentration</b>	3.19	1.39	13.20	2.61	2.16	1.99	2.04
<b>Concentration F. Dup</b>	3.12	1.35	2.20	2.53	2.24	1.99	2.01
<b>% Difference</b>	2.22	2.92	143	3.11	3.64	0.00	1.48

<b>Sample</b>	ML24-7	ML21-2	ML22.5-5	ML23.5-4	ML24-7	ML22.5-1	ML23.5-4
<b>Date</b>	Dec-98	Jun-99	Jun-99	Jun-99	Jun-99	Jun-00	Jun-00
<b>Concentration</b>	2.93	1.73	2.13	3.25	1.72	0.98	0.99
<b>Concentration F. Dup</b>	2.93	1.19	2.08	3.21	1.80	0.49	1.55
<b>% Difference</b>	0.00	37.0	2.38	1.24	4.55	66.7	44.1

<b>Sample</b>	ML24-5	ML25-4	ML22.5-6	ML23.5-2	ML24-7	ML25-7
<b>Date</b>	Jun-00	Jun-00	May-01	May-01	May-01	May-01
<b>Concentration</b>	0.92	0.98	13.20	8.37	7.10	5.61
<b>Concentration F. Dup</b>	1.00	1.28	13.70	8.69	6.66	6.85
<b>% Difference</b>	8.33	26.5	3.72	3.75	6.40	19.9

**Table F5.** RPD in Vinyl Chloride Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Transect 2 Multi-level Wells

Sample	ML21-6	ML22-2	ML23-3	ML22-4	ML23-6	ML25-1	ML22.5-5
<b>Date</b>	Jun-97	Jun-97	Jun-97	Sep-97	Sep-97	Sep-97	Mar-98
<b>Concentration</b>	36.8	3.40	8.70	1.10	ND	1.40	27.4
<b>Concentration F. Dup</b>	37.1	3.50	8.40	1.00	ND	1.10	20.5
<b>% Difference</b>	0.81	2.90	3.51	9.52	NA	24.0	28.8

Sample	ML25-2	ML21-7	ML21-3	ML22.5-3	ML23.5-2	ML25-5	ML21-5
<b>Date</b>	Mar-98	Sep-98	Sep-98	Sep-98	Sep-98	Sep-98	Dec-98
<b>Concentration</b>	2.50	ND	ND	1.60	2.40	3.70	12.6
<b>Concentration F. Dup</b>	3.10	ND	ND	1.60	1.90	5.40	11.7
<b>% Difference</b>	21.4	NA	NA	0.00	23.3	37.4	7.66

Sample	ML22.5-2	ML23.5-1	ML24-1	ML25-4	ML21-1	ML22.5-5	ML24-6
<b>Date</b>	Dec-98	Dec-98	Dec-98	Dec-98	Jun-99	Jun-99	Jun-99
<b>Concentration</b>	1.00	4.40	1.40	5.30	0.10	0.10	0.10
<b>Concentration F. Dup</b>	1.00	4.11	1.21	4.78	0.10	0.10	0.10
<b>% Difference</b>	0.00	6.82	14.6	10.3	0.00	0.00	0.00

Sample	ML22.5-1	ML23.5-4	ML24-5	ML22.5-6	ML23.5-2	ML24-7	ML25-6
<b>Date</b>	Jun-00	Jun-00	Jun-00	May-01	May-01	May-01	May-01
<b>Concentration</b>	ND	2.16	ND	41.4	24.6	2.68	ND
<b>Concentration F. Dup</b>	ND	2.05	ND	41.2	21.7	2.80	ND
<b>% Difference</b>	NA	5.23	NA	0.48	12.53	4.38	NA

Notes: NA, not applicable due to one or both duplicates being below limit of detection. ND, not detected.

**Table F6.** RPD in *cis*-DCE Concentrations (µg/L) for Field Duplicates Collected through Time in Elizabeth City Transect 2 Multi-level Wells

<b>Sample</b>	ML21-3	ML22-2	ML23-3	ML21-3	M22-4	ML25-1	ML22.5-5
<b>Date</b>	Jun-97	Jun-97	Jun-97	Sep-97	Sep-97	Sep-97	Mar-98
<b>Concentration</b>	ND	39.80	49.8	ND	ND	6.60	6.50
<b>Concentration F. Dup</b>	<1.0	42.60	54.5	ND	ND	6.40	6.10
<b>% Difference</b>	NA	6.80	9.01	NA	NA	3.08	6.35

<b>Sample</b>	ML25-2	ML21-7	ML22.5-3	ML23.5-2	ML25-5	ML21-5	ML22.5-2
<b>Date</b>	Mar-98	Sep-98	Sep-98	Sep-98	Sep-98	Dec-98	Dec-98
<b>Concentration</b>	2.90	65.0	1.30	4.50	14.3	135	2.87
<b>Concentration F. Dup</b>	2.50	69.6	1.40	3.90	14.4	137	2.20
<b>% Difference</b>	14.81	6.84	7.41	14.29	0.70	1.57	26.43

<b>Sample</b>	ML23.5-1	ML24-1	ML25-4	ML22.5-5	ML24-6	ML23.5-4	ML24-1
<b>Date</b>	Dec-98	Dec-98	Dec-98	Jun-99	Jun-99	Jun-00	Jun-00
<b>Concentration</b>	7.51	8.51	20.2	0.10	0.10	1.00	18.0
<b>Concentration F. Dup</b>	6.98	7.77	19.0	0.10	0.10	1.00	1.65
<b>% Difference</b>	7.32	9.09	6.12	0.00	0.00	0.00	166

<b>Sample</b>	ML25-4	ML22.5-6	ML23.5-2	ML24-7	ML25-6
<b>Date</b>	Jun-00	May-01	May-01	May-01	May-01
<b>Concentration</b>	18.3	3.28	33.8	ND	38.9
<b>Concentration F. Dup</b>	18.3	4.00	34.7	ND	37.2
<b>% Difference</b>	0.00	19.8	2.63	NA	4.47

Notes: NA, not applicable due to one or both duplicates being below limit of detection. ND, not detected.

**Table F7.** RPD in TCE Concentrations (µg/L) for Field Duplicates Collected through Time in Elizabeth City Transect 2 Multi-level Wells

<b>Sample</b>	ML21-3	ML23-3	ML25-1	ML22.5-5	ML25-4	ML25-2	ML21-7
<b>Date</b>	Jun-97	Jun-97	Sep-97	Mar-98	Mar-98	Mar-98	Sep-98
<b>Concentration</b>	21.1	3.10	17.1	6.90	2.20	3.00	54.8
<b>Concentration F. Dup</b>	7.50	3.40	17.4	6.30	1.60	2.40	60.6
<b>% Difference</b>	95.1	9.23	1.74	9.09	31.6	22.2	10.1

<b>Sample</b>	ML22.5-3	ML23.5-2	ML25-5	ML21-5	ML22.5-2	ML23.5-1	ML24-7
<b>Date</b>	Sep-98	Sep-98	Sep-98	Dec-98	Dec-98	Dec-98	Dec-98
<b>Concentration</b>	10.1	1.40	ND	152	14.3	2.92	ND
<b>Concentration F. Dup</b>	8.90	1.20	ND	156	14.6	3.02	ND
<b>% Difference</b>	12.6	15.4	NA	2.72	2.15	3.64	0.00

<b>Sample</b>	ML24-1	ML22.5-5	ML24-6	ML22.5-1	ML23.54	ML24-5	ML22.5-6
<b>Date</b>	Dec-98	Jun-99	Jun-99	Jun-00	Jun-00	Jun-00	May-01
<b>Concentration</b>	ND	0.15	0.15	1200	4.72	ND	12.1
<b>Concentration F. Dup</b>	ND	0.15	0.15	1210	4.17	ND	11.9
<b>% Difference</b>	NA	0.00	0.00	0.83	12.37	NA	1.67

<b>Sample</b>	ML23.5-2	ML24-7	ML25-6
<b>Date</b>	May-01	May-01	May-01
<b>Concentration</b>	48.4	1.00	34.9
<b>Concentration F. Dup</b>	47.6	1.18	34.6
<b>% Difference</b>	1.67	16.51	0.86

Notes: NA, not applicable due to one or both duplicates being below limit of detection. ND, not detected.

**Table F8.** RPD in Sodium Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Transect 2 Multi-level Wells

<b>Sample</b>	ML21-6	ML21-1	ML23-2	ML23.5-0	ML25-2	ML21-6	ML22.5-5
<b>Date</b>	Mar-98	Mar-98	Mar-98	Mar-98	Mar-98	Jun-98	Jun-98
<b>Concentration</b>	9.95	20.0	46.2	31.4	42.6	52.5	22.8
<b>Concentration F. Dup</b>	53.1	20.6	44.4	31.0	42.7	52.5	22.8
<b>% Difference</b>	137	2.96	3.97	1.28	0.23	0.00	0.00

<b>Sample</b>	ML22.5-1	ML24-7	ML21-7	ML21-1	ML23.5-1	ML24-1	ML21-7
<b>Date</b>	Jun-98	Jun-98	Sep-98	Sep-98	Sep-98	Sep-98	Dec-98
<b>Concentration</b>	28.3	7.41	21.6	25.1	43.7	33.5	21.7
<b>Concentration F. Dup</b>	28.6	7.43	22.2	22.6	44.3	33.2	21.7
<b>% Difference</b>	1.05	0.27	2.74	10.5	1.36	0.90	0.00

<b>Sample</b>	ML21-1	ML23.5-5	ML25-6	ML21-2	ML22.5-5	ML23.5-4	ML24-6
<b>Date</b>	Dec-98	Dec-98	Dec-98	Jun-99	Jun-99	Jun-99	Jun-99
<b>Concentration</b>	22.2	21.2	12.3	23.1	5.42	17.6	4.91
<b>Concentration F. Dup</b>	22.3	21.2	12.4	23.2	5.39	17.5	4.95
<b>% Difference</b>	0.45	0.00	0.81	0.43	0.56	0.57	0.81

<b>Sample</b>	ML22.5-1	ML23.5-4	ML24-5	ML25-4
<b>Date</b>	Jun-00	Jun-00	Jun-00	Jun-00
<b>Concentration</b>	23.7	30.2	14.1	46.26
<b>Concentration F. Dup</b>	23.6	30.6	14.1	46.67
<b>% Difference</b>	0.21	1.35	0.00	0.88

**Table F9.** RPD in Potassium Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Transect 2 Multi-level Wells

<b>Sample</b>	ML21-1	ML23-2	ML23.5-0	ML25-2	ML21-6	ML22.5-5	ML22.5-1
<b>Date</b>	Mar-98	Mar-98	Mar-98	Mar-98	Jun-98	Jun-98	Jun-98
<b>Concentration</b>	1.02	1.23	31.4	42.6	6.31	4.43	1.75
<b>Concentration F. Dup</b>	1.49	0.79	31.0	42.7	6.64	5.00	1.81
<b>% Difference</b>	37.5	43.6	1.28	0.23	5.10	12.1	3.37

<b>Sample</b>	ML24-7	ML21-7	ML21-1	ML23.5-1	ML24-1	ML21-7	ML21-1
<b>Date</b>	Jun-98	Sep-98	Sep-98	Sep-98	Sep-98	Dec-98	Dec-98
<b>Concentration</b>	2.01	5.18	0.30	1.93	2.33	5.53	0.78
<b>Concentration F. Dup</b>	2.10	5.31	0.30	1.86	2.44	5.42	0.76
<b>% Difference</b>	4.38	2.48	0.00	3.69	4.61	2.01	2.60

<b>Sample</b>	ML23.5-5	ML25-6	ML21-2	ML22.5-5	ML23.5-4	ML24-6	ML22.5-1
<b>Date</b>	Dec-98	Dec-98	Jun-99	Jun-99	Jun-99	Jun-99	Jun-00
<b>Concentration</b>	1.09	1.80	0.73	3.17	1.20	1.41	1.39
<b>Concentration F. Dup</b>	1.35	1.73	1.26	3.36	1.11	1.48	1.40
<b>% Difference</b>	21.3	3.97	53.3	5.82	7.79	4.84	0.65

<b>Sample</b>	ML23.5-4	ML24-5	ML25-4
<b>Date</b>	Jun-00	Jun-00	Jun-00
<b>Concentration</b>	2.48	3.17	2.812
<b>Concentration F. Dup</b>	2.45	3.12	2.810
<b>% Difference</b>	1.30	1.49	0.071

**Table F10.** RPD in Calcium Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Transect 2 Multi-level Wells

<b>Sample</b>	<b>ML21-6</b>	<b>ML21-1</b>	<b>ML23-2</b>	<b>ML23.5-0</b>	<b>ML25-2</b>	<b>ML21-6</b>	<b>ML22.5-5</b>
<b>Date</b>	Mar-98	Mar-98	Mar-98	Mar-98	Mar-98	Jun-98	Jun-98
<b>Concentration</b>	3.10	12.4	4.39	9.35	2.92	29.4	303
<b>Concentration F. Dup</b>	3.08	12.1	4.46	9.32	2.89	29.1	30.9
<b>% Difference</b>	0.65	2.45	1.58	0.32	1.03	1.03	163

<b>Sample</b>	<b>ML22.5-1</b>	<b>ML24-7</b>	<b>ML21-7</b>	<b>ML21-1</b>	<b>ML23.5-1</b>	<b>ML24-1</b>	<b>ML21-7</b>
<b>Date</b>	Jun-98	Jun-98	Sep-98	Sep-98	Sep-98	Sep-98	Dec-98
<b>Concentration</b>	9.14	1.89	27.0	13.0	2.51	2.12	26.2
<b>Concentration F. Dup</b>	9.14	1.91	27.4	10.5	2.53	2.06	26.6
<b>% Difference</b>	0.00	1.05	1.47	21.28	0.79	2.87	1.52

<b>Sample</b>	<b>ML21-1</b>	<b>ML23.5-5</b>	<b>ML25-6</b>	<b>ML21-2</b>	<b>ML22.5-5</b>	<b>ML23.5-4</b>	<b>ML24-6</b>
<b>Date</b>	Dec-98	Dec-98	Dec-98	Jun-99	Jun-99	Jun-99	Jun-99
<b>Concentration</b>	12.9	6.78	2.46	11.2	13.0	7.93	2.29
<b>Concentration F. Dup</b>	12.7	6.69	2.44	11.0	12.9	7.91	2.27
<b>% Difference</b>	1.56	1.34	0.82	1.80	0.77	0.25	0.88

<b>Sample</b>	<b>ML22.5-1</b>	<b>ML23.5-4</b>	<b>ML24-5</b>	<b>ML25-4</b>
<b>Date</b>	Jun-00	Jun-00	Jun-00	Jun-00
<b>Concentration</b>	10.5	14.8	7.35	3.307
<b>Concentration F. Dup</b>	10.5	14.5	7.29	3.309
<b>% Difference</b>	0.19	1.98	0.87	0.060

**Table F11.** RPD in Magnesium Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Transect 2 Multi-level Wells

<b>Sample</b>	<b>ML21-1</b>	<b>ML23-2</b>	<b>ML23.5-0</b>	<b>ML25-2</b>	<b>ML21-6</b>	<b>ML22.5-5</b>	<b>ML22.5-1</b>
<b>Date</b>	Mar-98	Mar-98	Mar-98	Mar-98	Jun-98	Jun-98	Jun-98
<b>Concentration</b>	7.03	6.73	6.68	1.44	14.2	4.38	5.69
<b>Concentration F. Dup</b>	6.89	6.64	6.56	1.41	14.0	4.48	5.67
<b>% Difference</b>	2.01	1.35	1.81	2.11	1.42	2.26	0.35

<b>Sample</b>	<b>ML24-7</b>	<b>ML21-7</b>	<b>ML21-1</b>	<b>ML23.5-1</b>	<b>ML24-1</b>	<b>ML21-7</b>	<b>ML21-1</b>
<b>Date</b>	Jun-98	Sep-98	Sep-98	Sep-98	Sep-98	Dec-98	Dec-98
<b>Concentration</b>	0.11	9.60	7.78	2.82	2.47	9.00	7.62
<b>Concentration F. Dup</b>	0.10	9.39	6.34	2.81	2.45	9.14	7.52
<b>% Difference</b>	12.8	2.21	20.4	0.36	0.81	1.54	1.32

<b>Sample</b>	<b>ML23.5-5</b>	<b>ML25-6</b>	<b>ML21-2</b>	<b>ML22.5-5</b>	<b>ML23.5-4</b>	<b>ML24-6</b>	<b>ML22.5-1</b>
<b>Date</b>	Dec-98	Dec-98	Jun-99	Jun-99	Jun-99	Jun-99	Jun-00
<b>Concentration</b>	2.69	1.14	6.73	1.72	1.27	0.25	6.85
<b>Concentration F. Dup</b>	2.67	1.12	6.68	1.74	1.28	0.23	6.81
<b>% Difference</b>	0.75	1.77	0.75	1.16	0.78	8.81	0.45

<b>Sample</b>	<b>ML23.5-4</b>	<b>ML24-1</b>	<b>ML25-4</b>
<b>Date</b>	Jun-00	Jun-00	Jun-00
<b>Concentration</b>	4.64	7.37	4.015
<b>Concentration F. Dup</b>	4.59	4.49	4.034
<b>% Difference</b>	1.04	48.6	0.472

**Table F12.** RPD in Total Iron Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Transect 2 Multi-level Wells

Sample	ML21-6	ML21-1	ML23-2	ML23.5-0	ML25-2	ML21-6	ML22.5-5
Date	Mar-98	Mar-98	Mar-98	Mar-98	Mar-98	Jun-98	Jun-98
Concentration	0.57	0.01	0.06	0.06	3.69	0.02	15.5
Concentration F. Dup	0.57	0.01	0.03	0.07	3.65	0.06	15.7
% Difference	0.00	0.00	54.9	18.2	1.09	89.2	1.28

Sample	ML22.5-1	ML24-7	ML21-7	ML21-1	ML23.5-1	ML24-1	ML21-7
Date	Jun-98	Jun-98	Sep-98	Sep-98	Sep-98	Sep-98	Dec-98
Concentration	0.54	0.00	5.85	0.01	0.02	0.03	6.23
Concentration F. Dup	0.54	0.01	5.91	0.01	0.02	0.05	6.34
% Difference	0.00	65.1	1.02	0.00	39.2	57.4	1.75

Sample	ML21-1	ML23.5-5	ML25-6	ML21-2	ML22.5-5	ML23.5-4	ML24-6
Date	Dec-98	Dec-98	Dec-98	Jun-99	Jun-99	Jun-99	Jun-99
Concentration	<0.01	0.49	0.47	0.01	3.59	0.49	0.06
Concentration F. Dup	<0.01	0.48	0.48	0.01	3.55	0.50	0.07
% Difference	NA	1.44	2.75	0.00	1.12	1.61	12.4

Sample	ML22.5-1	ML23.5-4	ML24-5	ML25-2	ML25-4
Date	Jun-00	Jun-00	Jun-00	Jun-00	Jun-00
Concentration	0.05	7.59	0.04	3.29	<0.035
Concentration F. Dup	0.05	7.42	0.04	3.22	<0.035
% Difference	0.00	2.19	0.00	2.18	NA

Notes: NA, not applicable due to one or both duplicates being below limit of detection. ND, not detected.

**Table F13.** RPD in Manganese Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Transect 2 Multi-level Wells

Sample	ML21-1	ML23-2	ML23.5-0	ML21-6	ML22.5-5	ML24-7	ML21-7
<b>Date</b>	Mar-98	Mar-98	Mar-98	Jun-98	Jun-98	Jun-98	Sep-98
<b>Concentration</b>	0.10	0.02	0.08	2.77	0.68	0.01	3.51
<b>Concentration F. Dup</b>	0.10	0.03	0.07	2.72	0.69	0.01	3.57
<b>% Difference</b>	0.00	8.33	5.26	1.82	1.76	0.00	1.69

Sample	ML21-1	ML24-1	ML21-7	ML23.5-5	ML25-6	ML21-2	ML23.5-4
<b>Date</b>	Sep-98	Sep-98	Dec-98	Dec-98	Dec-98	Jun-99	Jun-99
<b>Concentration</b>	0.09	0.01	3.41	0.24	0.32	0.15	0.08
<b>Concentration F. Dup</b>	0.14	0.14	3.46	0.24	0.33	0.15	0.08
<b>% Difference</b>	35.8	164	1.46	0.00	0.62	0.00	0.00

Sample	ML24-6	ML23.5-4	ML24-5	ML25-4
<b>Date</b>	Jun-99	Jun-00	Jun-00	Jun-00
<b>Concentration</b>	0.08	0.58	0.02	0.005
<b>Concentration F. Dup</b>	0.08	0.57	0.02	0.005
<b>% Difference</b>	0.00	1.92	0.00	0.00

**Table F14.** RPD in Total Chromium Concentrations (mg/L) for Field Duplicates Collected through Time in Elizabeth City Transect 2 Multi-level Wells

Sample	ML21-1	ML23-2	ML23.5-0	ML25-2	ML21-6	ML22.5-5	ML22.5-1
<b>Date</b>	Mar-98	Mar-98	Mar-98	Mar-98	Jun-98	Jun-98	Jun-98
<b>Concentration</b>	0.002	0.003	0.003	0.003	0.849	0.002	0.215
<b>Concentration F. Dup</b>	0.002	0.003	0.003	0.003	0.840	0.002	0.211
<b>% Difference</b>	0.00	0.00	0.00	0.00	1.07	0.00	1.88

Sample	ML24-7	ML21-7	ML21-1	ML23.5-1	ML24-1	ML21-7	ML21-1
<b>Date</b>	Jun-98	Sep-98	Sep-98	Sep-98	Sep-98	Dec-98	Dec-98
<b>Concentration</b>	0.002	0.002	0.002	0.002	0.003	0.002	0.002
<b>Concentration F. Dup</b>	0.002	0.002	0.456	0.002	0.003	0.002	0.002
<b>% Difference</b>	22.22	0.00	198.2	0.00	0.00	0.00	0.00

Sample	ML23.5-5	ML25-6	ML21-2	ML22.5-5	ML23.5-4	ML24-6	ML22.5-1
<b>Date</b>	Dec-98	Dec-98	Jun-99	Jun-99	Jun-99	Jun-99	Jun-00
<b>Concentration</b>	0.002	0.002	0.278	0.002	0.002	0.002	0.083
<b>Concentration F. Dup</b>	0.002	0.002	0.271	0.002	0.002	0.002	0.083
<b>% Difference</b>	0.00	0.00	2.55	0.00	0.00	0.00	0.00

Sample	ML23.5-4	ML24-5	ML25-4
<b>Date</b>	Jun-00	Jun-00	Jun-00
<b>Concentration</b>	0.006	0.002	0.002
<b>Concentration F. Dup</b>	0.005	0.002	0.002
<b>% Difference</b>	18.18	0.00	0.00



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