[illegible]

137395

R-585-2-6-19

# SITE INSPECTION OF
# C & R BATTERY
PREPARED UNDER

TDD NO. F3-8503-29
EPA NO. VA-281
CONTRACT NO. 68-01-6699

FOR THE

HAZARDOUS SITE CONTROL DIVISION
U.S. ENVIRONMENTAL PROTECTION AGENCY

FEBRUARY 24, 1986

NUS CORPORATION
SUPERFUND DIVISION

| SUBMITTED BY | REVIEWED BY | APPROVED BY |
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## APPENDICES

# SECTION 1

## 1.0 INTRODUCTION

### 1.1 Authorization

NUS Corporation performed this work under Environmental Protection Agency Contract No. 68-01-6699. This specific report was prepared in accordance with Technical Directive Document No. F3-8503-29 for the C & R Battery site located in Chesterfield County, Virginia.

### 1.2 Scope of Work

NUS FIT III was tasked to conduct a site inspection of the C & R Battery Recycling site, which is located just south of Richmond, Virginia. Specific elements of the TDD are detailed in appendix A of this report. It is significant to note that considerable information applicable to the C & R Battery site has been developed by FIT III and reported to EPA under previous TDDs. Refer also to the following reports for additional information: preliminary assessment report, TDD No. F3-8407-32; non-sampling site reconnaissance report, TDD No. F3-8502-13; and Hazard Ranking System report, TDD No. F3-8505-37.

### 1.3 Summary

On April 23, 1985, FIT III personnel, accompanied by Pauline Ewald and Kevin Greene, of the Virginia State Health Department, visited the C & R Battery site for the purpose of conducting the site investigation as tasked.

The subject site, a 4-acre, leased property, was used by Mr. Charles Guyton of Richmond, Virginia, from the early 1970s to mid-1985. Activities on site have been conclusively identified as the reclamation and recycling of lead and lead compounds from discarded auto and truck batteries. The reclamation process was facilitated by a nonspecified battery saw/breaker equipped with conveyors and automated material segregation components. In addition to the use of on-site machinery, the day-to-day operations of the site were accomplished by several laborers under the employment of the site proprietor, Mr. Charles Guyton.

Generally, on-site activities included the receiving of bulk shipments of discarded batteries, the processing of the batteries, and the on-site storage of both reclaimed lead and pulverized battery casings. Materials (lead, lead compounds, and battery casings) were stored on site in drums, open trailers, and large open tank containers or were piled on the open ground surface.

The Virginia State Water Control Board (VA SWCB) has been involved with monitoring site activities since the late 1970s. According to Mr. Charles Stitzer, of VA SWCB, during the approximately 15-year operation of the site, large volumes of batteries have been processed. Reports have been made that piles of crushed battery casings, in excess of 20 feet in height, have periodically been observed on site.

The regulatory history of the site is somewhat complex. VA SWCB has initiated numerous actions including a court-ordered Consent Injunction for the submittal of a site wastewater management and reclamation plan. Following several court appearances and the submittal and resubmittal of required plans, the site, up until closure in 1985, never reached compliance. The Virginia Occupational Safety and Health Administration (VA OSHA) has also had extensive involvement at the site. According to Mr. Richard Anderson, of VA OSHA, between 1978 and 1983, several cases of confirmed lead intoxication have been reported by physicians of site employees. VA OSHA has issued fines in excess of $60,000 to Mr. Guyton, for noncompliance with existing worker safety codes.

As of the date of preparation of this report, VA SWCB has reported that Mr. Guyton has abandoned the battery recycling facility and has reportedly left the state of Virginia.

The area within which the site is situated can be characterized as scattered residential and industrial. There are numerous homes within a 1-mile radius of the site which utilize private wells for drinking water sources.

A review of available geologic information reveals that the site area is situated over a probable recharge zone to the Middle Potomac aquifer. A sizable population (estimated at approximately 840) has been tentatively identified as using wells which probably tap this aquifer.

On-site soil samples collected by FIT III revealed high levels of several inorganic priority pollutants. Groundwater samples drawn from on-site monitoring wells by FIT III have also exhibited qualitative evidence of inorganic priority pollutant contamination.

From a toxicologic/human health assessment standpoint, the generation of lead-contaminated dusts from the site may be of potential health concern to residents living in the surrounding area. If untreated, shallow groundwater directly under the site was used as a potable water source, a high carcinogenic risk, along with risk of kidney damage, hemotological problems, and acute gastrointestinal problems, exists. Samples collected from 3 home wells within 1 mile of the site exhibited no inorganic compounds at levels which may pose human health concern. However, elevated levels of sodium were identified in 1 home well. The home owner should be notified of these levels.

## SECTION 2

# 2.0 THE SITE

## 2.1 Location

The C & R Battery site is located approximately 6 miles southeast of Richmond, along the north side of Bellwood Road, approximately 3,750 feet east of Interstate 95. The site is within Chesterfield County, at 37° 25' 04" latitude and 75° 24' 56" longitude on the Drewry's Bluff, Virginia 7.5 minute United States Geological Survey (U.S.G.S.) topographic quadrangle maps (see figures 1 and 2 in appendix B for site location maps and sketches).

## 2.2 Site Layout

The site consists of a battery processing saw/shredder designed to separate and recover lead from discarded auto and truck batteries. The battery crusher machine, reclaimed materials, waste materials, and all other related activities and equipment are confined to a single area of approximately 4 acres.

The site is basically a rectangular property which slopes generally 3 to 5 percent to the southeast. The battery breaker itself is located within the south central portion of the lot. An acid storage/containment area is also located within the central area of the site, adjacent to the battery crusher. Material stockpile areas (both reclaimed lead and scrap) are located just west and north of the battery crusher. According to Mr. Charles Guyton, the site operator, and available site diagrams as prepared by private consultants under contract to the operator, the battery crusher has been constructed on a large concrete pad (see appendix B, figure 2). The lateral extent of this pad and its structural continuity could not be field verified since it was buried by battery casings and soil.

The site is bordered on the south and west by open fields and wood lots. Capital Oil Company, a small fuel oil distributor, borders the site on the east. North of the site are residential properties and the James River. Adjoining terrain is generally topographically similar to the site, with the exception of the Drewry's Bluff area, located approximately 1,400 feet due northwest of the site. The Drewry's Bluff, an historic area, is characterized by a steep 100 to 120 feet high bluff overlooking the James River.

### 2.3 Ownership History

The 4-acre parcel on which the battery breaker is situated is currently under the ownership of William and Edward Zacharias of Richmond, Virginia. Information pertaining to site ownership prior to the Zacharias brothers' involvement has not been determined for this report. Mr. Charles Guyton rented the property and had done so since he began operations at the site in 1970.

### 2.4 Site Use History

According to Mr. Guyton, battery recycling activities at the site began in 1970. Products and waste materials generated by this operation include lead sulfide, lead oxide, lead, plastic battery casing materials, and sulfuric acid. Prior to 1970, the site had no specific use and was described by Mr. Guyton as a wooded vacant lot. Generally, on-site activities related to the operation include bulk/whole battery storage, battery processing to recover lead and lead sulfide, waste materials stockpiling, recovered materials stockpiling, and materials loading and shipping.

Evidence which indicates the possible use of the site for activities other than those described above has not been developed. Mr. Guyton, though present during the conducting of previous preliminary assessments and site reconnaissance field investigations, was not present during the site inspection. In fact, the site was abandoned at the time of the April 23, 1985 field visit. VA SWCB has reported that Mr. Guyton abandoned the site, ceasing operations permanently earlier that month.

## 2.5 Permit and Regulatory Action History

Regulatory actions by both EPA and VA SWCB have been summarized as follows:

Federal: EPA initiated applicable preliminary assessment, nonsampling site reconnaissance, site inspection, and hazard ranking system reports. Please refer to EPA file VA-281 for details.

State: VA SWCB has had extensive involvement with the site, beginning in the late 1970s. Generally, orders for the submission of a wastewater treatment permit application and a site reclamation plan have been issued to the operator. Upon several submissions of proposed reclamation plans and amended permit applications, the operation was never declared to be in compliance. Subsequent court orders had been issued and several court appearances had been made in relation to the VA SWCB's attempts at bringing the site into compliance. As of the latest date of site operation (early 1985), compliance had not been achieved. VA SWCB noted serious concerns over the financial stability of C & R Battery and its ultimate ability to assume the cost of reclamation.

VA OSHA has also had extensive involvement with the C & R Battery site. According to Mr. Richard Anderson, of VA OSHA, his first inspection of the site in 1983 revealed numerous violations of current OSHA standards. Air monitoring of the breathing zone on site at several work stations had indicated conditions well above the existing standard (standard for lead is 50 ug/cubic meters). Levels had been measured at ranges from 50 to 112 ug/cubic meters. Additionally, employees at the site had been found to have elevated levels of lead in blood samples. According to Mr. Anderson, excessive fines have been issued to the operator for noncompliance. (Although not confirmed, penalties in excess of $60,000 have reportedly been issued.)

## 2.6 Remedial Action To Date

There have been no EPA-related remedial actions at the site. As a part of its regulatory authority, VA SWCB requested a site reclamation plan and wastewater discharge permit application from the C & R Battery operator. The operator subsequently procured an engineering firm to prepare the applicable documents. As of August 20, 1984, VA SWCB had received several amendments to the proposed site reclamation plan, but had not approved any submission. During some time in late 1983 or early 1984, the operator took it upon himself to initiate reclamation. According to the operator's reports, battery casings had been removed, surface soils had been excavated, lime had been applied, and a clay cap had been placed over the northern area of the site.

(It should be noted, however, that during hand augering sample collection on site, FIT III observed buried crushed battery casings in 3 locations. Refer to sections 4 and 5 of this report for more details pertaining to these observations. The southern and central areas of the site have not received any remedial work (see appendix C).)

# SECTION 3

# 3.0 ENVIRONMENTAL SETTING

[illegible]

## 3.1 Water Supply

Water supplies for the population within a 3-mile radius of the C & R Battery site are developed from both surface water and groundwater sources. The areas situated west and south of the James River are serviced by the Chesterfield County Public Utility Water Service Department. Sources for the Chesterfield County supply system, according to Mr. Harold Anderson, waterworks supervisor, are developed from surface water sources, all of which are located outside of the 3-mile radius around the C & R Battery site. Available water line distribution maps indicate that the vast majority of this area is serviced by water main extensions. However, several small residential developments within the area do not have water line extensions and therefore depend on private wells.

An attempt was made to identify the locations of these home well areas through interpretation of water line distribution maps, as provided by the Utility Department, through subsequent telephone conversations with the utility department personnel, and through a door-to-door survey made under TDD no. F3-8502-13. Figure 4 in appendix B represents the summarized results of this effort.

In an attempt to identify water supplies for those areas situated north and east of the James River, the Henrico County Utility Department was contacted. According to Amy Wajciechlldski, an employee of the utility department, county distribution lines do not extend into the area encompassed by the 3-mile radius around the C & R Battery site. Residents within this area utilize private wells for domestic supplies.

## 3.2 Surface Waters

The C & R Battery site is drained by a small intermittent stream/drainage ditch which discharges into the James River at a point approximately 600 feet north of the site. The drainage ditch has been channeled within the vicinity of the C & R site. Low flow during summer months precludes macroinvertebrate and other aquatic animal life in the ditch. Likewise, there are no water intakes either upstream or downstream from the C & R Battery site. The stream gradient, from the C & R site boundary to the discharge point, averages approximately 6 percent.

## 3.3 Geology and Soils

The Soil Survey of Chesterfield County, Virginia indicates that original soils within the area occupied by the C & R Battery site are of the Pamunkey loam, 0 to 6 percent slope, soils mapping unit. The Pamunkey soil series is described as deep, well drained, nearly level to moderately steep soils. These soils are also described as having moderate permeability ranges.[1]

Surface soils were observed during the FIT III field investigation as light brown sandy clay. Numerous areas of discolored soil, including dark red stains, purple powdery stains, and gray and white sludge-like soils were also observed. Hand augering during sample collection revealed sandy clay soil to a depth of approximately 8 inches. Crushed battery casings were observed at 8 inches in all auger holes.[2]

A geotechnical study of the C & R Battery site was prepared by Sayre and Associates, of Richmond, Virginia, in December 1983. This study included the advancement of 4 exploratory borings, 2 of which were developed as shallow peizometers-monitoring wells. Additionally, Froehling and Robertson, Incorporated, of Richmond, Virginia, collected 11 hand auger samples across the site at various depths and locations (refer to appendix D for a copy of the described reports).

A review of the logs developed from the borings associated with the Sayre and Associates study reveal that strata below the C & R Battery site, to a depth of 45 feet, consist of alternating layers of clay, sand, and sand and gravel.[3] Specifically, the subsurface materials at the site consist of varying depths (1 to 10 inches) of crushed stone, plastic battery casing materials, sandy clay, and, in the central area of the site, a 6 inches thick concrete slab. A 3 to 8 feet thick layer of gray clay with brown sand seams exists under the surface layer. Beneath this clay, at depths of up to 27 feet, there is a layer of sandy clay. Under the sandy clay, there is a 10 feet thick layer of fine to coarse sand. At 37 feet, coarse sand and gravel was encountered. The deepest coring on site reached 45 feet. Bedrock was not encountered at that depth.[3]

A log of a test well, located approximately 3,200 feet northwest of the C & R Battery site at the Fort Darling National Park, indicates the presence of alternating layers of sand and gravel, sandy gravel and clay, and clay. These materials make up the overburden, which extends to a depth of 176 feet. Basement rock, extending from 176 feet to the bottom of the well at 205 feet, was recorded as red granite. The well was cased to a depth of 184 feet. A screened interval was placed at 90 to 105 feet below the surface. Water was encountered in this well at both 90 and 184 feet.[4]

Physiographically, the site lies at the western edge of the Atlantic Coastal Plain, within the reworked flood plain of the James River. The Coastal Plain Province is described as an eastwardly thickening and dipping sedimentary wedge composed principally of unconsolidated gravels, sands, silts, and clays. These deposits rest on a rock surface (Basement Complex) that also slopes gently eastward.

Available information from geological publications indicates that the site is situated over the Potomac Formation of Lower Cretaceous age.[5] The Potomac is described as consisting of alternating sequences of fine gravel, coarse sands, and silty to sandy clays.[5] Beneath the Potomac is Precambrian basement rock. The basement rock is described as a complex of schists, gneisses, granites, and intrusives.[5] The upper surface of the basement rock is highly weathered, forming a cover of saprolite.

### 3.4 Groundwaters

A recent publication (1984), entitled the "Hydrogeologic Framework of the Virginia Coastal Plain" has been utilized as a reference for the compilation of this section. This publication was developed by U.S.G.S. under the auspices of the Virginia Regional Aquifer System Analyses Program. The major goals of the report were to identify and define the regional hydrogeologic framework of the Coastal Plain sediments of Virginia and to further describe the subsurface Coastal Plain geology and hydrology.[5]

The publication includes a detailed description of each major aquifer system, delineated and defined throughout the course of a 4-year intensive field investigation. The investigation included the review of hundreds of well logs applicable to the 13,000-square-mile study area. The report is very recent and can be considered to supercede previously published information.

The described reference indicates that 3 distinct aquifer zones exist within the Potomac Formation, the upper, lower, and middle aquifers. Each is segregated by a confining clay layer within the eastern and southeastern area of the reference report study area. FIT III's interpretation of this report indicates that the C & R Battery site is situated within the outcrop area of the middle Potomac aquifer unit (see figure 5, appendix B). The cross section in figure 5 was developed through the interpretation of geologic descriptions and corresponding structural contour maps included in the reference report.

The thickness of the middle Potomac aquifer within the limits of the 3-mile radius around the site ranges from 0 feet dipping and thickening to 150 feet to the east.[5]

The reference report indicates that a clay layer, identified as the Middle Potomac confining bed and consisting of clay and clayey silt layers, extends along the top of the middle Potomac aquifer. This clay bed, as based on reference report contour maps, pinches out within the vicinity of the site. The description of the geology beneath the C & R Battery site in section 3.3 indicates a clay layer ranging from 3 to 27 feet in thickness. Whether or not this correlates to the middle Potomac confining bed and its continuity over the site is not documentable.

It is therefore concluded that the principal aquifer of concern is the middle Potomac sands and gravels.[5] As illustrated in figure 5, appendix B, this aquifer probably extends far enough west that shallow water supply wells (from 10 to 100 feet deep) within 3 miles of the C & R Battery site probably tap it. Wells deeper than 150 to 200 feet most likely draw from basement rock aquifer, unless screened at shallow levels. Since the basement rock and saprolitic cover are, in part, recharged by the overlying materials, the crystalline complex is also included as part of the aquifer.

From the site, extending north and eastward, the upper layers of the middle Potomac aquifer are truncated by the James River. The thickness of the middle Potomac, however, is such that lower layers of the aquifer extend under the river. The eastwardly dipping and thickening of the formation places the middle Potomac aquifer at increasing depths east of the site. Correspondingly, the middle Potomac confining layer also thickens to the east.

For groundwater contaminants originating at the C & R Battery site to affect wells located east of the James River, they must be drawn vertically down over 60 feet and then horizontally over distances greater than 1 mile. In addition, contaminants would have to cross the hydrologic drainage divide produced by the James River. Therefore, it is concluded that little probability exists for wells located east of the James River to be affected by the site. As such, the population served by wells drawing from the middle Potomac aquifer, saprolite, and crystalline rock, located within 3 miles of the site and west of the James River, will be considered as the target population.

### 3.5 Climate and Meteorology

The study area is located in an area which experiences warm summers and mild winters with an average annual temperature of about 57°F. The normal annual total precipitation ranges from 32 to 48 inches and the mean annual lake evaporation for the area is 40 inches. Net precipitation, therefore, ranges from 0 to 8 inches annually. The prevailing wind direction is to the south.

### 3.6 Land Use

Land use within a 1-mile radius of the site is a combination of agricultural, commercial, industrial, and scattered residential. An oil distribution/storage facility is located directly adjacent to the eastern boundary of the site and a vacant wood lot it located along the western border. The inactive, reclaimed Fort Darling Landfill is situated approximately 1,750 feet west of the site. Several private residential homes are located just north of the site, adjacent to the James River.

The 3-mile radius around the site can be characterized as heavily developed residential, commercial, and industrial within the western portion of the study area. In particular, the I-95 Richmond-Petersburg Turnpike corridor, which bisects the western portion of the study area, is a heavily developed commercial area. The 400-acre United States Defense Supply Center is situated approximately 2 miles due west of the site and several Civil War historic national parks are interspersed within the study area. Those lands located east of the James River within the study area are mostly residential.

### 3.7 Population Distribution

The population distribution within the 1-mile radius of the site can be characterized as generally sparse. Available current U.S.G.S. topographic maps indicate approximately 80 homes or 300 persons residing within this area. Population distribution becomes very dense within the eastern and western portions of the study area. Census tract maps have not been obtained for these areas, and current U.S.G.S. topographic maps depict residential developments as color-shaded areas, indicative of home development which is too dense for 7.5 minute map representation. Under these considerations, the total population within the 3-mile radius of the C & R Battery site cannot be determined at this time.

## 3.8 Critical Environments

The C & R Battery site is situated at 55 feet above mean sea level (MSL), and is located approximately 60 miles inland, away from coastal wetlands. The distance from the site to freshwater wetlands is greater than 1 mile.

The official "Virginia List of Endangered Vertebrates and Molluscs" includes only 1 species (the red cockaded woodpecker) as ranging within the area of the site. Sightings of this species, however, are limited to the counties south and southeast of the Chesterfield County (refer to appendix K for endangered species information).

As previously described, there are numerous historic Civil War battlefield parks within the study area. The Drewry's Bluff Fort Darling Park is situated approximately 2,600 feet northwest of the site and the Redmond National Battlefield Park is located across the James River, approximately 2 miles east of the site.

Finally, the James River itself can be considered within this section due to its recreational value. According to River Ways Naturalist Ralph White (Richmond Department of Parks and Recreation), the James River within the vicinity of the C & R Battery site is used extensively by pleasure boaters and fishermen.

## 3.9 References

1. United States Department of Agriculture, Soil Conservation Service. Soil Survey of Chesterfield County, Virginia. 1974.

2. NUS Corporation, FIT III. Site observations made during April 3, 1985 site inspection at the C & R Battery site, Chesterfield County, Virginia. TDD No. F3-8503-29.

3. Sayre and Associates. Geotechnical study of the C & R Battery Company. Chesterfield County, Virginia. December 1983.

4. Syndor Hydrodynamics, Incorporated. Well test information sheet for the Fort Darling test well. November 30, 1976.

5. Meng, Andrew, and John F. Harsh, United States Geological Survey. Hydrogeologic Framework of the Virginia Coastal Plain. Open file report 84-728. 1984.

# SECTION 4

## 4.0 WASTE TYPES AND QUANTITIES

Based on the previously described on-site operations, a review of analytical reports from samples collected, and observations made during the field investigation of the C & R Battery site, waste substances and significant characteristics associated with each can be summarized in the following table. For analytical results of samples collected on site (which details concentrations of inorganic priority pollutants) refer to section 6 of this report. For toxicologic considerations of existing contamination, refer to section 7 of this report.

WASTE CHARACTERIZATION SUMMARY TABLE

| WASTE TYPE | WASTE LOCATION | CONTAINMENT | ESTIMATED QUANTITY |
|---|---|---|---|
| raw lead | southern and central area of the site | open barrels, trailer trucks, piles | variable based on production; probably low at present time since facility is abandoned |
| various lead compounds and miscellaneous inorganic priority pollutants | distributed over entire site area | no containment | unknown |
| lead-contaminated soil | distributed over the site area | no containment | 170 tons (see appendix F) |
| lead-contaminated groundwater | under site area; extent of plume not identified | no containment | unknown |
| sulfuric acid | south central area of site | storage area but no continuous containment | unknown |
| agricultural grade lime | northern area of site | no containment | 150 tons (see appendix F) |

| WASTE TYPE | WASTE LOCATION | CONTAINMENT | ESTIMATED QUANTITY |
|---|---|---|---|
| crushed plastic battery casings | scattered over entire site area | no containment | unknown; some quantity may be buried on site |

# SECTION 5

Site Name: C & R Battery
TDD No.: F3-8503-29

# 5.0 FIELD TRIP REPORT

## 5.1 Summary

On Tuesday, April 23, 1985, FIT III team members Richard Gorrell, Edmund Reardon, Edward Helmig, Thomas Pearce, and Robert Werner visited the C & R Battery site to perform the site inspection as tasked. Accompanying the FIT team were Kevin Greene and Pauline Ewald, of the Virginia State Health Deparment.

Upon arrival at the site, a pre-sampling reconnaissance of the site was performed to familiarize FIT sampling personnel with proposed sample locations. Following this reconnaissance, background samples were obtained and on-site aqueous (groundwater) and soil samples were collected. Concurrent with on-site sample collection was the collection of off-site upgradient and downgradient home/private well samples.

In all, 12 aqueous and 11 solid samples were obtained including blanks, duplicates, and filtered groundwater samples.

On-site conditions had changed since FIT III's non-sampling site visit in March 1985. Most noticeably, the acid storage area, which was previously confined to a relatively small "lagoon type" area, had been expanded in size. This area was relatively uncontained with no access restrictions from public roads or other public or private properties. Under these conditions, a potential emergency response situation may exist.

## 5.2 Persons Contacted

### 5.2.1 Prior to Field Trip

Lee Cobaugh, P.E.
Cobaugh, Blanton Assoc.
P.O. Box 8822
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(Consultant)

Kevin Greene
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Keith Holliday, Acid Supervisor
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James Henley, Plant Manager
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Harold Anderson
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### 5.2.2 At the Site

Pauline Ewald
Kevin Greene
VA State Health Department
101 North 14th Street
Richmond, VA 23219
(804) 225-2802

### 5.2.3 Post Field Trip

Haywood Wigelsworth
Hydrogeologist
Henrico Co. Health Dept.
Water and Sewer Dept.
410 Dabbs House Road
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Ralph White, Naturalist
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**Post Field Trip (continued)**

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Richard Anderson, Inspector
Dept. of Labor and Industry
VA State Occup. Safety and
and Health Agency
P.O. Box 12064
Richmond, VA 23241

TDD Number 8503-29
EPA Number VA-281

## 5.3 SAMPLE LOG

Site Name C+R BATTERY

| TRAFFIC REPORTS | | | SAMPLING LOCATION | PHASE | SAMPLE DESCRIPTION | DATE | TIME | pH | COMMENTS/OBSERVATIONS | LABORATORY |
|---|---|---|---|---|---|---|---|---|---|---|
| Organic | Inorganic | High Hazard | MAP KEY No. | | | | | | | |
| N/A | MCB-226 | N/A | ON SITE WELL #1 | AQ | ON SITE GROUNDWATER | 4/23/85 | 1120 | N/A | CLEAR, STANDING | CHEM TECH |
| " | MCB-227 | N/A | ON SITE WELL #2 | AQ | ON SITE GROUNDWATER | " | 1015 | " | ORANGE STAIN | " |
| " | MCB-228 | N/A | ON SITE WELL #2A | AQ | DUPLICATE (MCB-226) | " | 1120 | " | CLEAR, STANDING | " |
| " | MCB-229 | N/A | ON SITE WELL # 11 | AQ | ON SITE GROUNDWATER | " | N/A | " | DRY | " |
| " | MCB 230 | N/A | BLANK | AQ | BLANK | " | 1440 | " | BLANK | " |
| " | MCB231 | N/A | UPSTREAM # 3 | SOL. | UPSTREAM SED. BACKGROUND | " | 0950 | " | LT B. SANDY CLAY | " |
| " | MCB232 | N/A | DOWNSTREAM # 4 | SOL | DOWNSTREAM SED. | " | 1000 | " | GRAY-B SANDY CLAY | " |
| " | MCB233 | N/A | ON SITE SOIL # 7 | SOL | ON SITE SURFACE SOIL | " | 1050 | " | LT B. SANDY CLAY | " |
| " | MCB-234 | N/A | ON SITE SOIL # 6 | SOL | ON SITE SURFACE SOIL | " | 1020 | " | DK GRAY/WHITE SLUDGE | " |
| " | MCB-235 | N/A | ON SITE SOIL # 12 | SOL | ON SITE SURFACE SOIL | " | 1105 | " | WHITE POWDERY SUB. | " |
| " | MCB-236 | N/A | ON SITE SOIL # 13 | SOL | ON SITE SURFACE SOIL | " | 1010 | " | GRAY CLAY/SLUDGE | " |
| " | MCB-237 | N/A | ON SITE SOIL # 14 | SOL | ON SITE SURFACE SOIL | " | 1030 | " | PURPLE/RED POWDER | " |
| " | MCB-238 | N/A | ON SITE SOIL # 15 | SOL | ONSITE SURFACE SOIL | " | 1030 | " | BROWN SANDY CLAY | " |
| " | MCB-239 | N/A | ON SITE SOIL # 15A | SOL | DUPLICATE (MCB-234) | " | 1020 | " | DK GRAY/WHITE SLUDGE | " |
| " | MCB-240 | N/A | BLANK | SOL | BLANK | " | 1440 | " | BLANK | " |
| " | MCB-241 | N/A | OFF SITE SOIL #5 | SOL | OFFSITE SOIL - BACKGROUND | " | 0940 | " | LT BR. SANDY CLAY | " |
| " | MCB-242 | N/A | ON SITE WELL #2 | AQ | ONSITE GW - FILTERED | " | 1015 | " | ORANGE STAIN | " |
| " | MCB-243 | N/A | ON SITE WELL # 11 | AQ | ON SITE GW - FILTERED | " | N/A | " | DRY | " |
| " | MCB-244 | N/A | ON SITE WELL #2A | AQ | DUPLICATE - FILTERED (MCB-311) | " | 1120 | " | CLEAR, STANDING | " |
| " | MCB-245 | N/A | BLANK | AQ | BLANK - FILTERED | " | 1440 | " | BLANK | " |

TDD Number 8503-29
EPA Number VA-281

## 5.3 SAMPLE LOG

Site Name C+R BATTERY

| TRAFFIC REPORTS | | | SAMPLING LOCATION | PHASE | SAMPLE DESCRIPTION | DATE | TIME | pH | COMMENTS/OBSERVATIONS | LABORATORY |
|---|---|---|---|---|---|---|---|---|---|---|
| Organic | Inorganic | High Hazard | MAP KEY NO. | | | | | | | |
| N/A | MCB-246 | N/A | HOME WELL # 8 | AQ | DOWNGRADIENT/OFF SITE | 4/23/85 | 1015 | N/A | (DOMESTIC USE) GROUND WATER | CHEM TECH |
| " | MCB 247 | " | HOME WELL # 9 | AQ | DOWNGRADIENT/OFF SITE | " | N/A | " | NOT COLLECTED | " |
| " | MCB-248 | " | HOME WELL # 10 | AQ | UPGRADIENT/OFF SITE | " | 1030 | " | (DOMESTIC USE) GROUNDWATER | " |
| " | MCB-249 | " | HOME WELL # 11 | AQ | OFF SITE | " | 1045 | " | GROUNDWATER | " |
| " | MCB-311 | " | ON SITE WELL # 1 | AQ | (FILTERED) ON SITE GROUNDWATER | " | 1120 | " | CLEAR, STANDING | " |
| | | | | | | | | | | |
| ★ | REFER TO FIGURES 1, 2 AND 4 IN APPENDIX B FOR CORRESPONDING SAMPLE LOCATION | | | | | | | | | |
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## 5.4 Site Observations

- Upon arrival at the site, at approximately 8:15 AM, it was determined that the site, an active battery recycling facility, was shut down for the day. There were no employees or other site representatives present during the entire time that FIT III collected samples and remained on site.

- The acid storage area had expanded in surficial area since the previous FIT III site visits. When 1 of the sampling team personnel kicked a small clump of soil material into 1 of the acid puddles, an obvious reaction occurred. There was fizzing and bubbling, which is indicative of an acid-base reaction.

- Numerous areas of discolored soil were observed around the battery saw area. Observed material included dark red to purple powdery substances, gray and gray-white sludge-like substances, white powdery substances (probably lime), gray powdery substances, and orange-brown powdery clay substances.

- An attempt was made to obtain hand auger samples to a depth of 2.5 feet, within the area described as reclaimed. A refusal depth of approximately 8 inches was noted in these auger holes. Crushed battery casings were observed at refusal depth within these 3 auger holes.

- Two, 4-inch, PVC-cased monitoring wells were discovered at the east central boundary of the site. Both wells were measured for total depth and depth to static water level. The first well was found to be approximately 18 feet deep. No water was observed in this well. The second well was found to be approximately 40 feet deep with a static water level at approximately 38.5 feet from surface elevation. Based on existing dry conditions, on the small volume of water in the well, and on time constraints, the decision was made not to purge the well and collect the sample. Water drawn from this well was observed to be orange stained with significant orange-colored suspended particulates.

- A 36-inch diameter, concrete-cased well was also discovered on site. This well was equipped with an above ground pump and related plumbing fixtures for providing water for the site office. At the time of the FIT field inspection, power was not available for operating the pump. Water level was recorded in this well at approximately 26 feet from surface elevation. Total depth of the well has been reported at approximately 30 feet. The sample was drawn from the standing water and observed to be clear with little or no suspended particulates.

- Upstream and downstream aqueous samples were not collected due to existing dry conditions.

- No abnormal HNU or radiation mini-alert readings were recorded at the site.

- The site operator had requested split samples. The splits were collected at all on-site sample locations and placed in the entrance to the site office. No site personnel were present to accept these split samples and sign sample receipt forms.

## 5.5 PHOTOGRAPH LOG

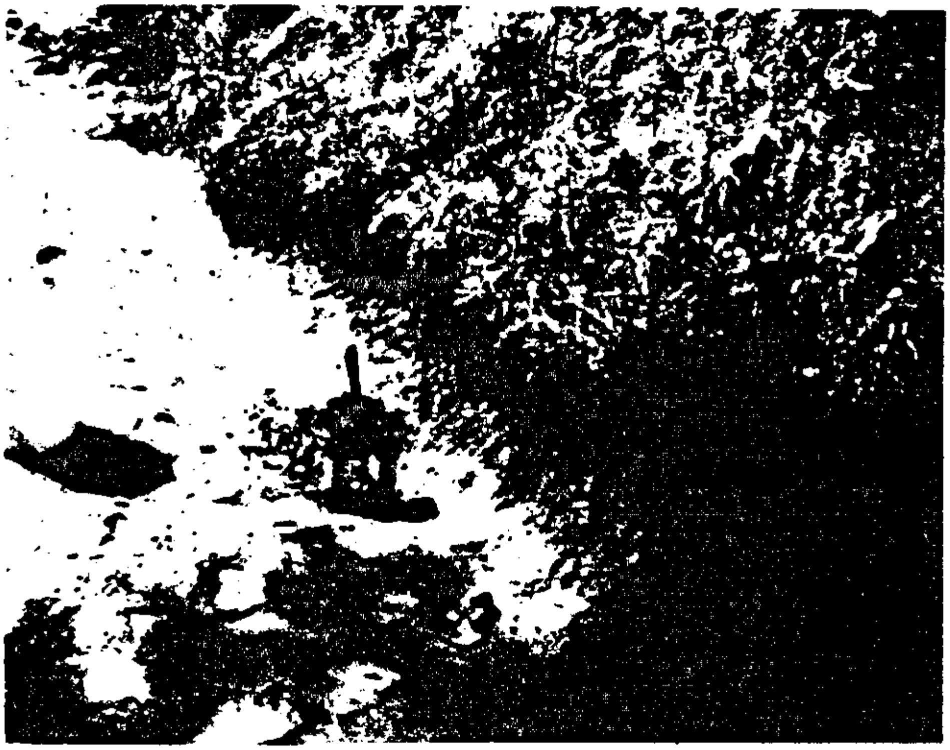

Photo 1-
Downstream Sample Location No. 4

Photo 2-
R. Gorrell and R. Werner recording

CIR BATTERY
F3-8503-29
VA-281

R1 P1
PIC 1

DOWNSTREAM SAMPLE LOCATION No 11

4/20/95

1000

ORIGINAL
(Red)

Richard J Terrell for TP
THOMAS PEARCE

R1 P1
Pic 1

CIR Battery
8503 29
VA-281

R [illegible] and R Weaver recording
[illegible] white [illegible]
[illegible]

1035

[illegible]

Photo 3-
Soil sample no. 6 (see orange clay and gray substance in background)

Photo 4-
R. Werner hand augering soil sample no. 15

C+R BATTERY
8505-24
VA-201

R1 P3
PHOTO No. 3

SOIL SAMPLE AREA (SEE ORANGE CLAY
AND GREY SUBSTANCE IN BACKGROUND)

4/23/85

ORIGINAL
(Red)

10/[illegible]

Richard J. Morrell for TP
Thomas Pearce

C+R BATTERY
# 8505-24
VA-201

R1 P5
PHOTO No. 4

R WERNER [illegible]
SAMPLE No. 15

4/23/85

Richard J. Morrell
Thomas Pearce

Photo 5-
R. Werner and E. Helmig collecting
soil sample no. 7

Photo 6-
E. Helmig hand augering soil sample
no. 12 (see white powder on surface)

CIR BATTERY
FB 8503 29
VA - 281

R1 P6
AUDIO No. 5

R WERNER AND E HERMANN
COLLECTING SOIL SAMPLE No. 7

4/23/95

1050

Richard J Garrell
RICHARD J GARRELL

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CIR BATTERY
8503 - 29
VA - 281

R1 P7
[illegible] 6

E HELMIG HAND AUGERING SOIL
SAMPLE No. 12. (SEE WHITE POWDER
SAMPLE.)

4/23/95

11[illegible]

Richard J Garrell
RICHARD J GARRELL

Photo 7-
T. Pearce and R. Gorrell collecting
groundwater sample no. 1

C&R BATTERY
8503-29
VA-281

RI FS
PHOTO No. 1

ORIGINAL
(Red)

T. PEARCE AND R. GORRELL COLLECTING
GROUNDWATER SAMPLE No. 1

4/23/85

TIME: 1130

Richard J Gorrell for RW
ROBERT WERNER

E3-8503-29

EPA

# POTENTIAL HAZARDOUS WASTE SITE
# SITE INSPECTION REPORT
## PART 1 - SITE LOCATION AND INSPECTION INFORMATION

**I. IDENTIFICATION**

| 01 STATE | 02 SITE NUMBER |
|---|---|
| VA | 281 |

**II. SITE NAME AND LOCATION**

01 SITE NAME (Legal, common, or descriptive name of site): C & R Battery

02 STREET, ROUTE NO., OR SPECIFIC LOCATION IDENTIFIER: 1320 Bellwood Road

| 03 CITY | 04 STATE | 05 ZIP CODE | 06 COUNTY | 07 COUNTY CODE | 08 CONG DIST |
|---|---|---|---|---|---|
| Richmond | VA | 23234 | Chesterfield | 760 | |

09 COORDINATES LATITUDE 37° 25' 04" LONGITUDE 77° 24' 54"

10 TYPE OF OWNERSHIP (Check one) ☒ A. PRIVATE ☐ B. FEDERAL ☐ C. STATE ☐ D. COUNTY ☐ E. MUNICIPAL ☐ F. OTHER ☐ G. UNKNOWN

**III. INSPECTION INFORMATION**

01 DATE OF INSPECTION: 04 / 23 / 85 (MONTH DAY YEAR)

02 SITE STATUS: ☐ ACTIVE ☒ INACTIVE

03 YEARS OF OPERATION: early 1970s / 1985 (BEGINNING YEAR / ENDING YEAR) ___ UNKNOWN

04 AGENCY PERFORMING INSPECTION (Check all that apply)
☐ A. EPA ☒ B. EPA CONTRACTOR NUS FIT III (Name of firm) ☐ C. MUNICIPAL ☐ D. MUNICIPAL CONTRACTOR ____ (Name of firm)
☐ E. STATE ☐ F. STATE CONTRACTOR ____ (Name of firm) ☐ G. OTHER ____ (Specify)

| 05 CHIEF INSPECTOR | 06 TITLE | 07 ORGANIZATION | 08 TELEPHONE NO. |
|---|---|---|---|
| Richard J. Gorrell | Environmental Engineer | NUS Corp. | (215) 687-951 |

| 09 OTHER INSPECTORS | 10 TITLE | 11 ORGANIZATION | 12 TELEPHONE NO. |
|---|---|---|---|
| Edmund Reardon | Environmental Engineer | NUS Corp. | (215) 687-9510 |
| Edward Helmig | Environmental Engineer | NUS Corp. | (215) 687-951 |
| Thomas Pearce | Environmental Techniciar | NUS Corp. | (215) 687-951 |
| Robert Werner | Geologist | NUS Corp. | (215) 687-951 |
| Kevin Greene | Geologist | VA State Health Dept. | (804) 225-280 |

| 13 SITE REPRESENTATIVES INTERVIEWED | 14 TITLE | 15 ADDRESS | 16 TELEPHONE NO. |
|---|---|---|---|
| Site representatives not present during site inspection | | | ( ) |
| Charles Guyton | Proprietor | P.O. Box 3715<br>Richmond, VA 23230 | (804) 271-120 |
| | | | ( ) |
| | | | ( ) |
| | | | ( ) |
| | | | ( ) |
| | | | |

| 17 ACCESS GAINED BY (Check one) | 18 TIME OF INSPECTION | 19 WEATHER CONDITIONS |
|---|---|---|
| ☒ PERMISSION<br>☐ WARRANT | 8:30 AM | Sunny, dry, 75°F |

**IV. INFORMATION AVAILABLE FROM**

| 01 CONTACT | 02 OF (Agency/Organization) | 03 TELEPHONE NO. |
|---|---|---|
| Darius Ostrauskas | U.S. EPA Region III | (215) 597-648 |

| 04 PERSON RESPONSIBLE FOR SITE INSPECTION FORM | 05 AGENCY | 06 ORGANIZATION | 07 TELEPHONE NO. | 08 DATE |
|---|---|---|---|---|
| Richard J. Gorrell | NUS Corp. | FIT III | (215) 687-9510 | 09 / 10 / 85 (MONTH DAY YEAR) |

EPA FORM 2070-13 (7-81)

ORIGINAL

EPA

# POTENTIAL HAZARDOUS WASTE SITE
# SITE INSPECTION REPORT
## PART 2 - WASTE INFORMATION

**I. IDENTIFICATION**

01 STATE: VA
02 SITE NUMBER: 281

## II. WASTE STATES, QUANTITIES, AND CHARACTERISTICS

**01 PHYSICAL STATES** (Check all that apply)

- ☒ A SOLID
- ☒ B POWDER, FINES
- ☐ C SLUDGE
- ☐ D OTHER ______ (Specify)
- ☐ E SLURRY
- ☒ F LIQUID
- ☐ G GAS

**02 WASTE QUANTITY AT SITE** (Measures of waste quantities must be independent)

TONS 171.8
CUBIC YARDS (see below)
NO. OF DRUMS ______

**03 WASTE CHARACTERISTICS** (Check all that apply)

- ☒ A TOXIC
- ☒ B CORROSIVE
- ☐ C RADIOACTIVE
- ☐ D PERSISTENT
- ☒ E SOLUBLE
- ☐ F INFECTIOUS
- ☐ G FLAMMABLE
- ☐ H IGNITABLE
- ☐ I HIGHLY VOLATILE
- ☐ J EXPLOSIVE
- ☒ K REACTIVE
- ☐ L INCOMPATIBLE
- ☐ M NOT APPLICABLE

## III. WASTE TYPE

| CATEGORY | SUBSTANCE NAME | 01 GROSS AMOUNT | 02 UNIT OF MEASURE | 03 COMMENTS |
|---|---|---|---|---|
| SLU | SLUDGE | | | |
| OLW | OILY WASTE | | | |
| SOL | SOLVENTS | | | |
| PSD | PESTICIDES | | | |
| OCC | OTHER ORGANIC CHEMICALS | | | |
| IOC | INORGANIC CHEMICALS | | | |
| ACD | ACIDS | unknown | | uncontained "puddles" of $H_2SO_4$ |
| BAS | BASES | | | |
| MES | HEAVY METALS | 171.8 | tons | based on soil analysis |

## IV. HAZARDOUS SUBSTANCES (See Appendix for most frequently cited CAS Numbers)

| 01 CATEGORY | 02 SUBSTANCE NAME | 03 CAS NUMBER | 04 STORAGE/DISPOSAL METHOD | 05 CONCENTRATION | 06 MEASURE OF CONCENTRATION |
|---|---|---|---|---|---|
| MES | lead | | contaminants found in | 62,958 | PPM |
| MES | cadmium | | on-site soils groundwater | 99 | ppm |
| MES | cyanide | | and surface drainage | 11 | ppb |
| MES | beryllium | | ways draining the site. | 124 | ppb |
| MES | mercury | | | variable | 99 ppm |
| MES | zinc | | | variable | 1,794 ppb |
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## V. FEEDSTOCKS (See Appendix for CAS Numbers)

| CATEGORY | 01 FEEDSTOCK NAME | 02 CAS NUMBER | CATEGORY | 01 FEEDSTOCK NAME | 02 CAS NUMBER |
|---|---|---|---|---|---|
| FDS | | | FDS | | |
| FDS | | | FDS | | |
| FDS | | | FDS | | |
| FDS | | | FDS | | |

## VI. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

Waste quantity based on concentrations of lead found in on-site soils and on volume of soils contained within contaminated areas. Analytical data developed by Froehling and Robertson, Inc., sample report 12/30/83. Soil volumes developed by Cobaugh, Blanton Associated for 5/23/84 site reclamation plan for C & R Battery site.

100170

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
## PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION

| 01 STATE | 02 SITE NUMBER |
|---|---|
| VA | 281 |

**II. HAZARDOUS CONDITIONS AND INCIDENTS**

01 ☐ A. GROUNDWATER CONTAMINATION — 02 ☐ OBSERVED (DATE 10/31/83) ☐ POTENTIAL ☐ ALLEGED

03 POPULATION POTENTIALLY AFFECTED 840 — 04 NARRATIVE DESCRIPTION

Approximately 221 homes have been identified within 3 miles of the site which draw groundwate from the aquifer which may be hydraulically connected to a contaminated aquifer under the C & R Battery site. 221 homes x 3.8 persons per home = 840 people.

01 ☐ B. SURFACE WATER CONTAMINATION — 02 ☐ OBSERVED (DATE 5/26/82) ☐ POTENTIAL ☐ ALLEGED

03 POPULATION POTENTIALLY AFFECTED 0 — 04 NARRATIVE DESCRIPTION

An aqueous sample, collected from an intermittent drainageway downgradient of the C & R Battery site, showed 3,440 PPB lead contamination.

01 ☐ C. CONTAMINATION OF AIR — 02 ☐ OBSERVED (DATE 8/18/83) ☐ POTENTIAL ☐ ALLEGED

03 POPULATION POTENTIALLY AFFECTED unknown — 04 NARRATIVE DESCRIPTION

Air samples collected on site by the VA OSHA during facility operation, within the breathing-zone of workers, showed elevated levels of lead.

01 ☐ D. FIRE/EXPLOSIVE CONDITIONS — 02 ☐ OBSERVED (DATE ____) ☐ POTENTIAL ☐ ALLEGED

03 POPULATION POTENTIALLY AFFECTED ____ — 04 NARRATIVE DESCRIPTION

N/A

01 ☐ E. DIRECT CONTACT — 02 ☐ OBSERVED (DATE ____) ☒ POTENTIAL ☐ ALLEGED

03 POPULATION POTENTIALLY AFFECTED 330 — 04 NARRATIVE DESCRIPTION

A small area on site, used specifically for storage of sulfuric acid which is drained from discarded batteries, was observed as entirely unrestricted to public/worker access or contact. There are 87 homes within a 1-mile radius of the site. 87 x 3.8 = 330. The potential for direct contact with lead also exists.

01 ☐ F. CONTAMINATION OF SOIL — 02 ☐ OBSERVED (DATE 12/19/83) ☐ POTENTIAL ☐ ALLEGED

03 AREA POTENTIALLY AFFECTED 4 (Acres) — 04 NARRATIVE DESCRIPTION

The C & R Battery site is approximately 4 acres in area. 26 soil samples were taken at various locations to a depth of 2 feet overthe entire area of the site. Lead contamination (between 292 PPM and 62,958) was observed in all samples obtained.

01 ☐ G. DRINKING WATER CONTAMINATION — 02 ☐ OBSERVED (DATE 10/21/83) ☐ POTENTIAL ☐ ALLEGED

03 POPULATION POTENTIALLY AFFECTED 840 — 04 NARRATIVE DESCRIPTION

An on-site well was found to have 0.74 PPM lead contamination. The population drawing from an aquifer zone which is hydraulically connected to the aquifer which the on-site well draws from, is approximately 840 (within 3 miles).

01 ☐ H. WORKER EXPOSURE/INJURY — 02 ☐ OBSERVED (DATE 9/83) ☐ POTENTIAL ☐ ALLEGED

03 WORKERS POTENTIALLY AFFECTED N/A — 04 NARRATIVE DESCRIPTION

In September 1983 an employee from the C & R Battery site was checked by the Virginia Occupational Safety and Health Administration and found to have excessive levels in blood (118 ug/dl). The site is now inactive.

01 ☐ I. POPULATION EXPOSURE/INJURY — 02 ☐ OBSERVED (DATE ____) ☒ POTENTIAL ☐ ALLEGED

03 POPULATION POTENTIALLY AFFECTED unknown — 04 NARRATIVE DESCRIPTION

There are approximately 380 persons who reside within a 1-mile radius of the C & R Battery site. This population is endangered via exposure to lead-contaminated dust from the site and via direct contact with sulfuric acid and lead on site.

ORIGINAL
(Red)

**EPA**

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
## PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

**I. IDENTIFICATION**
01 STATE VA
02 SITE NUMBER 281

**II. HAZARDOUS CONDITIONS AND INCIDENTS** (Continued)

01 ☐ J. DAMAGE TO FLORA 02 ☐ OBSERVED (DATE ______) ☒ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

Site inspections have revealed no evidence of damaged flora.

01 ☐ K. DAMAGE TO FAUNA 02 ☐ OBSERVED (DATE ______) ☒ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION (include name(s) of species)

Site inspections have revealed no evidence of damaged fauna.

01 ☐ L. CONTAMINATION OF FOOD CHAIN 02 ☐ OBSERVED (DATE ______) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

N/A

01 ☐ M. UNSTABLE CONTAINMENT OF WASTES (Spills Runoff Standing liquids Leaking drums) 02 ☐ OBSERVED (DATE 4/25/85) ☐ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED unknown 04 NARRATIVE DESCRIPTION

Sulfuric acid was observed partially contained, puddled in various locations on site. Lead contaminated soils are entirely uncontained on site.

01 ☐ N. DAMAGE TO OFFSITE PROPERTY 02 ☐ OBSERVED (DATE ______) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

N/A

01 ☐ O. CONTAMINATION OF SEWERS, STORM DRAINS, WWTPs 02 ☐ OBSERVED (DATE ______) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

N/A

01 ☐ P. ILLEGAL/UNAUTHORIZED DUMPING 02 ☐ OBSERVED (DATE ______) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

N/A

05 DESCRIPTION OF ANY OTHER KNOWN, POTENTIAL, OR ALLEGED HAZARDS The most significant hazard associated with the site include the risk to those who may be subjected to long term inhalation of dust from the site. Additional risks, in the immediate short term, exist to those who may come into direct contact with sulfuric acid on site.

**III. TOTAL POPULATION POTENTIALLY AFFECTED:** see below

**IV. COMMENTS**

Documented conditions associated with C & R Battery site have created several significant public health hazards. The total population affected by the site is variable depending on hazardous substance transport routes from the site.

**V. SOURCES OF INFORMATION** (Cite specific references, e.g., state files, sample analysis, reports)

NUS FIT III 8/20/84, 3/27/85, and 4/22/85 site inspections at the C & R Battery facility
VA Water Control Board file information, C & R Battery site
VA Occupational Safety and Health Administration file information, C & R Battery site

EPA FORM 2070-13 (7-81)

EPA

# POTENTIAL HAZARDOUS WASTE SITE
# SITE INSPECTION
## PART 4 - PERMIT AND DESCRIPTIVE INFORMATION

**I. IDENTIFICATION**

| 01 STATE | 02 SITE NUMBER |
|---|---|
| VA | 281 |

## II. PERMIT INFORMATION

| 01 TYPE OF PERMIT ISSUED (Check all that apply) | 02 PERMIT NUMBER | 03 DATE ISSUED | 04 EXPIRATION DATE | 05 COMMENTS |
|---|---|---|---|---|
| ☐ A. NPDES | | | | Interim status |
| ☐ B. UIC | VA0058459 | | | |
| ☐ C. AIR | | | | |
| ☐ D. RCRA | | | | |
| ☐ E. RCRA INTERIM STATUS | | | | |
| ☐ F. SPCC PLAN | | | | |
| ☐ G. STATE (Specify) | | | | |
| ☐ H. LOCAL (Specify) | | | | |
| ☐ I. OTHER (Specify) | | | | |
| ☐ J. NONE | | | | |

## III. SITE DESCRIPTION

| 01 STORAGE/DISPOSAL (Check all that apply) | 02 AMOUNT | 03 UNIT OF MEASURE |
|---|---|---|
| ☒ A. SURFACE IMPOUNDMENT | unknown | |
| ☒ B. PILES | | |
| ☐ C. DRUMS, ABOVE GROUND | | |
| ☐ D. TANK, ABOVE GROUND | | |
| ☐ E. TANK, BELOW GROUND | | |
| ☐ F. LANDFILL | | |
| ☐ G. LANDFARM | | |
| ☐ H. OPEN DUMP | | |
| ☒ I. OTHER contaminated soil (Specify) | 172 tons | |

04 TREATMENT (Check all that apply)

- ☐ A. INCINERATION
- ☐ B. UNDERGROUND INJECTION
- ☐ C. CHEMICAL/PHYSICAL
- ☐ D. BIOLOGICAL
- ☐ E. WASTE OIL PROCESSING
- ☐ F. SOLVENT RECOVERY
- ☐ G. OTHER RECYCLING/RECOVERY
- ☐ H. OTHER ________ (Specify)

05 OTHER

☒ A. BUILDINGS ON SITE

06 AREA OF SITE

4 (Acres)

07 COMMENTS The C&R Battery site, approximately 4 acres in size, is a relatively flat, open parcel of land located within a somewhat sparsely populated area. The chief activities on site have been lead reclamation from discarded batteries. A saw/breaker facilitates the reclamation process. Sulfuric acid is drained and stored in open areas on site. Lead sulfide and raw lead is stored in piles and/or drums. The site was active during initial site visits. Reports from VA WCB are that is is now abandoned.

## IV. CONTAINMENT

01 CONTAINMENT OF WASTES (Check one)

☐ A. ADEQUATE, SECURE ☐ B. MODERATE ☒ C. INADEQUATE, POOR ☐ D. INSECURE, UNSOUND, DANGEROUS

02 DESCRIPTION OF DRUMS, DIKING, LINERS, BARRIERS, ETC.

According to the site operator, a concrete PAD has been constructed under the battery breaker. The integrity of this PAD is questionable. The operator has constructed an earthen dike, approximately 3 ft. high, which extends along the eastern border of the site between the breaker and an intermittent drainageway. The length of the ditch and its integrity is inadequate to contain site runoff.

## V. ACCESSIBILITY

01 WASTE EASILY ACCESSIBLE ☒ YES ☐ NO

02 COMMENTS

Sulfuric acid pond/puddles were easily accessible during field investigations. Lead contaminated soils are entirely uncontained on site.

## VI. SOURCES OF INFORMATION (Cite specific references, e.g. state files, sample analysis, reports)

NUS FIT III 8/20,84, 3/27/85, and 4/23/85 site inspections at the C & R Battery site
VA Control Board file information on the C & R Battery site

EPA FORM 2070-13 (7-81)

ORIGINAL
(Red)

**EPA**

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
## PART 5 - WATER, DEMOGRAPHIC, AND ENVIRONMENTAL DATA

**I. IDENTIFICATION**

| 01 STATE | 02 SITE NUMBER |
|---|---|
| VA | 281 |

## II. DRINKING WATER SUPPLY

01 TYPE OF DRINKING SUPPLY *(Check as applicable)*

| | SURFACE | WELL |
|---|---|---|
| COMMUNITY | A. ☒ | B. ☐ |
| NON-COMMUNITY | C. ☐ | D. ☒ |

02 STATUS

| ENDANGERED | AFFECTED | MONITORED |
|---|---|---|
| A. ☐ | B. ☐ | C. ☒ |
| D. ☒ | E. ☒ | F. ☐ |

03 DISTANCE TO SITE

A. ≥10 (mi)
B. ≤ 3 (mi)

## III. GROUNDWATER

01 GROUNDWATER USE IN VICINITY *(Check one)*

☒ A. ONLY SOURCE FOR DRINKING
☐ B. DRINKING *(Other sources available)* COMMERCIAL, INDUSTRIAL, IRRIGATION *(No other water sources available)*
☐ C. COMMERCIAL, INDUSTRIAL, IRRIGATION *(Limited other sources available)*
☐ D. NOT USED, UNUSEABLE

02 POPULATION SERVED BY GROUND WATER 840 (within 3 miles)

03 DISTANCE TO NEAREST DRINKING WATER WELL <1,000 ft. (mi)

04 DEPTH TO GROUNDWATER 35 to 40 (ft)

05 DIRECTION OF GROUNDWATER FLOW southeast

06 DEPTH TO AQUIFER OF CONCERN unknown (ft)

07 POTENTIAL YIELD OF AQUIFER unknown (gpd)

08 SOLE SOURCE AQUIFER ☐ YES ☒ NO

09 DESCRIPTION OF WELLS *(Including usage, depth, and location relative to population and buildings)*

Depth to groundwater described above is applicable to an on-site monitoring well. Field reconnaissance within the vicinity of the site have indicated numerous private supply wells wit 3 miles of the site. Limited information indicates the probability of multiple flow zones within this area of VA. A hydraulic connection between zones has not been proven or disproven.

10 RECHARGE AREA
☒ YES
☐ NO
COMMENTS Available information indicates that the site is located within a recharge area to the Patuxent aquifer.

11 DISCHARGE AREA
☐ YES
☒ NO
COMMENTS

## IV. SURFACE WATER

01 SURFACE WATER USE *(Check one)*

☒ A. RESERVOIR, RECREATION DRINKING WATER SOURCE
☐ B. IRRIGATION, ECONOMICALLY IMPORTANT RESOURCES
☐ C. COMMERCIAL, INDUSTRIAL
☐ D. NOT CURRENTLY USED

02 AFFECTED/POTENTIALLY AFFECTED BODIES OF WATER

| NAME | AFFECTED | DISTANCE TO SITE |
|---|---|---|
| Unnamed, intermittent tributary to the James River | ☒ | <1,000 ft. (m |
| James River | ☐ | 600 ft. (mi) |
| | ☐ | (m |

## V. DEMOGRAPHIC AND PROPERTY INFORMATION

01 TOTAL POPULATION WITHIN

| ONE (1) MILE OF SITE | TWO (2) MILES OF SITE | THREE (3) MILES OF SITE |
|---|---|---|
| A. 330<br>NO. OF PERSONS | B. unknown<br>NO. OF PERSONS | C. unknown<br>NO. OF PERSONS |

02 DISTANCE TO NEAREST POPULATION <1.0 mile (mi)

03 NUMBER OF BUILDINGS WITHIN TWO (2) MILES OF SITE >300

04 DISTANCE TO NEAREST OFF-SITE BUILDING <2,000 ft. (mi)

05 POPULATION WITHIN VICINITY OF SITE *(Provide narrative description of nature of population within vicinity of site, e.g., rural, village, densely populated urban area)*

The population distribution within the area of the site is generally sparse characterized as suburban residential/industrial. Population distribution becomes more dense within those areas west of the site. The corider along Route 1-301 is densely developed residential and commercial.

ORIGINAL

EPA

# POTENTIAL HAZARDOUS WASTE SITE
# SITE INSPECTION REPORT
## PART 5 - WATER, DEMOGRAPHIC, AND ENVIRONMENTAL DATA

**I. IDENTIFICATION**

01 STATE: VA

02 SITE NUMBER: 281

## VI. ENVIRONMENTAL INFORMATION

01 PERMEABILITY OF UNSATURATED ZONE (Check one)

unknown ☐ A. $10^{-6} - 10^{-8}$ cm/sec ☐ B. $10^{-4} - 10^{-6}$ cm/sec ☐ C. $10^{-4} - 10^{-3}$ cm/sec ☐ D. GREATER THAN $10^{-3}$ cm/sec

02 PERMEABILITY OF BEDROCK (Check one)

unknown ☐ A. IMPERMEABLE (Less than $10^{-6}$ cm/sec) ☐ B. RELATIVELY IMPERMEABLE ($10^{-4} - 10^{-6}$ cm/sec) ☐ C. RELATIVELY PERMEABLE ($10^{-2} - 10^{-4}$ cm/sec) ☐ D. VERY PERMEABLE (Greater than $10^{-2}$ cm/sec)

03 DEPTH TO BEDROCK: unknown (ft)

04 DEPTH OF CONTAMINATED SOIL ZONE: at least 2 feet (ft)

05 SOIL pH: 3.5 to 12.3

06 NET PRECIPITATION: 8 (in)

07 ONE YEAR 24 HOUR RAINFALL: 2.8 (in)

08 SLOPE

SITE SLOPE: 3 to 5 %

DIRECTION OF SITE SLOPE: northeast

TERRAIN AVERAGE SLOPE: 3 to 5 %

09 FLOOD POTENTIAL

SITE IS IN N/A YEAR FLOODPLAIN

10 N/A ☐ SITE IS ON BARRIER ISLAND, COASTAL HIGH HAZARD AREA, RIVERINE FLOODWAY

11 DISTANCE TO WETLANDS (5 acre minimum)

ESTUARINE A. >3.0 (mi)

OTHER B. >3.0 (mi)

12 DISTANCE TO CRITICAL HABITAT (of endangered species)

>3.0 (mi)

ENDANGERED SPECIES:

13 LAND USE IN VICINITY

DISTANCE TO:

COMMERCIAL/INDUSTRIAL A. <1.0 (mi)

RESIDENTIAL AREAS; NATIONAL/STATE PARKS, FORESTS, OR WILDLIFE RESERVES B. <1.0 (mi)

AGRICULTURAL LANDS

PRIME AG LAND C. unknown (mi)

AG LAND D. <1.0 (mi)

14 DESCRIPTION OF SITE IN RELATION TO SURROUNDING TOPOGRAPHY

The site is generally topographically similar to surrounding properties. The general vicinity is relatively flat with steeper slopes associated with land bordering the James River to the north.

## VII. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

NUS FIT III 8/20/84, 3/27/85, and 4/23/85 site inspections at the C& R Battery site
Uncontrolled Hazardous Waste Site Ranking System; User's Manual
U.S.G.S Topographic Map; 7.5 minute series, Drewry's Bluff, VA 1980 photorevised
VA WCB file information on the C & R Battery site
Hyrogeological interpretation developed by M. Plitnick, US EPA Region III

ORIGINAL
(Red)

**EPA**

## POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 6 - SAMPLE AND FIELD INFORMATION

**I. IDENTIFICATION**
01 STATE VA
02 SITE NUMBER 281

### II. SAMPLES TAKEN

| SAMPLE TYPE | 01 NUMBER OF SAMPLES TAKEN | 02 SAMPLES SENT TO | 03 ESTIMATED DA RESULTS AVAI |
|---|---|---|---|
| GROUNDWATER | numerous | periodic samples collected by VA WCB & operat | ors current |
| SURFACE WATER | numerous | " " " " " " | availab<br>" |
| WASTE | | | |
| AIR | numerous | air monitoring in breathing zone on site by VAO | SHA |
| RUNOFF | | | |
| SPILL | | | |
| SOIL | numerous | site reclamation plan include augers to 2 ft. | currentl<br>available |
| VEGETATION | | | |
| OTHER | NUS FIT III c<br>groundwater | ollected on site groundwater samples, off site back<br>samples, on-site soils, and off-site background soi | gorund<br>s, see bel |

### III. FIELD MEASUREMENTS TAKEN

| 01 TYPE | 02 COMMENTS |
|---|---|
| depth to groundwater | measured with well sounder by NUS FIT on 4/23/85 (see below) |
| | |
| | |
| | |
| | |

### IV. PHOTOGRAPHS AND MAPS

01 TYPE ☒ GROUND ☐ AERIAL

02 IN CUSTODY OF NUS FIT III F3-8505-29 US EPA III, VA 281
(Name of organization or individual)

03 MAPS
☒ YES
☐ NO

04 LOCATION OF MAPS Prelilminary Assessment F3-8407-32, Field Trip Report F3-8503-29, HRS, F3-8505-370

### V. OTHER FIELD DATA COLLECTED (Provide narrative description)

On 4/23/85 FIT III performed a standard site inspection at the C & R Battery site. In all, 12 aqueous and 11 solid samples were obtained,including blanks, duplicates, filtered groundwater samples, background groundwater samples,and background soil samples. Refer to section 6 of the site inspection report under TDD no. 8503-29. For analytical results of samples collected-

Water Levels in on-site Monitoring Wells: W-1-26
(as measured on 4/23/85) W-2-dry
W-11-dry

### VI. SOURCES OF INFORMATION (Cite specific references, e.g. state files, sample analysis, reports)

NUS FIT III 4/23/85 site inspection of the C&R Battery site (F3-8507-29)
VA WCB file information, C&R Battery site

EPA FORM 2070-13 (7-81)

**EPA**

# POTENTIAL HAZARDOUS WASTE SITE
# SITE INSPECTION REPORT
## PART 7 - OWNER INFORMATION

**I. IDENTIFICATION**

| 01 STATE | 02 SITE NUMBER |
|---|---|
| VA | 281 |

**II. CURRENT OWNER(S)**

01 NAME: William and Edward Zacharias
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.): 1306 Bellwood Road
04 SIC CODE:
05 CITY: Richmond
06 STATE: VA
07 ZIP CODE: 23234

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.):
04 SIC CODE:
05 CITY:
06 STATE:
07 ZIP CODE:

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.):
04 SIC CODE:
05 CITY:
06 STATE:
07 ZIP CODE:

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.):
04 SIC CODE:
05 CITY:
06 STATE:
07 ZIP CODE:

**PARENT COMPANY** (If applicable)

08 NAME: N/A
09 D+B NUMBER:
10 STREET ADDRESS (P.O. Box, RFD #, etc.):
11 SIC CODE:
12 CITY:
13 STATE:
14 ZIP CODE:

08 NAME: N/A
09 D+B NUMBER:
10 STREET ADDRESS (P.O. Box, RFD #, etc.):
11 SIC CODE:
12 CITY:
13 STATE:
14 ZIP CODE:

08 NAME: N/A
09 D+B NUMBER:
10 STREET ADDRESS (P.O. Box, RFD #, etc.):
11 SIC CODE:
12 CITY:
13 STATE:
14 ZIP CODE:

08 NAME: N/A
09 D+B NUMBER:
10 STREET ADDRESS (P.O. Box, RFD #, etc.):
11 SIC CODE:
12 CITY:
13 STATE:
14 ZIP CODE:

**III. PREVIOUS OWNER(S)** (List most recent first)

01 NAME: Unknown
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.):
04 SIC CODE:
05 CITY:
06 STATE:
07 ZIP CODE:

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.):
04 SIC CODE:
05 CITY:
06 STATE:
07 ZIP CODE:

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.):
04 SIC CODE:
05 CITY:
06 STATE:
07 ZIP CODE:

**IV. REALTY OWNER(S)** (If applicable; list most recent first)

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.):
04 SIC CODE:
05 CITY:
06 STATE:
07 ZIP CODE:

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.):
04 SIC CODE:
05 CITY:
06 STATE:
07 ZIP CODE:

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.):
04 SIC CODE:
05 CITY:
06 STATE:
07 ZIP CODE:

**V. SOURCES OF INFORMATION** (Cite specific references, e.g., state files, sample analysis, reports)

VA WCB file information on the C&R Battery site

EPA FORM 2070-13 (7-81)

**EPA**

# POTENTIAL HAZARDOUS WASTE SITE
# SITE INSPECTION REPORT
## PART 8 - OPERATOR INFORMATION

**I. IDENTIFICATION**

01 STATE: VA
02 SITE NUMBER: 281

## II. CURRENT OPERATOR (Provide if different from owner)

01 NAME: Inactive
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.):
04 SIC CODE:
05 CITY:
06 STATE:
07 ZIP CODE:
08 YEARS OF OPERATION:
09 NAME OF OWNER:

## OPERATOR'S PARENT COMPANY (If applicable)

10 NAME: N/A
11 D+B NUMBER:
12 STREET ADDRESS (P.O. Box, RFD #, etc.):
13 SIC CODE:
14 CITY:
15 STATE:
16 ZIP CODE:

## III. PREVIOUS OPERATOR(S) (List most recent first; provide only if different from owner)

01 NAME: Charles Guyton
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.): P.O. Box 3715
04 SIC CODE:
05 CITY: Richmond
06 STATE: VA
07 ZIP CODE: 23230
08 YEARS OF OPERATION: 15
09 NAME OF OWNER DURING THIS PERIOD: Charles Guyton

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.):
04 SIC CODE:
05 CITY:
06 STATE:
07 ZIP CODE:
08 YEARS OF OPERATION:
09 NAME OF OWNER DURING THIS PERIOD:

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.):
04 SIC CODE:
05 CITY:
06 STATE:
07 ZIP CODE:
08 YEARS OF OPERATION:
09 NAME OF OWNER DURING THIS PERIOD:

## PREVIOUS OPERATORS' PARENT COMPANIES (If applicable)

10 NAME: N/A
11 D+B NUMBER:
12 STREET ADDRESS (P.O. Box, RFD #, etc.):
13 SIC CODE:
14 CITY:
15 STATE:
16 ZIP CODE:

10 NAME: N/A
11 D+B NUMBER:
12 STREET ADDRESS (P.O. Box, RFD #, etc.):
13 SIC CODE:
14 CITY:
15 STATE:
16 ZIP CODE:

10 NAME: N/A
11 D+B NUMBER:
12 STREET ADDRESS (P.O. Box, RFD #, etc.):
13 SIC CODE:
14 CITY:
15 STATE:
16 ZIP CODE:

## IV. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

NUS FIT III Preliminary Assessment (F3-8407-32), Non-sampling Site Reconnaissance (F3-8502-13), Site Inspection (F3-8503-29), HRS (F3-8505-37).
EPA File Information VA 281
VA WCB File Information for the C & R Battery site

**EPA**

# POTENTIAL HAZARDOUS WASTE SITE
# SITE INSPECTION REPORT
## PART 10 - PAST RESPONSE ACTIVITIES

**I. IDENTIFICATION**
01 STATE VA
02 SITE NUMBER 281

**II. PAST RESPONSE ACTIVITIES**

01 ☐ A. WATER SUPPLY CLOSED 02 DATE ______ 03 AGENCY ______
04 DESCRIPTION
unknown

01 ☐ B. TEMPORARY WATER SUPPLY PROVIDED 02 DATE ______ 03 AGENCY ______
04 DESCRIPTION
unknown

01 ☐ C. PERMANENT WATER SUPPLY PROVIDED 02 DATE ______ 03 AGENCY ______
04 DESCRIPTION
unknown

01 ☐ D. SPILLED MATERIAL REMOVED 02 DATE ______ 03 AGENCY ______
04 DESCRIPTION
unknown, not reported

01 ☐ E. CONTAMINATED SOIL REMOVED 02 DATE ______ 03 AGENCY ______
04 DESCRIPTION
unknown, not reported

01 ☐ F. WASTE REPACKAGED 02 DATE ______ 03 AGENCY ______
04 DESCRIPTION
N/A

01 ☐ G. WASTE DISPOSED ELSEWHERE 02 DATE ______ 03 AGENCY ______
04 DESCRIPTION
N/A

01 ☐ H. ON SITE BURIAL 02 DATE 4/23/85 03 AGENCY NUS FIT III, EPA
04 DESCRIPTION Site inspection revealed buried battery casings located within the northern portion of the C&R site

01 ☐ I. IN SITU CHEMICAL TREATMENT 02 DATE ______ 03 AGENCY ______
04 DESCRIPTION
N/A (proposed but nevr implemented)

01 ☐ J. IN SITU BIOLOGICAL TREATMENT 02 DATE ______ 03 AGENCY ______
04 DESCRIPTION
N/A

01 ☐ K. IN SITU PHYSICAL TREATMENT 02 DATE ______ 03 AGENCY ______
04 DESCRIPTION
N/A

01 ☐ L. ENCAPSULATION 02 DATE ______ 03 AGENCY ______
04 DESCRIPTION
N/A

01 ☐ M. EMERGENCY WASTE TREATMENT 02 DATE ______ 03 AGENCY ______
04 DESCRIPTION
N/A

01 ☐ N. CUTOFF WALLS 02 DATE ______ 03 AGENCY ______
04 DESCRIPTION
N/A

01 ☐ O. EMERGENCY DIKING/SURFACE WATER DIVERSION 02 DATE unknown 03 AGENCY operator
04 DESCRIPTION The operator constructed anearthen dike between battery breaker and drainage way. Action in response to state requirement.

01 ☐ P. CUTOFF TRENCHES/SUMP 02 DATE ______ 03 AGENCY ______
04 DESCRIPTION
N/A

01 ☐ Q. SUBSURFACE CUTOFF WALL 02 DATE ______ 03 AGENCY ______
04 DESCRIPTION
N/A

EPA FORM 2070-13 (7-81)

EPA

# POTENTIAL HAZARDOUS WASTE SITE
# SITE INSPECTION REPORT
## PART 9 - GENERATOR/TRANSPORTER INFORMATION

**I. IDENTIFICATION**

| 01 STATE | 02 SITE NUMBER |
|---|---|
| VA | 281 |

## II. ON-SITE GENERATOR

01 NAME: C & R Battery, Charles Guyton
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.): P.O. Box 3715
04 SIC CODE:
05 CITY: Richmond
06 STATE: VA
07 ZIP CODE: 23230

## III. OFF-SITE GENERATOR(S)

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.)
04 SIC CODE
05 CITY
06 STATE
07 ZIP CODE

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.)
04 SIC CODE
05 CITY
06 STATE
07 ZIP CODE

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.)
04 SIC CODE
05 CITY
06 STATE
07 ZIP CODE

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.)
04 SIC CODE
05 CITY
06 STATE
07 ZIP CODE

## IV. TRANSPORTER(S)

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.)
04 SIC CODE
05 CITY
06 STATE
07 ZIP CODE

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.)
04 SIC CODE
05 CITY
06 STATE
07 ZIP CODE

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.)
04 SIC CODE
05 CITY
06 STATE
07 ZIP CODE

01 NAME: N/A
02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.)
04 SIC CODE
05 CITY
06 STATE
07 ZIP CODE

## V. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

(see section 8, operator information)

[illegible]
(Red)

**EPA**

# POTENTIAL HAZARDOUS WASTE SITE
# SITE INSPECTION REPORT
## PART 10 - PAST RESPONSE ACTIVITIES

**I. IDENTIFICATION**
01 STATE: VA
02 SITE NUMBER: 281

**II. PAST RESPONSE ACTIVITIES** (Continued)

01 ☐ R. BARRIER WALLS CONSTRUCTED 02 DATE ________ 03 AGENCY ________
04 DESCRIPTION
N/A

01 ☐ S. CAPPING/COVERING 02 DATE unknown 03 AGENCY operator
04 DESCRIPTION According to site operator, a clay cap was placed over the northern portion of the site.

01 ☐ T. BULK TANKAGE REPAIRED 02 DATE ________ 03 AGENCY ________
04 DESCRIPTION
N/A

01 ☐ U. GROUT CURTAIN CONSTRUCTED 02 DATE ________ 03 AGENCY ________
04 DESCRIPTION
N/A

01 ☐ V. BOTTOM SEALED 02 DATE ________ 03 AGENCY ________
04 DESCRIPTION
N/A

01 ☐ W. GAS CONTROL 02 DATE ________ 03 AGENCY ________
04 DESCRIPTION
N/A

01 ☐ X. FIRE CONTROL 02 DATE ________ 03 AGENCY ________
04 DESCRIPTION
N/A

01 ☐ Y. LEACHATE TREATMENT 02 DATE ________ 03 AGENCY ________
04 DESCRIPTION
N/A

01 ☐ Z. AREA EVACUATED 02 DATE ________ 03 AGENCY ________
04 DESCRIPTION
N/A

01 ☐ 1. ACCESS TO SITE RESTRICTED 02 DATE ________ 03 AGENCY ________
04 DESCRIPTION
N/A

01 ☐ 2. POPULATION RELOCATED 02 DATE ________ 03 AGENCY ________
04 DESCRIPTION
N/A

01 ☐ 3. OTHER REMEDIAL ACTIVITIES 02 DATE 1983 03 AGENCY operator
04 DESCRIPTION

As a part of its regulatory authority, the VA SWCB requested a site reclamation plan and a wastewater discharge permit application from the C&R Battery operator. The operator subsequently procured an engineering firm to prepare the applicable documents. As of 8/20/84, the VA SWCB had received several amendments to the proposed site reclamation plan, but had not approved any submission. During some time in late 1983 or early 1984, the operator took it upon himself to initiate reclamation. According to the operator's reports, battery casings have been removed , surface soils have been excavated, lime has been applied,and a clay cap has been placed over the northern area of the site.

**III. SOURCES OF INFORMATION** (Cite specific references, e.g., state files, sample analysis, reports)

NUS FIT III Preliminary Assessment (F3-8407-32)
Statemetns made by Mr.Charles Buyton, Site Operator
VA SWCB File Information of the C&R Battery site

EPA FORM 2070-13 (7-81)

ORIGINAL
(Red)

**EPA**

# POTENTIAL HAZARDOUS WASTE SITE
# SITE INSPECTION REPORT
## PART 11 - ENFORCEMENT INFORMATION

| I. IDENTIFICATION | |
|---|---|
| 01 STATE | 02 SITE NUMBER |
| VA | 281 |

## II. ENFORCEMENT INFORMATION

01 PAST REGULATORY/ENFORCEMENT ACTION ☒ YES ☐ NO

02 DESCRIPTION OF FEDERAL, STATE, LOCAL REGULATORY/ENFORCEMENT ACTION

FEDERAL: EPA initiated applicable preliminary assessment report, non-sampling site reconnaissance report, site inspection report, and hazard ranking system reports. Refer to EPA file VA 281 for details.

STATE: VA SWCB has had extensive involvement with the site beginning in the late 1970s. Generally, orders for the submission of wastewater treatment permit. application, a site reclamation plan have been issued to the operator. Upon several submissions of proposed reclamation plans, ammended permit applications, the operator has of yet to be declared in compliance. Subsequent court orders have been issued and several court appearances have been made in relation to the Water Control Board's attempts at bringing the site into compliance. As of the latest date of site operation (early 1985) compliance had not been achieved. The WCB noted serious concerns over the financial stability of C&R Batery and its ultimate ability to assume the cost of site reclamation.

VA Occupational Safety and Health Administration has also had extensive involvement with the C&R Battery site. According to Mr. Richard Anderson of VAOSHA, his first inspection of the site in 1983 revealed numerous violations of current OSHA standards. Air monitoring of the breathing zone on site, at several work stations, have indicated conditions well above existing standards (standard for lead is 50 ug/cu meter). Levels have been measured at ranges from 5 to 112 ug/cubic meters. Additionally, employees at the site have been found to have elevated levels of lead in blood samples. According to Mr. Anderson, excessive fines have been issued to the operator for non compliance. (Although not confirmed, penalties in excess of $ 60,000 have been issued.)

## III. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

VA SWCB file information on the C&R Battery site
Mr. Richard Anderson, Inspector, VA Occupational Safety and Health Administration
(804) 786-6285

ORIGINAL
(Red)

# SECTION 6

## 6.0 LABORATORY DATA

### 6.1 Sample Data Summary

The sample data summary correctly identifies sample MCB239 as a field duplicate of sample MCB234. However, the attached Quailty Assurance Review lists MCB238 and MCB239 as field duplicates, due to an error on the NUS sample shipping log which was not identified until after receipt of the Quality Assurance Review from EPA Central Regional Laboratory.

## SAMPLE DATA SUMMARY
## TARGET COMPOUNDS

TDD Number F3-8503-29
EPA Number Case # 4265 VA-281

☐ Organic ■ Inorganic

Site Name C&R Battery
Date of Sample 4-23-85
revised 7-9-85

Compounds Detected

| Sample Number | Sample Description and Location | Phase | Units | ALUMINUM | ANTIMONY | ARSENIC | BARIUM | BERYLLIUM | CADMIUM | CALCIUM | CHROMIUM | COBALT | COPPER | IRON | LEAD | MAGNESIUM | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MCB 311 | Duplicate (244) | AQ | ug/l | UJ 159. | | | | | | 132300. | | | | UJ 314. | | 8340. | ON SITE WELL - No. 1 FILTERED |
| MCB 242 | ON SITE WELL No. 2 | AQ | ug/l | 1649. | | | | 5.0 | 6.6 | 33110. | | J 28. | | J 6198. | R 16. | 20610. | ON SITE WELL No 2 FILTERED |
| MCB 244 | Duplicate (311) | AQ | ug/l | UJ 153. | | | | | | 118800. | | | | UJ 188. | R 23. | 8119. | ON SITE WELL No 2A FILTERED |
| MCB 245 | Blank | AQ | ug/l | UJ 85. | | | | | | 894. | | | | UJ 105. | | | |
| MCB 226 | Duplicate (228) | AQ | ug/l | 823. | | | | | | 117500. | | | | UJ 2020. | R 326. | 7949. | ON SITE WELL No 1 |
| MCB 227 | ON SITE WELL No. 2 | AQ | ug/l | 458500. | | 80. J | 2466. | 124. | 90. | 30870. | 701. | J 135. | 571. | J 1338000. | J 2157. | 34600. | ON SITE WELL No 2 |
| MCB 223 | Duplicate (226) | AQ | ug/l | UJ 469. | | | | | | 116400. | | | | UJ 2743. | | 7746. | ON SITE WELL No. 2A |
| MCB 230 | Blank | AQ | ug/l | UJ 135. | | | | | | 232. | | | | UJ 658. | | 160. | DRINKING |
| MCB 24[illegible] | HOME WELL No 8 | AQ | ug/l | UJ 123. | | | | | | 15340. | | | | UJ 654. | | 6017. | DRINKING |
| MCB 248 | HOME WELL No. 10 | AQ | ug/l | UJ 89. | | | | | | 8544. | | | 28. | UJ 166. | | 882. | DRINKING |
| MCB 249 | HOME WELL No. 11 | AQ | ug/l | UJ 245. | | | | | | 9831. | | | | J 3971. | | 7179. | |
| MCB 231 | UPSTREAM No. 3 | sol. | mg/kg | 30913. | | | J 153. | J 4.0 | J 3.[illegible] | 3061. | J 33. | 16. | | 36271. | J 530. | 47737. | |
| MCB 232 | DOWNSTREAM No 4 | sol. | mg/kg | 13694. | | | J 27. | | 6.2 J | 264. | 30. J | | | 10570. | J 544. | 1562. | |
| MCB 233 | ON SITE SOIL No. 7 | sol. | [illegible] | [illegible] | 641. R | 24. J | J 100. | | 8.5 J | 63035. | 13. J | | 74. J | 13107. | J 4900[illegible]. | 19[illegible]. | |

NOTE: For a review of this data and non-target, tentatively identified compounds, please see the Analytical Quality Assurance section of this report.

◇ Denotes results of questionable qualitative significance based upon quality assurance review of data.

TDO Number F3-8503-29
EPA Number Case # 4265 VA-281

## SAMPLE DATA SUMMARY
## TARGET COMPOUNDS

☐ Organic ■ Inorganic

Site Name C&R Battery
Date of Sample 4-23-85
revised 7-9-85

Compounds Detected

| Sample Number | Sample Description and Location | Phase | Units | ALUMINUM | ANTIMONY | ARSENIC | BARIUM | BERYLLIUM | CADMIUM | CALCIUM | CHROMIUM | COBALT | COPPER | IRON | LEAD | MAGNESIUM | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mcb 234 | ON SITE SOIL No 6 (239) | sol. | mg/kg | 8137. | R 194. | J 19. | J 85. |  | J 60. | 95922. | J 8.2 |  | J 91. | 10063. | J 38119. | 1600. |  |
| mcb 235 | ON SITE SOIL No 12 | sol. | mg/kg | 8506. | R 200. | J 12. | J 96. |  | J 18. | 222256. | J 10. |  | J 59. | 9891. | J 40494. | 2212 |  |
| mcb 236 | ON SITE SOIL No. 13 | sol. | mg/kg | 11575. | R 245. | J 39. | J 103. |  | J 96. | 121512. | J 20. |  | J 108. | 14993. | J 67731. | 2896. |  |
| mcb 237 | ON SITE SOIL No. 14 | sol. | mg/kg | 1992. | R 2027. | J 60. | J 49. |  | J 21. | 11749. | J 5.2 |  | J 28. | 6591. | J 57100. | 658. |  |
| mcb 238 | ON site Soil No. 15 | sol. | mg/kg | 8464. | R 50. | J 8.4 | J 69. |  | J 12. | 25218. | J 15. |  | J 39. | 12956. | J 27659. | 855. |  |
| mcb 239 | Duplicate (234) | sol. | mg/kg | 11114. | R 346. | R 103. | J 63. |  | J 99. | 153273 | J 19. |  | J 140. | 15125. | J 35084 | 2947. |  |
| mcb 240 | Blank | sol. | mg/kg |  |  |  |  |  |  |  |  |  |  |  | 25. |  |  |
| mcb 241 | BACKGROUND SOIL | sol. | mg/kg | 14995. |  | J 38. | J 101. | J 2.7 |  | 445. | J 15. |  |  | 20756. | J 182. | 1723. |  |
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NOTE: For a review of this data and non-target, tentatively identified compounds, please see the Analytical Quality Assurance section of this report.

◇ Denotes results of questionable qualitative significance based upon quality assurance review of data.

## SAMPLE DATA SUMMARY
## TARGET COMPOUNDS

TDD Number E3-8503-29
EPA Number Case # 4265 VA-281

☐ Organic ☒ Inorganic

Site Name C&R Battery
Date of Sample 4-23-85
revised 7-9-85

Compounds Detected

| Sample Number | Sample Description and Location | Phase | Units | MANGANESE | MERCURY | NICKEL | POTASSIUM | SELENIUM | SILVER | SODIUM | THALLIUM | TIN | VANADIUM | ZINC | CYANIDE | % SOLIDS | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MCB 311 | Duplicate (244) | AQ | ug/l | J. 358. | | | 5558. | | | 21980. | | | | UJ 139. | | | ON SITE WELL NO. 1 FILTERED |
| MCB 242 | ON SITE WELL No. 2 | AQ | ug/l | J 3063. | | 110. | 1909. | | | 17983. | | | | 358. | | | ON SITE WELL No 2 FILTERED |
| MCB 244 | Duplicate (311) | AQ | ug/l | J 355. | | | 5373. | | | 21200. | | | | UJ. 89. | | | ON SITE WELL NO 2A FILTERED |
| MCB 245 | Blank | AQ | ug/l | | | | | | | 1615. | | | | UJ. 56. | | | |
| MCB 226 | Duplicate (228) | AQ | ug/l | J. 517. | | | 5598. | | | 20680. | | | | UJ. 119. | | | ON SITE WELL No. 1 |
| MCB 227 | ON SITE WELL No 2 | AQ | ug/l | J. 4469. | | 635. | 12926. | | | 7785. | | | 1107. | 1794. | | | ON SITE WELL No 2 |
| MCB 228 | Duplicate (226) | AQ | ug/l | J 478. | | | 5837. | | | 19960. | | | | UJ 117. | | | ON SITE WELL No. 2A |
| MCB 230 | Blank | AQ | ug/l | | | | | | | | | | | 26. J | | | |
| MCB 346 | HOME WELL No 8 | AQ | ug/l | 51. J | | | 8739. | | | 211600. | | | | UJ 17. | | | DRINKING |
| MCB 248 | HOME WELL No 10 | AQ | ug/l | | | | 2654. | | 10. | 9237. | | | | UJ 50. | 11.0 | | DRINKING |
| MCB 249 | HOME WELL No 11 | AQ | ug/l | 161. J. | | | 3931. | | 11. | 12950. | | | | UJ 68. | | | |
| MCB 231 | UPSTREAM No. 3 | sol. | mg/kg | 621. J | J 0.31 | 32. J | 1128. | | | | | | 59. J | 98. J | 0.36 J | 76.7 | |
| MCB 232 | DOWNSTREAM No 4 | sol. | mg/kg | 37. J | J 0.31 | | 605. | | | | | 19. R | 89. J | 52. J | | 84.2 | |
| MCB 233 | ON SITE SOIL No. 7 | sol | mg/kg | 3.1. J | J 0.60 | | | | 11. R | | | 101. R | 35. J | 133. J | 0.30 J | 90.9 | |

**NOTE:** For a review of this data and non-target, tentatively identified compounds, please see the Analytical Quality Assurance section of this report.

◇ Denotes results of questionable qualitative significance based upon quality assurance review of data.

TDD Number F3-8503-29
EPA Number Case # 4265 VA 281

## SAMPLE DATA SUMMARY
## TARGET COMPOUNDS

☐ Organic ■ Inorganic

Site Name C & R Battery
Date of Sample 4-23-85
revised 7-7-85

Compounds Detected

| Sample Number | Sample Description and Location | Phase | Units | Manganese | Mercury | Nickel | Potassium | Selenium | Silver | Sodium | Thallium | Tin | Vanadium | Zinc | Cyanide | % Solids | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MCB 234 | ON SITE SOIL No. 6 (239) | sol. | mg/kg | 87.$^{J}$ | 0.99$^{J}$ | 31.$^{J}$ | 938. | | | 1605. | 8.8 | 23.$^{R}$ | 13.$^{J}$ | 73.$^{J}$ | | 79.2 | |
| MCB 235 | ON SITE SOIL No. 12 | sol. | mg/kg | 226.$^{J}$ | 0.77$^{J}$ | | | 11.$^{R}$ | 732. | | | 18.$^{J}$ | 70.$^{J}$ | 0.76$^{J}$ | | 82.0 | |
| MCB 236 | ON SITE SOIL No. 13 | sol. | mg/kg | 243.$^{J}$ | 0.65$^{J}$ | 56.$^{J}$ | 768. | | | 1346. | | | 25.$^{J}$ | 220.$^{J}$ | | 76.7 | |
| MCB 237 | ON SITE SOIL No. 14 | sol. | mg/kg | 131.$^{J}$ | 0.60$^{J}$ | 15.$^{J}$ | 509. | | 14.$^{R}$ | | | 189.$^{R}$ | | 30. | | 99.3 | |
| MCB 238 | ON Site Soil No. 15 | sol. | mg/kg | 230.$^{J}$ | 0.44$^{J}$ | | | | | | | 25.$^{R}$ | 25.$^{J}$ | 75.$^{J}$ | 0.64$^{J}$ | 89.5 | |
| MCB 239 | Duplicate (234) | sol. | mg/kg | 194.$^{J}$ | 0.57$^{J}$ | 61.$^{J}$ | 1357. | | | 1985. | | | 16.$^{J}$ | 118.$^{J}$ | | 71.8 | |
| MCB 240 | Blank | sol. | mg/kg | | 0.23 | | | | | | | | | 10. | 0.25$^{J}$ | | |
| MCB 241 | BACKGROUND SOIL | sol. | mg/kg | 395.$^{J}$ | 0.30$^{J}$ | | 666. | | 5.6$^{R}$ | 658. | | 18.$^{R}$ | 38.$^{J}$ | 57.$^{J}$ | | 91.2 | |
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**NOTE:** For a review of this data and non-target, tentatively identified compounds, please see the Analytical Quality Assurance section of this report.

◊ Denotes results of questionable qualitative significance based upon quality assurance/review of data.

### 6.2.2 Inorganic Data Lab Case 4265

#### 6.2.2.1 Introduction

The findings offered in this report are based upon a review of all available sample data, blank results, matrix spike and duplicate analysis results, ICP interference QC, calibration data, and quality assurance documentation.

#### 6.2.2.2 Qualifiers

*It is recommended that this data package be utilized only with the following* qualifier statements:

- The results which may be qualitatively questionable are listed below:

| Constituent | Samples With Questionable Results |
|---|---|
| Aluminum | MCB311, MCB244, MCB246, MCB248, MCB249, MCB228 |
| Iron | MCB311, MCB244, MCB226, MCB228, MCB246, MCB248 |
| Zinc | MCB311, MCB244, MCB226, MCB228, MCB246, MCB248, MCB249 |

- The aforementioned results were designated questionable since there is evidence to doubt the presence of these constituents at any concentration less than or equal to the levels reported. However, it can be assumed that concentrations significantly greater than the levels reported for these samples cannot be present.

- Low level results for lead in aqueous samples should be considered highly questionable (Code R). The high level reported for MCB227 should be considered an estimate of the true amount present (code J).

- Actual detection limits for arsenic, cobalt, and manganese in the aqueous matrix may be slightly higher than reported. Reported results may be biased low for arsenic (25-45%), cobalt (25-35%), and manganese (25-35%) in the aqueous matrix. Values have been coded J to reflect the quantitative uncertainty of the results.

- Actual detection limits for tin in the aqueous matrix may be significantly higher than reported (30 ug/L). In fact, the reported detection limit for MCB227 is 300 ug/L.

- The reported results for antimony, cadmium, lead, silver, tin, and zinc in solid sample MCB233 may not accurately reflect the average concentration for these constituents in this sample or others of a similar matrix.

- The reported results or antimony, cadmium, copper, magnesium, nickel, potassium, sodium, tin, and cyanide in field duplicate samples MCB238/239 (solid) may not accurately reflect the average concentrations of these constituents in these samples or others of a similar matrix.

- Actual detection limits for arsenic and selenium in the solid matrix may be biased slightly higher than reported. Reported results may be biased low for arsenic (30-50%) in the solid matrix.

- Reported results may be biased high for barium (40-60%), beryllium (40-60%), cadmium (60-80%), chromium (30-50%), copper (35-55%), manganese (20-40%), mercury (30-50%), nickel (25-45%), tin (300-450%), vanadium (40-50%), and zinc (25-45%) in the solid matrix.

- The impact, on solid sample results, of the poor field and lab precision and poor spike recovery is as follows:

  antimony -- data rejected--extreme precision problems

  arsenic -- values considered valid estimates (J) except for MCB239 (review of the raw data suggests that 103 is an anomaly and should be rejected).

  barium -- values considered estimates due to recovery problems
  beryllium
  chromium
  manganese
  mercury
  nickel
  vanadium

  cadmium -- estimated due to precision (field and lab) and recovery problem

  copper -- estimated due to precision (field and lab) and recovery problem
  zinc
  cyanide

  silver -- data rejected--extreme recovery problems

  tin -- data rejected--extreme precision and accuracy problems

  Data has been coded J or R to reflect these qualifiers.

- The presence/absence of cyanide in MCB234, MCB237, and MCB239 could not be determined.

- Mercury results for all aqueous samples could not be validated.

### 6.2.2.3 Findings

- Field blank analysis revealed the presence of aluminum, iron, and zinc at levels sufficient to question the aforementioned results for these parameters.

- Aqueous field duplicate (MCB244/311 and MCB226/228) analysis for lead exhibited unusually large relative percent differences for groundwater-type samples. That fact, along with failure to recover lead in the matrix spike, suggests that the reliability of the aqueous lead results is severely compromised and the results should be rejected. The level reported in MCB227, however, is sufficiently large that it can be considered an indicator, not only of the presence of lead, but also the relative order of magnitude. Due to the problems discussed above, however, the value should be considered an estimate of the true concentration.

- Low matrix spike recovery was reported for arsenic (65%), cobalt (70%), and manganese (70%) in the aqueous matrix.

- Extremely low matrix spike recovery was reported for lead (0%) and tin (0%) in the aqueous sample MCB244. Lead values have been coded to reflect the poor recovery. False negatives for tin cannot be ruled out.

- Duplicate laboratory analysis of solid samples MCB233 revealed poor precision for antimony, cadmium, lead, silver, tin, and zinc.

- Solid field duplicate results for antimony, arsenic, cadmium, copper, magnesium, nickel, potassium, solium, tin, zinc, and cyanide exhibited high relative percent differences. This variability is normally associated with poor sample homogeneity.

- Low matrix spike recovery was reported for arsenic (60%) and selenium (60%) in the solid matrix.

- High matrix spike recovery was reported for barium (141%), beryllium (152%), cadmium (172%), chromium (138%), copper (144%), manganese (131%), mercury (142%), nickel (136%), tin (376%), vanadium (147%), and zinc (135%) in the solid matrix.

- The laboratory reported that interference problems precluded a quantitative determination of cyanide in MCB234, MCB237, and MCB239.

- Laboratory failed to analyze matrix spike and duplicate samples for mercury in the aqueous samples.

- Review of method of standard addition analysis by furnace raw data for MCB238/239 revealed an analytical anomaly. The 103 ug/L value should be rejected.

### 6.2.2.4 Summary

This Quality Assurance Review has identified the following areas of concern; field blank contamination, sample non-homogeneity and poor precision, poor matrix spike results, and matrix interferences.

Please see the accompanying support documentation appendix for specifics on this Quality Assurance Review.

Report prepared by Steve L. Markham: Steve L. Markham Date: 7-10-85

Patricia J. Krantz: Patricia J Krantz Date: 7-10-85

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Original
(Red)

# SECTION 7

# 7.0 TOXICOLOGICAL EVALUATION

## 7.1 Summary

High levels of lead (up to 67,731 mg/kg) and elevated levels of a few other inorganics (cadmium, arsenic, copper) were reported in on-site soil samples. The generation of lead-contaminated dusts may be of potential health concern to residents living in the surrounding area.

Elevated levels of lead (up to 2,157 ug/l) and several other inorganics, including arsenic (80 ug/l), a recognized human carcinogen, and beryllium (124 ug/l), a suspect human carcinogen, were measured in unfiltered samples from on-site monitoring wells (MWs). The groundwater contamination may be, at least in part, site related. If the untreated groundwater were used as a potable water source, it might pose a carcinogenic risk as high as $4.3 \times 10^{-2}$ and cause other toxicities, including neurotoxicity, kidney damage, hematological problems, and acute gastrointestinal effects. With the exception of beryllium (5 ug/l), which might pose a carcinogenic risk of up to $3.7 \times 10^{-4}$, there were no inorganics confidently identified at levels of immediate concern to human health in filtered MW samples.

With the possible exception of an elevated sodium concentration (211,600 ug/l) in home well no. 8, there were no inorganics reported at levels of human health concern in samples collected from 3 off-site private wells. The levels of iron and manganese measured in home well nos. 8 and 11 might affect the palatability of the water.

Limited sampling of a site-adjacent intermittent stream/drainage ditch, which was dry at the time of the survey, did not provide sufficient evidence of off-site release of contaminants.

## 7.2 Support Data

Samples collected in this survey were analyzed for inorganic priority pollutants only. The presence of organic contaminants in these samples cannot be ruled out.

### 7.2.1 On-Site Contamination

### 7.2.1.1 Soil/Surface

High levels (up to 67,731 mg/kg) of lead were reported in on-site soil samples. For the sake of perspective, it may be noted that lead has been reported in natural soils at concentrations of up to 700 mg/kg, a concentration of 16 mg/kg being considered average.[1] On-site lead levels were also substantially higher than the concentration (182 mg/kg) measured in the off-site background soil sample which was collected in a site-adjacent open field.

Notably elevated concentrations of cadmium (up to 99 mg/kg) and arsenic (up to 62 mg/kg), and a slightly elevated level of copper (up to 140 mg/kg) were also confidently reported in on-site soil samples. Maximum concentrations that have been reported for these inorganics in natural soils are as follows: cadmium (1 mg/kg), arsenic (17 mg/kg), and copper (100 mg/kg).[2 to 4] Although elevated levels (up to 2,027 mg/kg) of antimony were reported, they could not be verified by the quality assurance chemists due to "extreme precision problems" (see section 6.2.2.2).

Of the identified inorganic contaminants, the high levels of lead, in particular, might pose health hazards to residents in the area. Local inhabitants might potentially be exposed to lead via the inhalation of contaminated airborne particulates. According to the site leader, conditions on site were very dusty. *Children might also be exposed to lead through pica, the ingestion of nonfood* substances, which in this case might potentially become contaminated with lead dust. Although there are no individuals who are known to regularly frequent the site, which is currently inactive, site access is not restricted. It may be noted that the population within a 1-mile radius of the site has been characterized as "sparse" and estimated at approximately 300 (see section 3.7). It may also be mentioned that air sampling conducted at on-site work stations by the Virginia Occupational Safety and Health Administration (VA OSHA) in 1987, when the site was active, revealed levels of lead in the breathing zone that were above standards (see section 2.5).

Whether residents are currently at significant risk would depend upon the ambient air levels of lead, their exposure to lead by other routes (i.e., total lead intake), and personal susceptibility factors (e.g., age). Infants and young children are considered a high risk group for lead toxicity. Children can absorb ingested lead to a greater extent than adults and are more sensitive to its effects.[5] Excessive lead exposure can result in neurotoxicity, nephrotoxicity, and/or a reduction in hemoglobin synthesis, resulting in anemia. Altered testicular function is also a sensitive indicator of chronic lead exposure.[5] There is currently considerable concern as to the possible effects of increased lead exposure in young children on their subsequent behavioral and intellectual development.

It should be noted that there is reportedly an open, accessible (sulfuric) acid storage area on site. Samples collected during this survey were not analyzed, however, for the possible presence of acid. If strong acids are present, they could potentially pose a serious health hazard via direct skin or eye contact and, possibly, the inhalation of vapors. Depending on the concentration and length of exposure, contact could result in damage ranging from irritation to severe burns.

### 7.2.1.2 Groundwater

Filtered and unfiltered samples were collected on site from MW nos. 1 (same as 2A) and 2. Lead and several other inorganics, including arsenic, chromium, beryllium, cadmium, barium, iron, manganese, aluminum, nickel, and/or vanadium were reported at elevated levels in unfiltered samples. The heaviest contamination was reported in the sample from MW no. 2. A few of these inorganics (lead, cadmium, arsenic) were also reported at elevated levels in on-site soil samples. The contamination of the groundwater may, at least in part, be site related. If the groundwater were used, untreated, as a potable water source, it could pose a number of health hazards.

Arsenic (80 ug/l) is a recognized human carcinogen by the oral route. Beryllium (124 ug/l) is a suspect human carcinogen. Epidemiological evidence has suggested, but not established, an association between inhalation exposure to beryllium in the workplace with human cancer.[7] Beryllium has been shown to induce cancer in animals via inhalation, intratracheal, and intravenous routes.[7] Using carcinogenic risk factors based on foreign epidemiological studies (arsenic) and animal data (beryllium), it can be calculated that the lifetime ingestion of 2 liters of the groundwater per day might pose a carcinogenic risk of up to $4.3 \times 10^{-2}$ (4.3 in 100).[8] It should be noted that there is currently some question as to whether concentrations of arsenic similar to that reported in the MW sample significantly increase human cancer risk. The results of epidemiological studies conducted in the United States did not reveal increased incidences of cancer in communities whose drinking water contained up to 200 ug/l of arsenic.[9] There is evidence that trace amounts of arsenic (25 to 50 ug) may actually be essential for human health.[8] The reported concentration of arsenic exceeds the primary Maximum Contaminant Level (MCL) for public drinking water supplies.[6]

Reported levels of lead (up to 2,157 ug/l), cadmium (90 ug/l), chromium (701 ug/l), nickel (635 ug/l), and barium (2,460 ug/l) also exceeded primary MCLs (50 ug/l for lead and chromium, 10 ug/l for cadmium, 150 ug/l for nickel, 1,000 ug/l for barium).[6] The toxic effects of lead were previously discussed in this section. The *kidney is the main target organ of chromium and cadmium toxicity resulting from* overexposure via ingestion. Hexavalent chromium is a recognized human carcinogen by the inhalation route. However, there is no conclusive evidence linking the ingestion of chromium with cancer. The oral toxicity of nickel is considered to be low and there is evidence that small amounts of dietary nickel may be essential for human health. The most sensitive effects of the long-term ingestion of nickel have been reported in animals at 5,000 ug/l. Among the effects observed after several generations of exposure were a decrease in litter size, an increase in the number of runts, and increased pup mortality.[10] Excessive exposure to barium may adversely affect the cardiovascular system.[6]

Manganese (4,468 ug/l) and iron (1,338,000 ug/l) were reported at levels greatly exceeding secondary MCLs recommended to prevent unpleasant taste and odor (50 ug/l for manganese, 300 ug/l for iron). At the reported level, iron might also pose a health hazard. The chronic intake of excessive dietary iron can lead to hemosiderosis, an abnormal accumulation of iron in body tissues, particularly the liver and reticuloendothelial system. The iron deposition may subsequently result in tissue dysfunction.

Aluminum was measured at a concentration (458,500 ug/l) that substantially *exceeds a 7-day Suggested No-Adverse-Response Level (SNARL) of 5,000 ug/l.* The SNARL is based upon a study on rats in which decreases in liver glycogen and coenzyme A were the minimal observed effects.[5] There is no MCL or other drinking water criterion for vanadium, but the reported level (1,107 ug/l) would not be expected to be toxic in the absence of significant exposure by other routes. There is currently no evidence of chronic oral toxicity caused by the excessive ingestion of vanadium via food or water. It has been reported that the daily ingestion of doses as high as 17,500 ug have been tolerated in healthy adults without any adverse effects.[11]

The high levels of metals in the groundwater would probably render it highly unpalatable and might cause acute gastrointestinal distress. It is unlikely that the groundwater could be tolerated as a potable source by most individuals, even on a short-term basis.

Only a few inorganics (beryllium, cadmium, iron, manganese, nickel) were confidently reported at elevated levels in filtered MW samples. The reported lead levels could not be confirmed by the quality assurance chemists (see section 6.2.2). The levels reported in filtered samples were substantially below those measured in unfiltered samples. The sampling results suggest that most of the inorganic contamination that was measured in the unfiltered samples was due to the presence of undissolved, suspended particulates, the mobility of which would be anticipated to be limited in groundwater systems. The potential mobility of the inorganic contaminants could increase, however, if substantial amounts of acid were to infiltrate the soil and groundwater. Sulfuric acid is reported to be among the wastes present on site. Acids can increase the water solubility of lead and other metal/metalloid salts.

The potential health hazards that may be posed by the levels of inorganics present in the filtered samples are fewer and less severe than those posed by the concentrations in unfiltered samples. The possible carcinogenic risk posed by the long-term daily ingestion of the measured level of beryllium (5 ug/l) is estimated to be 3.7 x $10^{-4}$ (3.7 in 10,000). The reported levels of lead (up to 23 ug/l, if present), cadmium (6.6 ug/l), and nickel (110 ug/l) are below primary MCLs. However, cadmium and, possibly, lead concentrations exceeded proposed RMCLs (5 ug/l for cadmium and 20 ug/l for lead).[5] RMCLs are nonenforceable health goals. The RMCL for lead has been proposed to insure the protection of children, the most sensitive subpopulation. Measured levels of iron (up to 6,198 ug/l) and manganese (up to 2,063 ug/l) exceeded secondary MCLs. These levels might affect the palatability of the water, but are not of apparent concern to human health.

### 7.2.2 Off-Site Contamination

The main concern regarding on-site contamination is the degradation of the groundwater. Groundwater is used as a potable water source in the area surrounding the site. On-site contaminants might also potentially impact upon a site-adjacent intermittent stream/drainage ditch. The stream, which receives runoff from the site, discharges into the James River 600 feet north of the site.

Samples were collected from 3 local private wells. With the possible exception of the sodium concentration (211,600 ug/l) measured in the sample from home well no. 8, there were no inorganics measured in these unfiltered samples at levels of concern to human health. Lead was not reported at or above the contract required quantitation limit of 5 ug/l in any off-site well samples.

The iron and manganese levels measured in home wells no. 8 (654 ug/l iron, 51 ug/l manganese) and no. 11 (3,971 ug/l iron, 161 ug/l, manganese) exceeded secondary MCLs. The levels might affect the palatability of the water, but pose no health threats.

The level of sodium measured in the home well no. 8 sample might pose a health hazard to individuals that are on severe or moderate sodium-restricted diets. Those potentially at risk include individuals with hypertension, congestive heart failure, renal disease, cirrhosis of the liver, toxemia of pregnancy, or Menieres disease, individuals on prolonged corticosteroid therapy, and, possibly, infants.[9,12] A guideline of 20,000 ug/l of sodium in drinking water has been suggested to protect high risk populations.[5] Adverse health effects may occur in individuals who are on severe salt-restricted diets and whose daily sodium intake must be restricted to 500 mg per day, if the sodium concentration in drinking water exceeds 20,000.[12] For individuals that are on a moderate sodium-restricted diet (less than 2,000 mg/day), the portion that is allowable to water intake varies. In many cases, an allowance is made for concentrations of up to 100,000.[17]

Sediment samples were collected from the site-adjacent stream at up- and downstream locations; aqueous samples could not be collected because the streambed was dry. With the exception of a slightly increased level of cadmium in the downstream sample (6.2 vs. 3.3 mg/kg, upstream), which is of doubtful significance, the levels of inorganics in the downstream sample were similar to or less than the concentrations measured in the upstream sample. Lead levels in both samples were similar (530 and 544 mg/kg). Although the lead concentrations are substantially above averages (10 to 20 mg/kg) reported for soils and sediments, they are not unusual for soils.[1,13] As previously noted, lead has been measured in natural soils at concentrations of up to 700 mg/kg.[1] It may be noted that a lead concentration of 3,440 ug/l was reportedly measured in a downstream aqueous sample that was collected in 1982 (see section 5.6) from the drainageway.

The generation of lead dusts from the site might potentially result in a general contamination of local soils and surface waters. If environmental lead levels were to become elevated, they might impact upon the local flora and fauna. It may be noted that an endangered bird species, the red-cockaded woodpecker, is reported to range within the site area, although it has not been sighted in the immediate site vicinity (see section 3.8).

Prepared by: ________________________ Date: February 18, 1986

Isabel Mandelbaum, Ph.D.
Toxicologist

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11. National Research Council of Canada. 1980. Effects of Vanadium in the Canadian Environment. Publication No. 18132 of the Environmental Secretariat.

12. National Academy of Sciences. 1977. Drinking Water and Health, vol. 1. Washington, D.C.: National Academy Press.

13. Andrew-Jones, D.A. 1968. The application of geochemical techniques to mineral exploration. Mineral Industries Bulletin 116:31.

# APPENDIX A

1. COST CENTER:

ACCOUNT NO.:

## REM/FIT ZONE CONTRACT
## TECHNICAL DIRECTIVE DOCUMENT (TDD)

2. NO.: F3-8503-29

3. PRIORITY:
☒ HIGH
☐ MEDIUM
☐ LOW

4. ESTIMATE OF TECHNICAL HOURS: 180

4A. ESTIMATE OF SUBCONTRACT COST:

5. EPA SITE ID: VA-281

5A. EPA SITE NAME: C & R Battery
Richmond, Va.

6. COMPLETION DATE: 3 wks. after OA

7. REFERENCE INFO.:
☒ YES ☐ NO
☐ ATTACHED
☒ PICK UP

8. GENERAL TASK DESCRIPTION: Conduct a site inspection of the subject site.

9. SPECIFIC ELEMENTS:

1.) Review background information.
2.) Contact state and local agencies for relevant information.
3.) Arrange for site access. Coordinate lab analysis.
4.) Perform sampling according to approved sampling plan prepared under TDD F3-8502-13.
5.) Conduct on and off-site inspection and sampling.
6.) Take and ship samles according to standard protocol.
7.) Prepare and submit field trip report due 2 wks. after site inspection.
8.) Perform Quality Assurance Review of lab data.
9.) Prepare and submit report, include in cover letter recommendations for need of HRS.
10.) All work on this project to be performed acording to: WP-SI-1, Rev.I.

10. INTERIM DEADLINES:

11. DESIRED REPORT FORM: FORMAL REPORT ☒ LETTER REPORT ☐ FORMAL BRIEFING ☐

OTHER (SPECIFY):

12. COMMENTS:
State Code 051 County Code 760

13. AUTHORIZING RPO: Harold G Byer
(SIGNATURE)

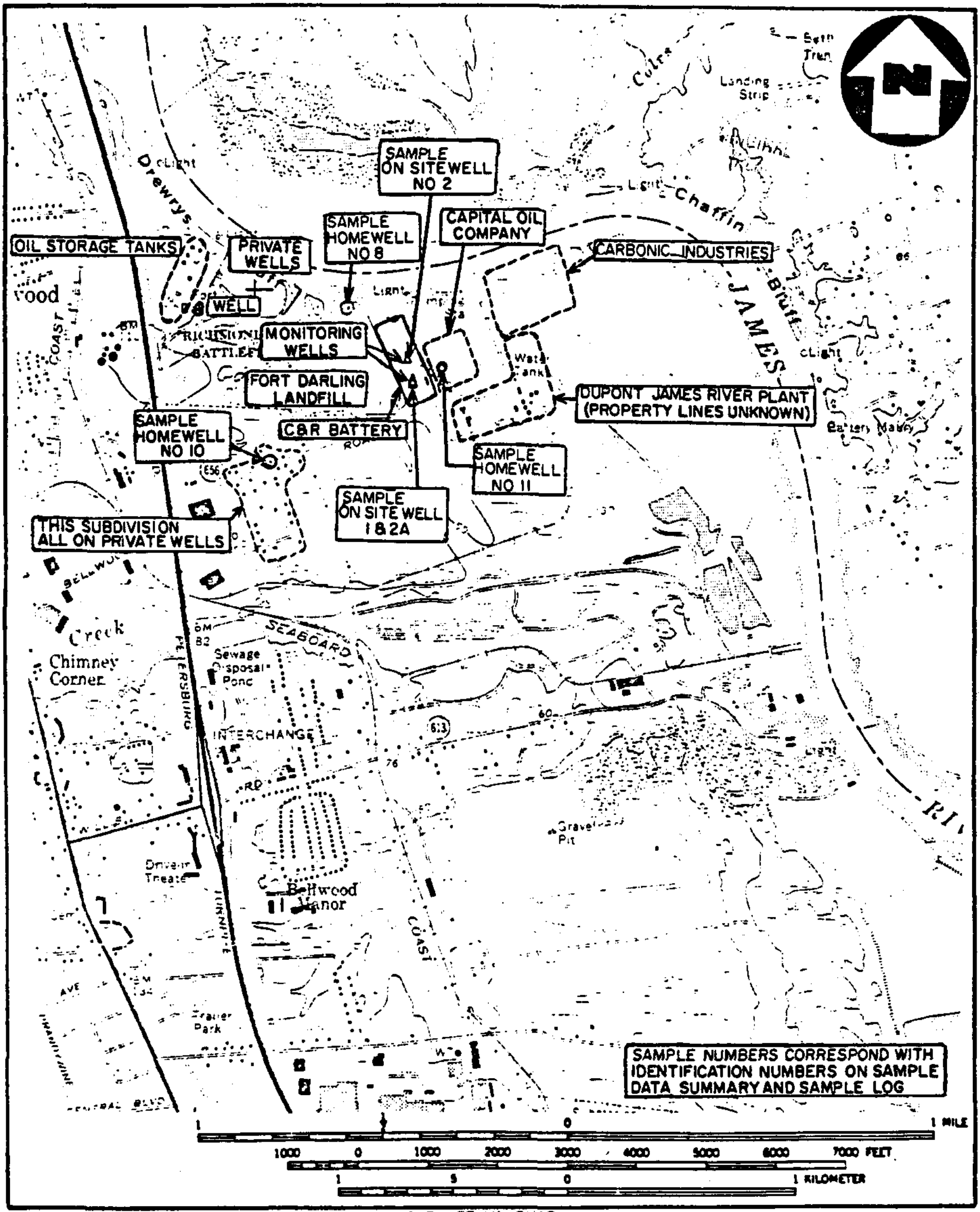
14. DATE: 4/5/85

15. RECEIVED BY: ☒ ACCEPTED ☐ ACCEPTED WITH EXCEPTIONS ☐ REJECTED
(CONTRACTOR RPM SIGNATURE)

16. DATE: 4/8/85

Sheet 1 White – FITL Copy
Sheet 2 Canary – DPO Copy
Sheet 3 Pink – Contracting Officer's Copy (Washington, D. C.)
Sheet 4 Goldenrod – Project Officer's Copy (Washington, D. C.)

# APPENDIX B



SAMPLE NUMBERS CORRESPOND WITH IDENTIFICATION NUMBERS ON SAMPLE DATA SUMMARY AND SAMPLE LOG

SOURCE: (7.5 MINUTE SERIES) USGS DREWRYS BLUFF, VA. QUAD

SITE LOCATION / MAP & GROUNWATER SAMPLE LOCATIONS

C & R BATTERY RICHMOND VA.

SCALE 1:24000

FIGURE 1

NUS CORPORATION

A Halliburton Company

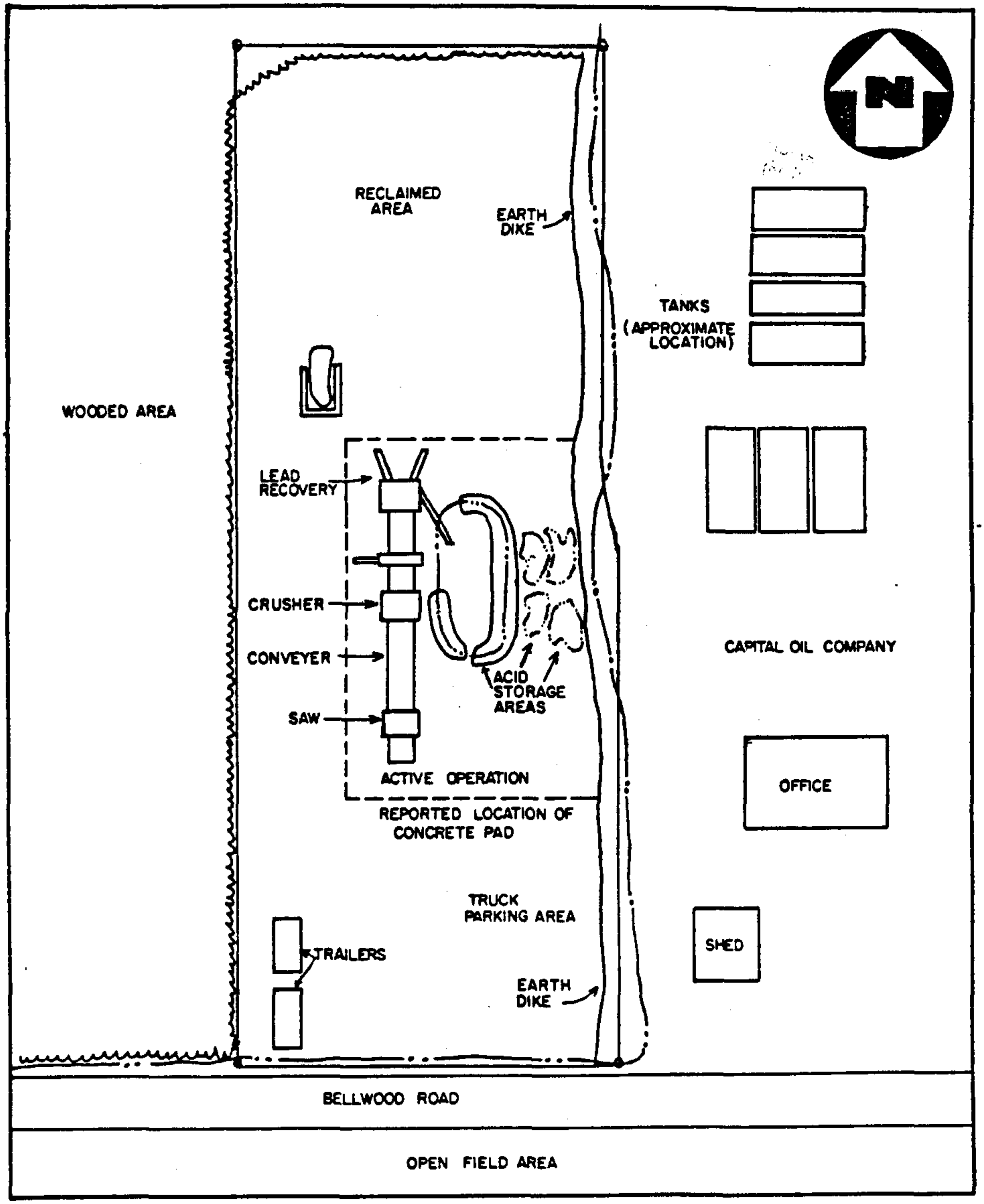


FIGURE 2

SITE SKETCH
C & R BATTERY SITE RICHMOND VA.
(NO SCALE)

NUS CORPORATION
A Halliburton Company

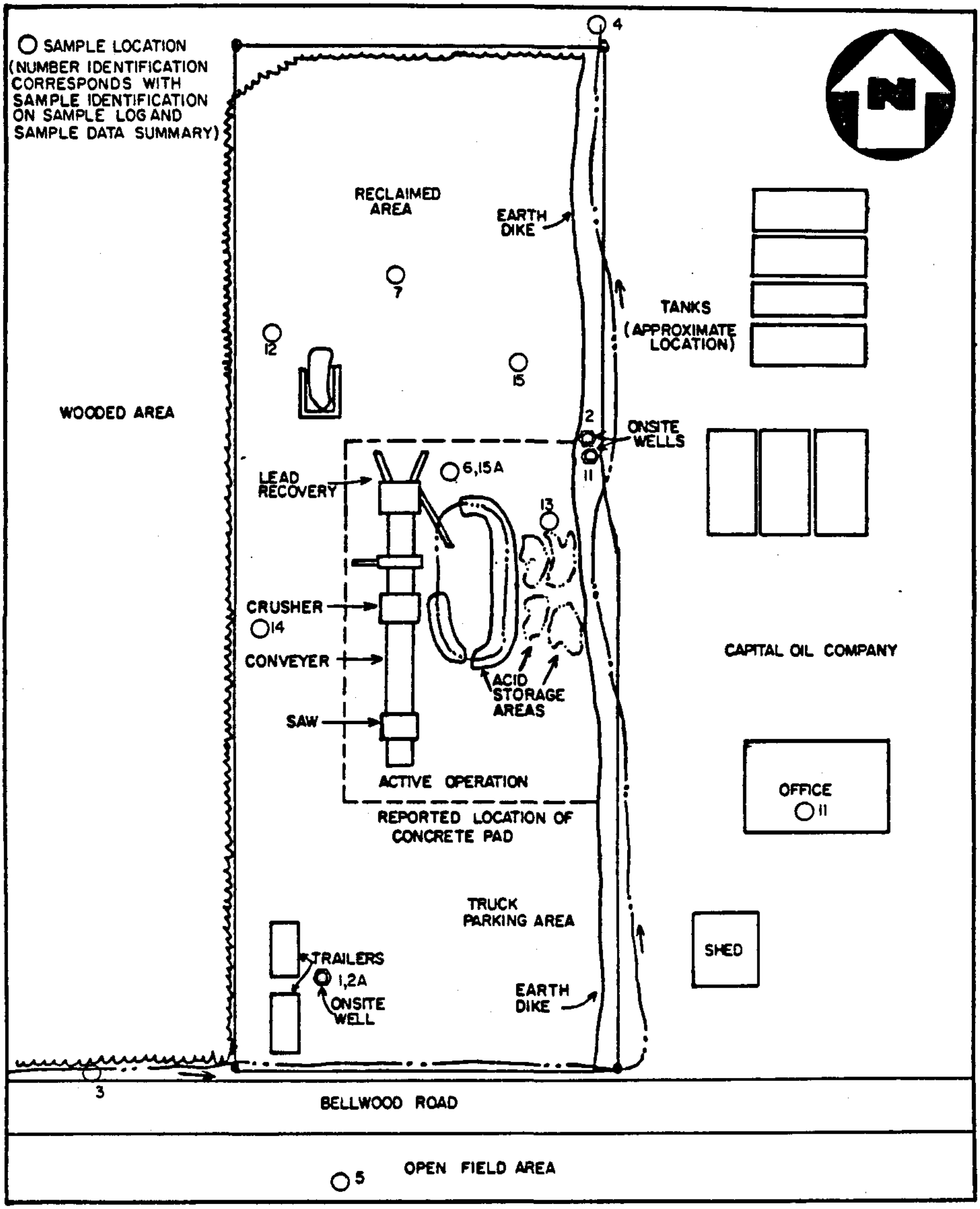


FIGURE 3

SAMPLE LOCATION MAP

C&R BATTERY SITE RICHMOND VA.

(NO SCALE)

NUS CORPORATION

A Halliburton Company

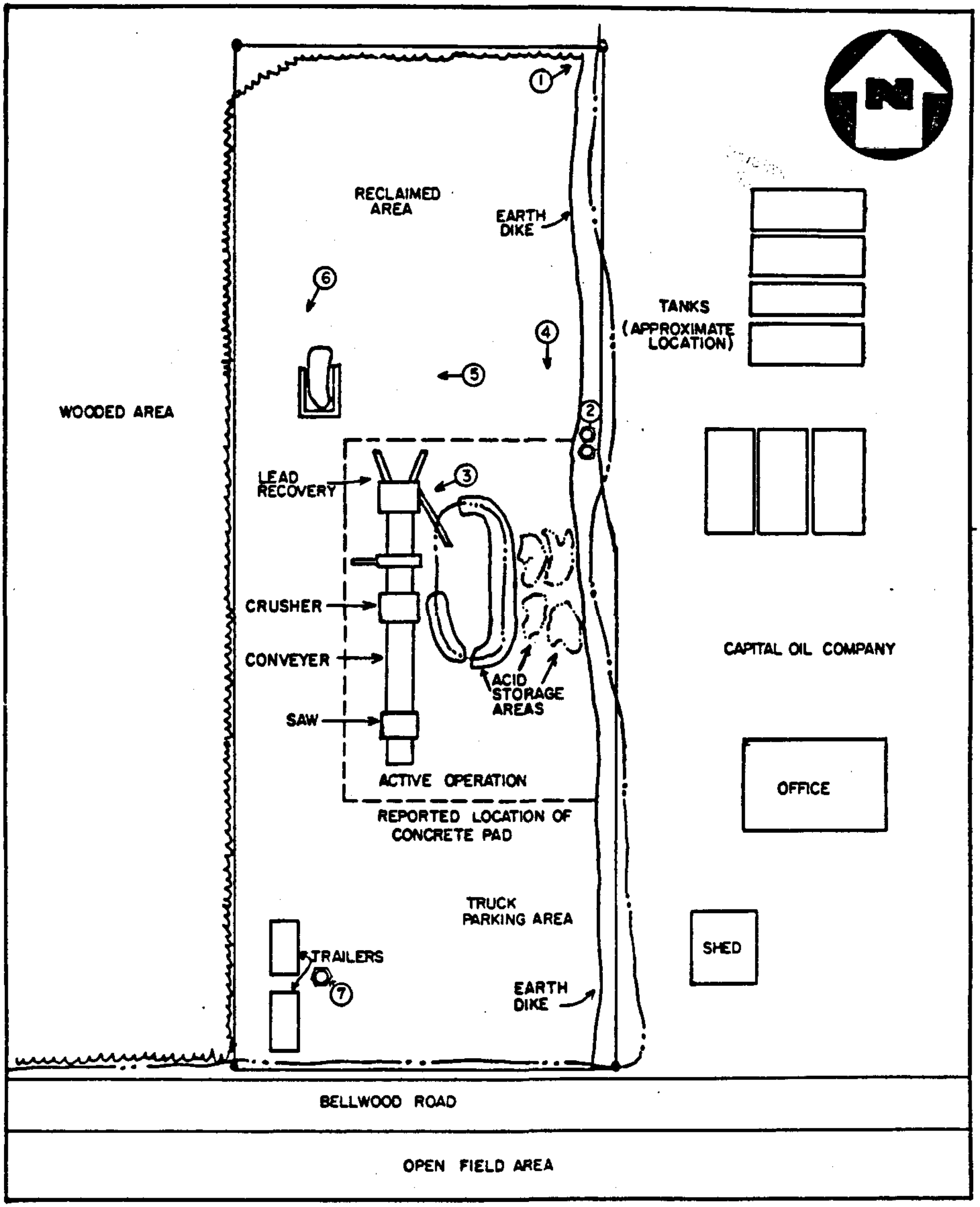
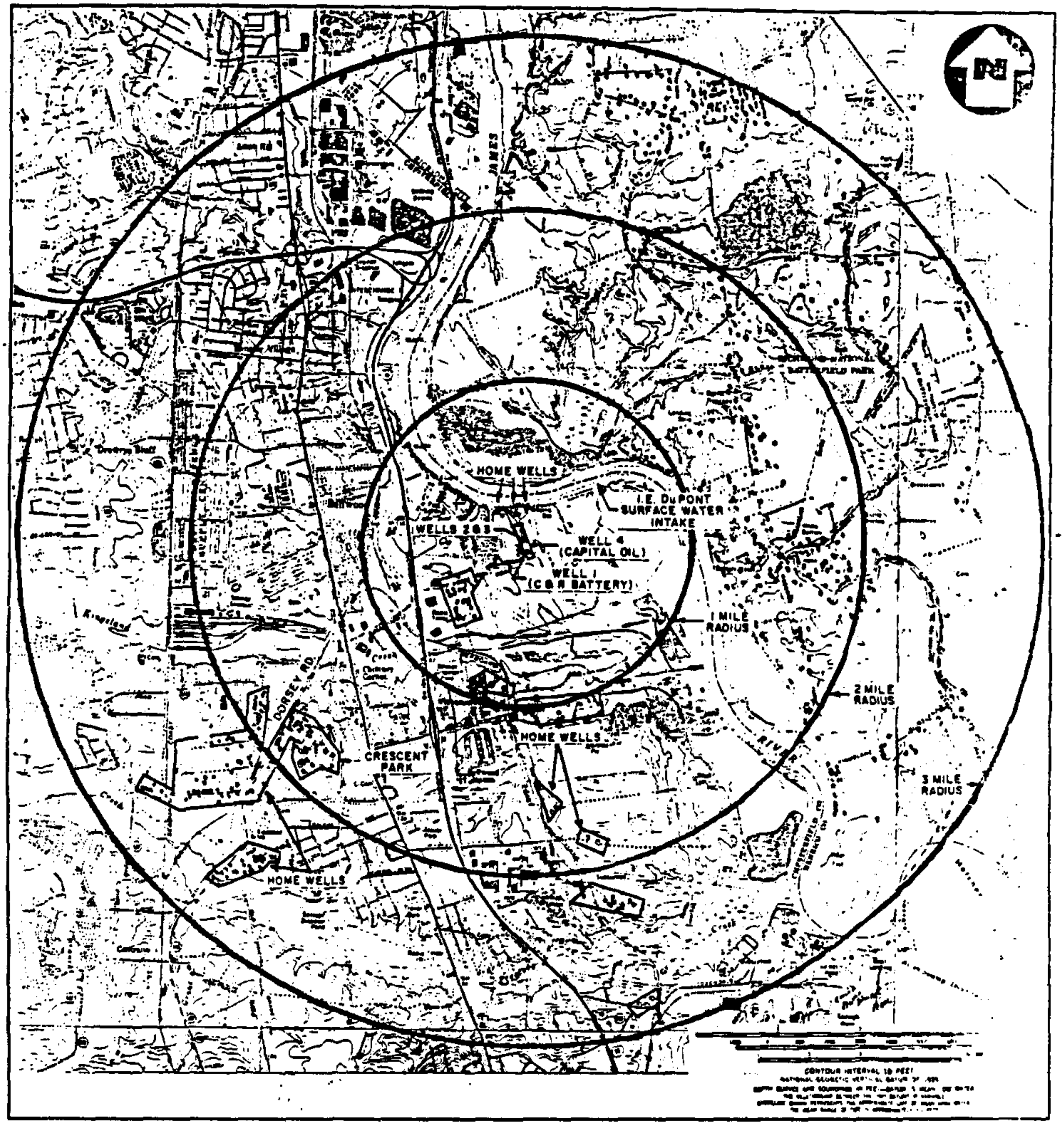


PHOTO LOCATION MAP
C & R BATTERY SITE RICHMOND VA.
(NO SCALE)

FIGURE 4

NUS CORPORATION
A Halliburton Company



SOURCES: Base map developed from U.S.G.S. 7.5 minute topographic map series: Drewry's Bluff, VA 1981 photo revised, Dutch Gap, VA 1981 photorevised, Chester, VA 1969. Home well locations developed from telephone conversations with A. Wajciechildski of the Henrico County Public Utility Dept., T. Cook, and B. Brown, Chesterfield County Public Utility Department and from water line distribution system layout map as provided to NUS FIT III by T. Cook of the Chesterfield County Public Utility Department.

Home Well Locations
Target Population

WELL NUMBERS CORRESPOND TO
WELL DATA SUMMARY SHEET
ATTACHED

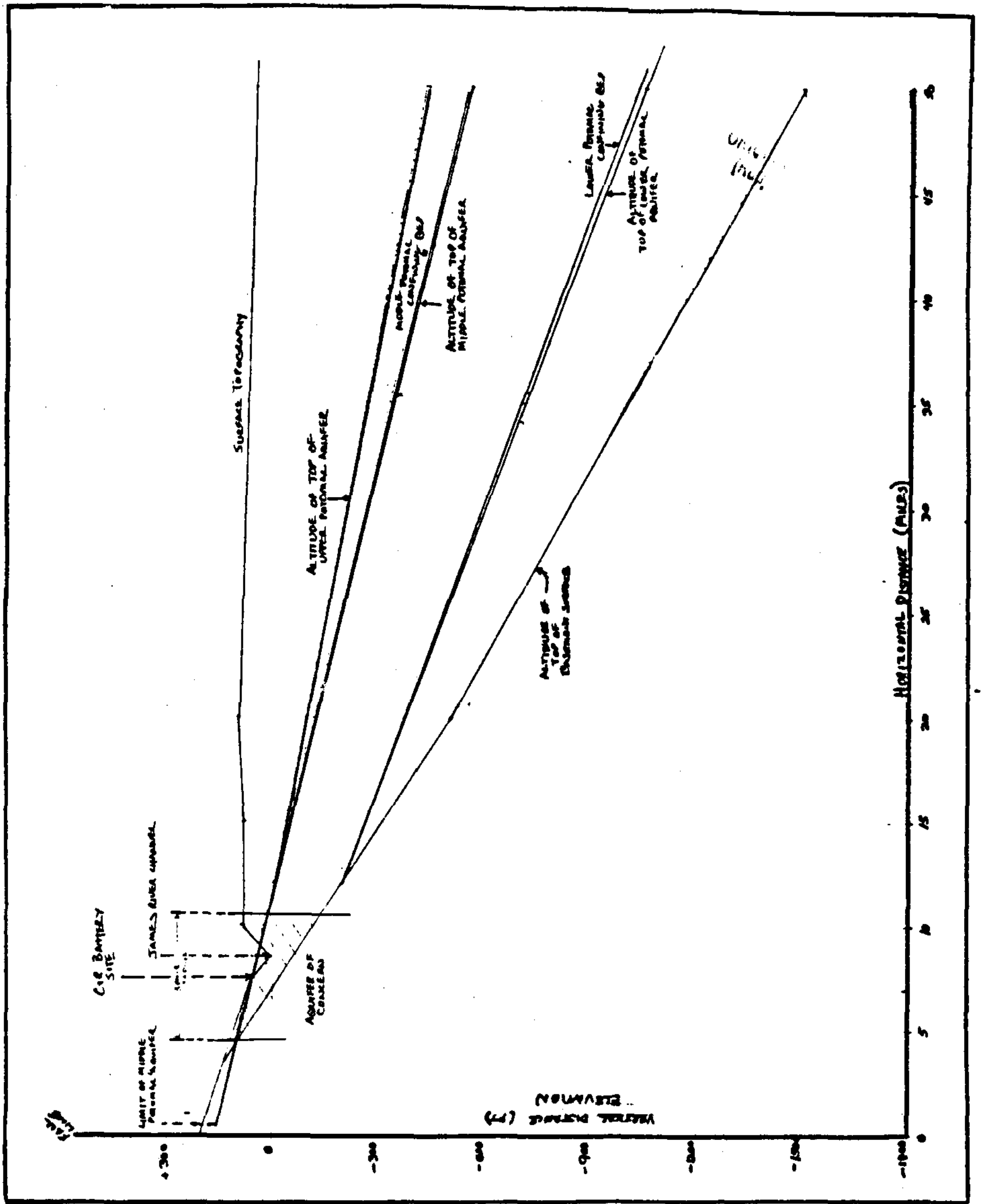
3 MILE RADIUS MAP

C&R BATTERY SITE, CHESTERFIELD CO., VA.

(SCALE AS INDICATED)

FIGURE 5

NUS CORPORATION
A Halliburton Company



SOURCE: CROSS SECTION DEVELOPED THROUGH INTERPREATION OF HYDROGEOLOGIC FRAMEWORK OF THE VIRGINIA COASTAL
PLAN BY A MENG AND J.F. HARSH, USGS 1984

HYDROGEOLOGIC CROSS SECTION
C&R BATTERY SITE RICHMOND VA.

FIGURE 6

NUS CORPORATION
A Halliburton Company

# APPENDIX C

3. CALCULATION METHODS: Using the results of the laboratory tests by F & R labs, a copy of which is attached, the number of tons of lime were calculated for an area controlled by each sampling point, and to a depth as tested. This volume was computed using the Parts per Thousand indicated in the tests. This methodology as referenced in the EPA publication mentioned on Page 1 calls for the pH of the soil lime mixture to be raised to 6.5. The calculation sheet dated May 8, 1984 indicates the amounts of agricultural ground limestone required in each area. The total amount of this type lime required is 100 tons to bring the pH to 6.5 if mixing could be accomplished with laboratory precision.

4. PARAMETERS AND PROPOSED PLAN: Since the lime will have to be mixed with the soil by readily available grading and farm implements, a 50% excess will be used to allow for the inevitable less than perfect mixing. In addition C & R Battery management proposes to use a burnt lime, which has more readily available $(OH)^-$ hydroxyl ions.

It is proposed to plow the areas required to a depth of two feet, and apply the lime in the quantities calculated including the 50% excess. The soil-lime mixture will then be mixed by multiple rotary discs until a uniform mixture is observed. A light sprinkling, 1 gallon per square yard will be applied to promote the reaction if the soils are dry, or if damp, no water will be added. This will permit an initial reaction to take place between the lead and the lime forming lead hydroxide $Pb(OH)_2$ which is a very low solubility product. The excess hydroxyl ion in the soil would preserve this condition. The area would then be protected from percolating water that might remove this excess lime.

We propose to accomplish this portion of the stabilization by capping the area treated with a six inch layer of impervious clay, spread over the top and in a two foot deep trench at the edges of the treated area, all compacted to 95% Proctor.

The area now covered by the waste pond holding acidic wastes, will be pumped out, and lime added with testing in the field to attain a pH equal to that of the other areas.

All surfaces not covered by the industrial process operation or the waste treatment facility will receive four inches of topsoil and be seeded with fescue grass, with proper fertilization and protection until a stand is obtained.

5. CONCLUSION: With this treatment and capping, utilizing the burnt lime and the 50% excess we can expect a pH above 7 and well on the basic side of neutral. The lead in the soil will have its solubility reduced and lead migration will be reduced to the point where the industrial process plant for battery reclamation could be placed on it and the waste treatment plant to serve the process plant could be operated without danger to the environment.

JHColbaugh, P.E.

Consulting & Design for Industry
P.O.Box 8822, Richmond, Va. 23225
Tel.
(804) 271-9407

PROJ. SHEET NO. OF
ISSUE DATE

| | | | |
|---|---|---|---|
| ✓ | CIVIL | MADE BY: LRC | DATE 5/8/84 |
| | STRUCTURAL | SHEET NO. OF | |
| | MECHANICAL | | |
| | ELECTRICAL | CHECKED BY: | DATE |
| | INSTRUMENTATION | | |
| ✓ | PROCESS | PROJ. ENGR | DATE |

PROJECT C&R Battery
SITE RECLAMATION

SUBJECT Lime Stabilization of Le
in Soil on Site.

Calculations Based on averages per sample & Volumes bounded by Median lines between sample points.

cuft ×10
2000

| PLAN Point of Sample / No. Sample | L ft | × D ft | = A ft² | × H ft | = V ft³ | using soil @ 100 pcf × 1/20 (Tons) | × FACTOR | = Required TONS AG LIME | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 1A / 3 | | | | | | | | — | pH 6. |
| 2A / 5,6 | | | | | | | | — | pH 7 |
| 1 / 2 | 114' | Av. 50' | = 5700 | (2'-1') | 5700 | 265 | .0055 | 1.57 | pH 5.7 |
| 2 / 4 | | | | | | | | — | pH 7.0 |
| 3 / 7 | Av 101 | 64 | = 6464 | (1'-0') top | 6464 | 323.$^{2}$ | .0058 | 1.87 | pH 5. |
| 3 / 8 | | | 6464 | (2'-1') | 6464 | 323.$^{2}$ | .0153 | 4.95 | pH 3. |
| 4 / 9 | | | | | | | | — | pH 11. |
| 5 / 10 | | | | | | | | — | pH 7. |
| 6 / 11,12 | | | | | | | | — | pH 10.6 |
| 6A / 13 | Δ 102 | 96/2 | 4896 | (1-0') | 4896 | 244.8 | 0.0144 | 3.53 | pH 4 |
| 6A / 14 | | | 4896 | (2-1) | 4896 | 244.8 | 0.0145 | 3.55 | pH 4 |
| 7 / 15 | √ 150 | Av 72 | 10,800 | (1'-0') | 10,800 | 540 | 0.0074 | 4.00 | pH |
| 7 / 16 | | | 10,800 | (2'-1') | 10,800 | 540 | 0.0147 | 7.94 | pH |
| 8 / 17 | 135<br>193 | 45/2<br>50 | 12,688 | (1'-0') | 12,688 | 634.4 | 0.0073 | 4.63 | pH 5 |
| 8 / 18 | | | 12,688 | (2'-1') | 12,688 | 634.4 | 0.0155 | 9.83 | pH 3 |
| 9 / 19 | 128 | 75 | 9,600 | (1'-0') | 9,600 | 480 | (0.0073 interp) | 3.50 | pH 6 |
| 9 / 20 | | | 9,600 | (2'-1') | 9,600 | 480 | 0.0138 | 6.63 | pH 4 |
| 9A / 21 | | | 15,269 | (1'-0') | 15,269 | 763.4 | 0.0138 (interp) | 10.54 | pH |
| 9A / 22 | | | 15,269 | (2'-1') | 15,269 | 763.4 | 0.0083 | 6.34 | pH 4 |
| 10 / 23 | 221 | (52+60)/2 | 11,050 | (1'-0') | 11,050 | 552.5 | 0.0130 | 7.18 | pH |
| 10 / 24 | | | 11,050 | (2'-1') | 11,050 | 552.5 | 0.0155 | 8.56 | pH |
| 11 / 25 | 265<br>220 | (85+40)/2<br>48/2 | 21,842.$^{5}$ | (1'-0') | 21,842 | 1092 | 0.0068 | 7.43 | pH |
| 11 / 26 | | | 21,842 | (2'-1') | 21,842 | 1092 | 0.0080 | 8.74 | pH |

Σ 100.79 TONS AG

Use 150 tons Burnt Lime.

SINCE 1881

**FROEHLING & ROBERTSON, INC.**
FULL SERVICE LABORATORIES • ENGINEERING/CHEMICAL
*"OVER ONE HUNDRED YEARS OF SERVICE"*

December 30, 1983

ORIGINAL
(Red)

No: K-52-397-12-A

Preleminary Analysis of Soil

Made For: Cobough Blanton Associates
P.O. Box 8822
Richmond, Virginia 23225

Re: C & R Battery Works
Chesterfield, County, Virginia

0 - 0 - 0

| Sample No. | Sample I.D. | pH Value | Total Lead (pb), mg/l |
|---|---|---|---|
| 1 | HP-1, 0 to 1.0' | 6.9 | 17,997 ppm* |
| 2 | HP-1, 1.0 to 2.0' | 5.7 | 22,000 |
| 3 | HP-1A, 0 to 1.0' | 6.7 | 4396 |
| 4 | HP-2, 0 to 0.5' | 7.0 | 43,569 |
| 5 | HP-2A, 0 to 1.0' | 7.2 | 3431 |
| 6 | HP-2A, 1.0 to 1.3' | 8.2 | 3233 |
| 7 | HP-3, 0 to 1.0' | 5.2 | 7857 |
| 8 | HP-3, 1.0 to 2.0' | 3.7 | 91.7 |
| 9 | HP-4, 0.0 to 0.5' | 11.8 | 25,755 |
| 10 | HP-5, 0.0 to 0.8' | 7.6 | 62,958 |
| 11 | HP-6, 0.0 to 1.0' | 10.6 | 13,366 |
| 12 | HP-6, 1.0 to 2.0' | 12.3 | 32,391 |
| 13 | HP-6A, 0.0 to 1.0' | 4.8 | 4589 |
| 14 | HP-6A, 1.0 to 2.0' | 4.5 | 292 |
| 15 | HP-7, 0.0 to 1.0' | 5.8 | 35,379 |
| 16 | HP-7, 1.0 to 2.0' | 4.6 | 6039 |
| 17 | HP-8, 0.0 to 1.0' | 5.5 | 29,595 |
| 18 | HP-8, 1.0 to 2.0' | 3.5 | 1114 |
| 19 | HP-9, 0.0 to 1.0' | 6.0 | 25,583 |

* 7/5/85 TELECON WITH RAY SHOWALTER, VERIFYING THAT ANALYSIS WAS REPORTED IN PPM.

HEADQUARTERS: 3015 DUMBARTON ROAD • BOX 27524 • RICHMOND, VA. 23261 • TEL (804) 264-2701
BRANCHES: ASHEVILLE, NC • BALTIMORE, MD • CHARLOTTE, NC • CROZET, VA • FAYETTEVILLE, NC • GREENVILLE, SC • NORFOLK, VA • RALEIGH, NC • ROANOKE, VA • LYNCHBURG, VA.

CHARTER MEMBER CHARTER MEMBER MEMBER SINCE 1904

ORIGINAL
(Red)

| Sample No. | Sample I.D. | pH Value | Total Lead (pb), mg/l<br>PPM |
|---|---|---|---|
| 20 | HP-9, 1.0 to 2.0' | 4.6 | 446 |
| 21 | HP-9A, 0.0 to 1.0' | 4.6 | 22,172 |
| 22 | HP-9A, 1.0 to 2.0' | 4.2 | 3598 |
| 23 | HP-10, 0.0 to 1.0' | 4.7 | 42,344 |
| 24 | HP-10, 1.0 to 2.0 | 3.8 | 2638 |
| 25 | HP-11, 0.0 to 1.0' | 4.9 | 60,635 |
| 26 | HP-11, 1.0 to 2.0' | 4.3 | 9331 |

Respectfully,

August A. Thieme
Chief Chemist & Director
Chemical & Biological Services

Ray Showalter
Chemist

SINCE
F&R
1881

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING/CHEMICAL
*"OVER ONE HUNDRED YEARS OF SERVICE"*

April 17, 1984

No: L-52-034-4-A

Analysis of Soil

Made For: Cobough Blanton Associates
P.O. Box 8822
Richmond, Virginia 23225

Re: C & R Battery Works
Chesterfield County, Virginia

Method of Test: E.P.A. 600/2-78-054
Lime requirement by S.M.P. Buffer page 67

Reference: Report K-52-397-12-A

| Sample | Agricultural Ground Limestone with T.N.P. 90 % +, Tons per 1000 tons of Soil (Parts per Thou |
|---|---|
| 2 | 5.5 |
| 7 | 5.8 |
| 8 | 15.3 |
| 13 | 14.4 |
| 14 | 14.5 |
| 15 | 7.4 |
| 16 | 14.7 |
| 17 | 7.3 |
| 18 | 15.5 |
| 20 | 13.8 |

HEADQUARTERS: 3015 DUMBARTON ROAD • BOX 27524 • RICHMOND, VA. 23261 •
TEL (804) 264-2701
BRANCHES: ASHEVILLE, NC • BALTIMORE, MD • CHARLOTTE, NC • CROZET, VA •
FAYETTEVILLE, NC • GREENVILLE, SC • NORFOLK, VA • RALEIGH, NC • ROANOKE,
VA • LYNCHBURG, VA.

CHARTER MEMBER CHARTER MEMBER ASTM MEMBER SINCE 1904

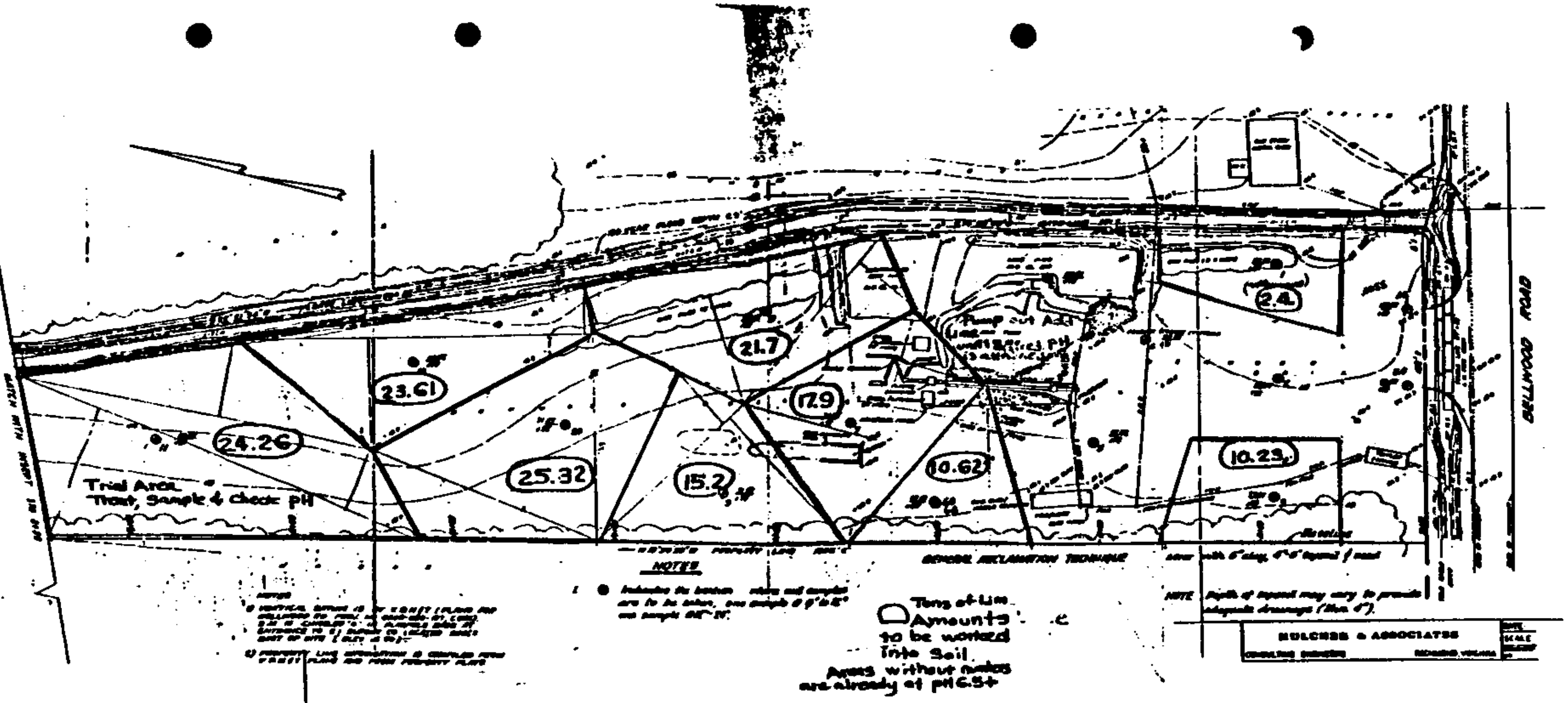
| Sample | Agricultural Ground Limestone with T.N.P. 90 % +, tons per 1000 tons of Soil |
|---|---|
| 22 | 8.3 |
| 23 | 13.0 |
| 24 | 15.5 |
| 25 | 6.8 |
| 26 | 8.0 |

Note: The above values represent that amount of limestone per unit to raise pH to 6.5.

Respectfully,

August A. Thieme

August A. Thieme
Chief Chemist & Director
Chemical & Biological Services



Pump out Add Lime

Trial Area, Treat, Sample & check pH

Tons of Lime Amounts to be worked into Soil

Areas without notes are already at pH 6.5+

Original
[illegible]

# APPENDIX D

COMMONWEALTH of VIRGINIA

STATE WATER CONTROL BOARD
Piedmont Regional Office
4010 West Broad Street
P.O. Box 6745
Richmond, Virginia 23230
(804) 257-1006

Richard N. Burton
Executive Director

Post Office Box 11143
chmond, Virginia 23230
(804) 257-0056

ORIGINAL
(Red)

July 23, 1984

Mr. Charles L. Guyton
C&R Battery Company, Inc.
c/o Mr. C. B. Neblett, Jr.
Baer and Neblett
2907 Hungary Springs Road
Richmond, VA 23228

<u>CERTIFIED MAIL</u>
<u>RETURN RECEIPT REQUESTED</u>

Dear Mr. Guyton:

The staff of the State Water Control Board has reviewed the revised Site Reclamation Plan dated May 23, 1984 for the C&R Battery Company. We received this plan on June 4, 1984.

The plan was also reviewed by staff of the State Department of Health, Bureau of Hazardous Waste Management. A copy of a letter dated June 25, 1984 from Mr. Robert Wickline is enclosed for your information.

We have the following questions and comments on the plan:

1. The soil pH must be raised to at least 9.5 standard units in order to stabilize the high concentrations of lead in the soil.

   Agricultural lime (calcium carbonate) should be used to raise the pH as much as possible. Hydrated lime ($Ca(OH)_2$) or burnt lime ($CaO$) should then be used to raise the pH to 9.5. We recommend the use of hydrated lime because of the hazards of working with burnt lime.

   Uniform lime application rates for the agricultural and hydrated or burnt lime should be used for the entire site. The rates would be the highest rates indicated by the soil analyses. Calculations should be submitted showing the amounts of agricultural and hydrated or burnt lime to be used. The cation exchange capacity (CEC) of the soil layers will be needed to determine the quantities of limes needed. A commercial laboratory experienced in soil analysis should be able to make a recommendation on the quantities of the limes needed.

2. A one-foot thick clay cap having a coefficient of permeability of $1 \times 10^{-7}$ cm/sec will be required. The cap should be placed and compacted in six inch lifts. The following information will be required on the material to be used for the clay cap: A map which locates and gives the exact dimensions of the borrow area for the material; the results from a representative number of samples from the borrow material analyzed per appropriate ASTM procedures for particle size analysis, plastic and liquid limits, and plasticity index; and laboratory permeability testing of the material at or up to 4% above optimum water content compacted to at least 95% Standard Proctor Density or 90% Modified Proctor Density. A technical specification detailing the step-by-step placement of the cap is also required.

   A foot of clay (vs. the proposed six inches) is necessary to ensure that an adequate cap is provided. It is difficult to achieve a uniform thickness of six inches if only a single six inch layer is provided. Also, the State's Hazardous Waste Regulations indicate that a two feet thick clay cap is needed for cover of hazardous wastes. Although this case does not involve hazardous wastes, the lead concentrations in the soil are very high and, in fact, the soil was found to be toxic per the EP Toxicity Test. A one foot thick cap is, therefore, appropriate, particularly, when compared to the original Site Reclamation Plan which provided for a six inch clay cap after soil with lead concentrations in excess of 100 mg/kg had been removed.

   The owner must ensure that the reclamation plan is performed in accordance with the approved plans. In regard to the clay cap, this will include representative testing of each in-place lift to include water content and density to show that the required permeability was obtained, and testing to demonstrate that the material actually used for the cap was the same material originally tested in the laboratory. We recommend that a geotechnical or soils engineer be retained to supervise the performance of the reclamation plan and to do the required testing. If a geotechnical or soils engineer is not hired, please include with your response to this letter a plan for staff review and approval detailing the testing that you intend to do to demonstrate compliance with the approved plans. Upon completion of the plan, a written statement that the reclamation plan was completed in accordance with the approved plans must be submitted.

3. An eight to ten inch (minimum) layer of topsoil or a gravel cover will be required over the clay for stabilization purposes. As indicated in the revised reclamation plan, the topsoil would be seeded with fescue grass and lime and fertilizer added to establish a good grass cover. Eight to ten inches (minimum) of topsoil is needed for the grass to establish a healthy root system and to provide enough moisture storage so that the grass can withstand drought conditions.

4. Please provide plans showing the finished grading of the site and the site drainage system. As mentioned in previous correspondence, a minimum slope of 1% is required on the finished site and positive drainage must be provided.

5. An erosion and sediment control plan should be prepared and submitted to Chesterfield County for review and approval. This plan should address erosion control during the performing of the reclamation plan and until a healthy stand of grass is obtained.

6. Please propose the location of three additional wells for ground water monitoring of the site. One of these three wells should be upgradient of the site. The existing 2-inch well installed in December 1983 should also be incorporated into the monitoring program. The provision of one upgradient well and three downgradient wells is consistent with the State's Hazardous Waste Regulations which provide appropriate guidance in this case.

7. Sample results have not been submitted for sample location # 12. Please provide this data and revise the plan as appropriate.

8. Please comment on the results of the soil sample at location # 6. The high pH values observed may be due to the sample containing lime, which is located in this area.

9. Process and vehicle areas must be covered with concrete or asphalt, etc. to protect the clay cap.

Please resubmit the reclamation plan to address the above concerns.

If you have any questions or comments, please contact Mr. Ray Jenkins of this office.

Sincerely,

Peter L Trexler

Peter L. Trexler, Director
Division of Surveillance, Field
Studies and Applied Technology

jt

cc: SWCB - Bureau of Applied Technology
SWCB - Bureau of Enforcement
Attorney General's Office - Mr. John Butcher
Mr. Charles L. Guyton
Mr. L. R. Cobaugh, P.E.
Mr. Bruce S. Hulcher, Ph.D.
Mr. Robert G. Wickline
Mr. Richard M. McElfish, P.E.

~~625~~/1229

# COMMONWEALTH of VIRGINIA

*Department of Health*
*Richmond, Va. 23219*

JAMES B KENLEY, M.D.
COMMISSIONER

June 25, 1984

RECEIVED
JUN 26 1984
PRO

Peter L. Trexler, Director
Division of Surveillance, Field
Studies and Applied Technology
State Water Control Board
Piedmont Regional Office
4010 West Broad Street
Richmond, Virginia 23230

Dear Mr. Trexler:

We have reviewed the Site Reclamation Plan dated May 23, 1984, for C & R Battery Company, Inc. as prepared by Cobaugh, Blanton Associates. We generally concur with the scheme proposed; however, there are some items of which you should be aware.

The materials in the "...area now covered by waste pond holding acidic wastes..." cannot be treated and disposed of in the manner described in the plan. This would be considered a treatment of a hazardous waste, and that activity would require a permit from our program. The time and difficulty in acquiring such a permit would probably be prohibitive. We suggest these materials be packaged without treatment, shipped and disposed of in accordance with current Virginia Hazardous Waste Management Regulations.

Field tests to verify the amount of lime needed to treat the soil should be made before proceeding (such verification is implied on the drawing, but it is not discussed in the plan). Lead in this soil matrix will be composed of sulfates, carbonates, hydroxides and oxides of lead and some organo-lead compounds. It is difficult to predict the optimum pH for their precipitation; however, a pH of 9.5 might be a better target since this is in the normal range of lead hydroxide precipitation. Tests could determine the optimal pH for minimum lead solubility. Also, a pH of 7.0 or greater is normally needed for lead absorption on clays.

The clay cap will be thin and delicate. Normally, additional sand, soil and vegetation would protect the cap. Some method of keeping vehicles and activity away from the cap must be established. Any areas to be used for process areas, vehicle areas, work areas or similar abuse must be covered with asphalt or concrete. Any splash-prone areas should receive special consideration.

This appears to be a viable plan. We hope it will result in a resolution of this problem. If we can help in any further manner, please do no hesitate to contact us.

Sincerely,

Robert Wickline

Robert G. Wickline, P.E.
Technical Program Director
Bureau of Hazardous Waste Management

RGW:438/mcw

cc: SWCB - Bureau of Applied Technology
SWCB - Bureau of Enforcement
Attorney General's Office - Mr. John Butcher

# APPENDIX D

# GEOTECHNICAL STUDY

## C & R BATTERY COMPANY
## CHESTERFIELD COUNTY, VIRGINIA

Prepared for

COBAUGH & ASSOCIATES
Richmond, Virginia

Prepared by

SAYRE & ASSOCIATES, p.c.
Richmond, Virginia

Project: 83056

December 1983

[illegible]

# TABLE OF CONTENTS

# GEOTECHNICAL STUDY

## C & R BATTERY COMPANY
## CHESTERFIELD COUNTY, VIRGINIA

### INTRODUCTION

Upon the authorization of Mr. Lee R. Cobaugh, P.E., we have completed a geotechnical study at the site of the proposed improvements for C & R Battery Company on Bellwood Road in Chesterfield County, Virginia. The purpose of our study was to provide professional opinions and recommendations concerning the soil design criteria for the foundations of the structures and to determine the depth to the water table. Our study included a reconnaissance of the site, review of a previous investigation, test borings, installation of a ground water monitor well, and an analysis of the collected data.

### SUMMARY OF FINDINGS

The soil in the top 8 feet is capable of supporting the proposed concrete tanks and other minor structures. The maximum allowable soil pressure is 3500 psf.

On-site soil after stripping the top 8 to 12 inches can possibly be used for constructing the berm after verification with additional testing.

The ground water level was 40 feet below the surface at the time of our investigation.

## DESCRIPTION OF SITE

C & R Battery Company is located on the north side of Bellwood Road, near the east end of the road, in Chesterfield County, Virginia. The James River is about 1000 feet north of the site.

The topography of the site is gently sloping to the east. A drainage ditch is along the east property line and flows to the north and eventually to the James River. The difference in elevation across the site is 3 to 4 feet. Drainage of the site is fair to poor, with pockets of water standing over the site.

The site is cleared of vegetation except along the western property line and the northern end of the property. Equipment and plant structures are in scattered areas over the site.

The area lies at the western edge of the Atlantic Coastal Plain physiographic province. The soils have been deposited as part of an old reworked flood plain of the James River. Soils typically consist of clays, sands, and sands and gravels in varying thickness of strata. Boulders and cobbles are found at depths of 35 to 50 feet.

## DESCRIPTION OF PROJECT

A layout plan entitled "C & R Battery, Inc." dated January 7, 1983, prepared by Hulcher & Associates, shows three concrete tanks and other improvements, including soil berms around certain portions of the plant. One of the below-grade concrete tanks will be 35 x 35 feet, and the other two will be 50 x 50. The tanks will be in the ground about 6 feet, and the tops will be flush with the surface.

## SUBSURFACE INVESTIGATION

Two test borings and a groundwater monitor well were made at locations suggested by the engineer. The two test borings were made at tank locations, and the groundwater monitor well was made near the third tank and the low point of the site. Two borings were drilled for the groundwater monitor well; one to 20 feet, and the other to 45 feet. Groundwater was not present in the 20-foot boring.

The test borings were made using a truck-mounted drill rig with continuous-flight hollow-stem augers. Split-barrel soil samples and standard penetration resistance values (N = blows per foot) were obtained simultaneously in accordance with ASTM Method D-1586 at 2 feet, 4 feet, and then at 5-foot intervals to the bottom of each boring. Test borings 1 and 2 were drilled to depths of 25 and 15 feet respectively.

Boring 3 was drilled for the groundwater monitor well to 20 feet without sampling. Boring 4 was drilled for the groundwater monitor well to 45 feet and was sampled from 24 feet to the bottom of the boring at 5-foot intervals.

Observations were made in each boring for the presence of groundwater. Logs of the borings are in the Appendix.

A 2-inch PVC pipe with a 5-foot screen and 0.01-inch openings at the bottom was installed for the groundwater monitor well. Pea gravel was placed in the bottom 10 feet of the hole around the pipe, and natural soil used to backfill up to within 2 feet of the surface. The final 2 feet were backfilled with concrete.

## DESCRIPTION OF SOIL

The site is covered with varying depths (1 to 10 inches) of crushed stone, pieces of batteries, and concrete pavement. A 6-inch concrete slab is around the processing and plant operations areas.

Beneath the surface materials, there is a stratum of moderately firm gray clay with brown sand seams. The thickness of the clay stratum is estimated at 3 to 8 feet. The clay is impervious and has standard penetration resistance values of 9 to 19 blows per foot.

From 3 to 8 feet to a depth of 27 feet, there is a layer of sandy clay. The sandy clay is moderately firm with N values of 9 to 22 blows per foot. At 22 feet there is a 1 to 2-foot thick gravel seam which protrudes into the sandy clay.

The sandy clay is underlain by a 10-foot thick layer of fine to coarse sand, which is moderately dense. Starting at 37 feet to the bottom of the deepest boring there is a dense coarse sand and gravel.

Groundwater was measured at 40 feet during drilling and following installation of the monitor well.

## DISCUSSION

Soil conditions for shallow foundations are good at this site, after stripping of the surface debris. The gray clay near the surface and the underlying sandy clay stratum are capable of providing satisfactory support for spread or continuous footings. In the top 8 feet the allowable soil pressure is 3500 psf for the undisturbed clayey soils.

The weight of the overburden soil removed in excavating for the proposed tanks will exceed the weight the tanks will exert on the soil at a depth of 6 feet.

The natural clay soil found on the site could possibly be used for constructing the berms after additional investigation.

It will be necessary that we sample and test the clay to determine if the clay has the desired soil characteristics for the berm.

Groundwater is present in the coarse sand and gravel stratum which begins at a depth of 37 feet below the surface. Water was measured in the monitor well on December 20, 1983 at 40 feet below the surface. The water level is approximately the level of the James River and the ground water level can be expected to vary with the level of the river.

## LIMITATIONS

The analysis and recommendations submitted in this report are based upon the data obtained from soil borings performed at the locations shown on the sketch in the Appendix. This report does not reflect any variations which may occur between these borings. The nature and extent of variations between the borings may not become evident until construction is underway. If variations become evident, this firm should be notified so that immediate observations can be made of the conditions and appropriate recommendations can be rendered.

This report has been prepared for Cobaugh & Associates to be used in the design of the proposed structures. Anyone using this report for any purpose other than design of the structures described herein must draw his own conclusions regarding construction procedures and soil conditions.

We recommend that this report in its entirety, including the Appendix, be furnished as information to prospective bidders. We disclaim all responsibility and liability for any part which is removed, quoted, or reproduced separately from the entire report.

We request the opportunity to review those portions of the plans and specifications for this project which pertain to earthwork to determine if they are consistent with our recommendations.

SAYRE & ASSOCIATES, p.c

William R. Pully

December 21, 1983

William R. Pully, P.E.

COMMONWEALTH OF VIRGINIA
WILLIAM R. PULLY
LICENSE No.
2244
PROFESSIONAL ENGINEER

# APPENDIX

Original
Red

## NOTES TO BORING LOGS

These notes refer to and are a part of the accompanying boring logs.

1. The borings were made by a boring contractor under the continuous observation of an engineer of Sayre & Associates. These boring logs were compiled from Sayre & Associates field logs and the results of visual examination of the soil samples in our laboratory.

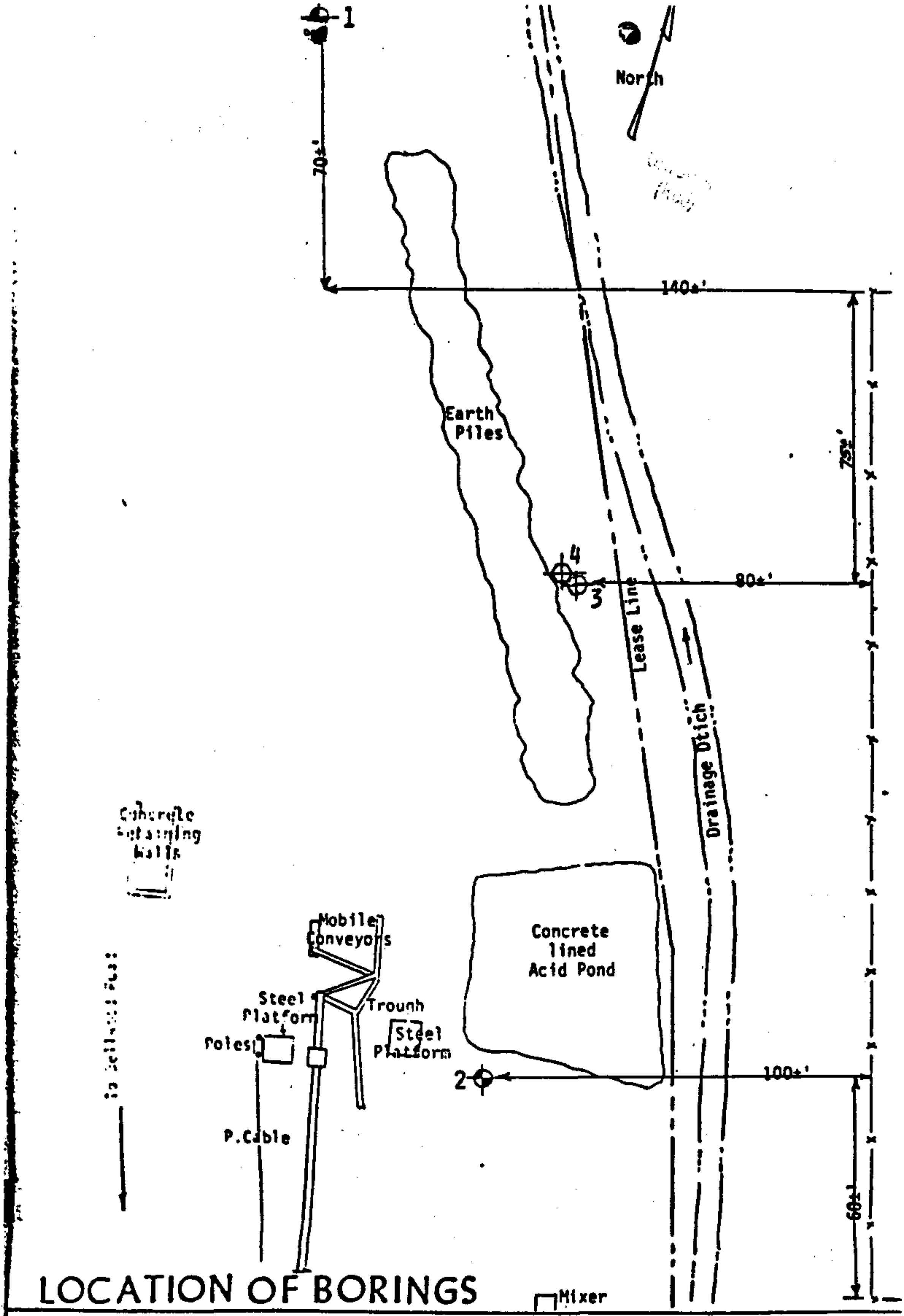
2. The logs of the borings apply only at the specific boring locations and at the dates indicated. They are not warranted to be representative of subsurface conditions at other locations and times.

3. The depth of the indicated boundaries between soil or rock strata is approximate. The transition between the strata may be gradual.

4. The ground water levels shown on the boring logs represent average or typical values observed during the period of the boring operation or shortly after completion of a boring. These observations do not reflect seasonal changes in the water table or the effects of intense rainfall or runoff. In any excavation, trickling flow or seepage may be encountered from perched water which is at levels above the water table observed in the borings.

5. Soil samples recovered from the borings and which remained after laboratory testing have been stored at Ayers & Ayers, Inc., Richmond, Virginia, and are available for inspection by appointment. The soil samples will be discarded sixty days after completion of the borings unless a request is received to retain them for a longer period.

6. The locations of borings were determined by tape measurement from the chain link fence just east of the property. Elevations of borings were approximately determined by interpolation between plan contours. The location and elevation of the borings should be considered accurate only to the degree implied by the method used.



# LOCATION OF BORINGS

C & R BATTERY, INC.
BELLWOOD ROAD
CHESTERFIELD COUNTY, VA

scale APPROX. 1" = 50±'
date DECEMBER 1983

SAYRE & ASSOCIATES, p.c. geotechnical engineers

# NOTES TO BORING LOGS (continued)

## Definition of Terms and Abbreviations

All soil descriptions are based on visual examination and on the following definitions of terms and abbreviations:

### Components

GRAVEL - particles larger than 1/4" diameter

SAND - particles smaller than 1/4" diameter and larger than No. 200 sieve (individual grains visible to naked eye)

SILT - particles smaller than No. 200 sieve (individual grains not distinguishable); low plasticity to non-plastic

CLAY - particles smaller than No. 200 sieve; medium to high plasticity

TOPSOIL - surface soil containing a significant proportion of organic matter

FILL - man-made deposit

### Composition

GRAVEL, SAND, SILT, CLAY - major component (50% or more)

gravelly, sandy, silty, clayey - secondary component (33% to 50%)

some - minor component (10% to 33%)

trace - minor component (1% to 10%)

and - two major components (nearly equal proportions)

### Moisture

saturated - below water table

wet - much above optimum

moist - near optimum

dry - much below optimum

### Structure

stratified - layers 1/2 to 12 inches thick

laminated - layers less than 1/2 inch thick

### Color

dark, light - significant difference in shade

mottled - irregularly colored, usually indicates lack of drainage

WOH - weight of hammer

RQD - rock quality designation (% of core which is 4" or longe

NSR - no sample recovered

# BORING LOG

Boring No.: 1 Elevation — Top of Boring 43.5±' Date of Boring: December 9, 1983

Project: 83056 C & R Battery, Inc.

Location: Bellwood Road, Chesterfield County, Virginia

Type of Boring: Hollow-stem auger

illing Contractor: Ayers & Ayers, Inc., Richmond, Virginia

| Depth | Stratum Description | Sample Depth | Sample Blows* Core Recovery** | Sample Description |
|---|---|---|---|---|
| 0 | Crushed stone, pieces of plastic and gray clay | | | |
| | | 1.5 | 5-7-6 | Gray CLAY, moist |
| | | 3.0 | 3-3-6 | Gray CLAY, moist |
| | | 4.5 | 3-7-12 | Gray CLAY with brown sand seams, moist |
| 5 | Gray CLAY | 6.0 | | |
| | | 8.5 | 8-6-8 | Gray fine sandy CLAY, trace silt, moist |
| 10 | | 10.0 | | |
| | | 13.5 | 8-10-9 | Gray fine sandy CLAY, trace gravel moist |
| 15 | Gray sandy CLAY | 15.0 | | |
| | | 17.0 | 2-7-6 | Gray fine sandy CLAY, moist |
| | | 18.5 | 3-3-6 | Brown sandy CLAY, wet |
| '0 | | 20.0 | | |
| | Brown SAND and GRAVEL | 22.5 | 52 in 6" | Brown SAND and GRAVEL, moist |
| | Brown silty SAND | 23.5 | 7-14-21 | Brown silty fine SAND, moist |
| 25 | Boring terminated at 25.0 ft. | 25.0 | | |
| ) | | | | |
| 35 | | | | |
| '5 | | | | |

und Water Data:

ater level is ________ ft. below ground surface ________ hrs. after completion.

io ground water encountered during drilling.

**SAYRE & ASSOCIATES, p.c.**

*Geotechnical Engineers*
*Richmond, Virginia*

* No. of Blows 140-lb. Hammer, 30-in. Fall, Required to Drive 2 in. O.D., 1.375 in I.D. Sampler 6 Inches.

** Core Recovery as Percent of Length of Drill Run.

**Boring No.:** 2 **Elevation – To[illegible] Boring:** 45±' **Date of [illegible]g:** December 9, 1983

**Project:** 83056 C & R Battery, Inc.

**Location:** Bellwood Road, Chesterfield County, Virginia

**Type of Boring:** Hollow-stem auger

**Drilling Contractor:** Ayers & Ayers, Inc., Richmond, Virginia

| Depth | Stratum Description | Sample Depth | Sample Blows* Core Recovery** | Sample Description |
|---|---|---|---|---|
| 0 | Concrete slab - 6" | | | |
| | Crushed stone - 4-6" | | | |
| | Gray CLAY | 2.0<br>3.0 | 9-7 | Gray CLAY, trace sand, moist |
| 5 | Brown micaceous sandy CLAY | 4.0<br>5.0 | 11-20 | Brown micaceous sandy CLAY, trace<br>moist |
| 10 | | 9.0<br>10.0 | 8-14 | Brown micaceous sandy CLAY, trace<br>moist |
| 15 | Boring terminated at 15.0 ft. | 14.0<br>15.0 | 4-5 | Brown micaceous sandy CLAY, trace<br>wet |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |
| 40 | | | | |
| 45 | | | | |

**Ground Water Data:**

Water level is _________ ft. below ground surface _________ hrs. after completion.

No ground water encountered during drilling.

**SAYRE & ASSOCIATES,**

*Geotechnical Engineers*
*Richmond, Virginia*

* No. of Blows 140-lb. Hammer, 30-in. Fall, Required to Drive 2 in. O.D., 1.375 in I.D. Sampler 6 Inches.

** Core Recovery as Percent of Length of Drill Run.

See NOTES TO BORING LOG which are a part of this log.

# BORING LOG

**Probe** 3 **Elevation – Top of Boring:** 431±' **Date of Boring:** December 19, 1983

**Project:** C & R Battery

**Location:** Bellwood Road, Chesterfield County, Virginia

**Type of Boring:** Hollow-stem auger

**Drilling Contractor:** Ayers & Ayers, Inc., Richmond, Virginia

| Depth | Stratum Description | Sample Depth | Sample Blows* Core Recovery** | Sample Description |
|---|---|---|---|---|
| 0 | FILL-crushed stone, plastic 6" | | | |
| | Gray CLAY | | | |
| 5 | | | | |
| 10 | Brown and gray sandy CLAY | | | |
| 15 | | | | |
| 20 | Boring terminated at 20.0 ft. | | | 2" PVC pipe installed. 5' screen with 0.01 inch opening at bottom of hole. |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |
| 40 | | | | |
| 45 | | | | |

ORIGINAL (Red)

**Ground Water Data:**

Water level is ________ ft. below ground surface ________ hrs. after completion.

No groundwater encountered during drilling.

**SAYRE & ASSOCIATES, p.c**

*Geotechnical Engineers*
*Richmond, Virginia*

* No. of Blows 140-lb. Hammer, 30-in. Fall, Required to Drive 2 in. O.D., 1.375 in I.D. Sampler 6 Inches.

** Core Recovery as Percent of Length of Drill Run.

See NOTES TO BORING LOG which are a part of this log.

Project: 83056 C & R Battery Inc. | Date of B[illegible]: December 19-20, 1983

Location: Bellwood Road, Chesterfield County, Virginia

Type of Boring: Hollow-stem auger

Drilling Contractor: Ayers & Ayers, Inc., Richmond, Virginia

| Depth | Stratum Description | Sample Depth | Sample Blows* Core Recovery** | Sample Description |
|---|---|---|---|---|
| 0 | Gray CLAY | | | |
| 5 | | | Probe to 24 ft. | |
| 10 | Brown and gray sandy CLAY | | | Gravel seam at 9.0 ft. |
| 15 | | | | |
| 20 | | | | |
| 25 | | 24.5<br>25.5 | 15-17 | Brown and gray sandy CLAY, moist |
| 30 | Brown SAND | 29.5<br>30.5 | 8-12 | Brown fine to medium SAND, moist |
| 35 | | 34.5<br>35.5 | 7-10 | Brown fine to medium SAND, moist |
| | | | | (Large gravel) |
| 40 | Brown SAND and GRAVEL | 39.5<br>40.5 | 20-25 | Brown coarse SAND AND GRAVEL, saturated |
| | | | | (Running sand) |
| 45 | Boring terminated at 45.0 ft. | 44.0<br>45.0 | 40-45 | Brown coarse SAND AND GRAVEL, saturated |

Ground Water Data:

Water level is 40.0 ft. below ground surface 1/2 hrs. after completion.

**SAYRE & ASSOCIATES, p.c.**

*Geotechnical Engineers*
*Richmond, Virginia*

* No. of Blows 140-lb. Hammer, 30-in. Fall, Required to Drive 2 in. O.D., 1.375 in I.D. Sampler 6 Inches.
** Core Recovery as Percent of Length of Drill Run.
See NOTES TO BORING LOG which are a part of this log.

SINCE 1881
**FROEHLING & ROBERTSON, INC.**
FULL SERVICE LABORATORIES • ENGINEERING/CHEMICAL
*"OVER ONE HUNDRED YEARS OF SERVICE"*

Richmond, Virginia
December 30, 1983

RECEIVED
JAN 6 1984
PRO

Carpano
cc: BAT - Alexander
BE - Stutzer
AGO - Butcher
by hand at meeting

Cobaugh Blanton Associates
P. O. Box 8822
Richmond, Virginia 23225

Re: Summary of Field Exploration
C&R Battery Works
Chesterfield Co., VA

Gentlemen:

Included herein are descriptions of the hand probe borings performed on Decembe 19, 1983 at C&R Battery Works, Bellwood Road, Richmond, VA. The descriptions includ total depth, depth and number of samples procured from each probe and, in some insta a material description of the soils encountered in the probes.

Probes HP-5, HP-4, HP-2, HP-2A, and HP-1A met auger refusal at depths shallower than 2.0 feet as noted in the descriptions. Probe HP-1 was offset ±5.0 feet in orde to obtain sample two (S-2) from 1.0 to 2.0 feet. Surveyed markers for HP-2, HP-9A, and HP-10 were disturbed prior to our arrival at the site, and these probes were relocated in the field by tape measure.

Samples were placed immediately in plastic sample bags, properly labeled and fastened to minimize the possibility of contamination.

Very truly yours,

FROEHLING & ROBERTSON, INC.

John P. Cassidy, Manager
Geotechnical Department

JPC/dw

HEADQUARTERS: 3015 DUMBARTON ROAD • BOX 27524 • RICHMOND, VA 23261 •
TEL (804) 264-2701
BRANCHES: ASHEVILLE, NC • BALTIMORE, MD • CHARLOTTE, NC • CROZET, VA •
FAYETTEVILLE, NC • GREENVILLE, SC • NORFOLK, VA • RALEIGH, NC • ROANOKE, VA • LYNCHBURG, VA

CHARTER MEMBER CHARTER MEMBER MEMBER SINCE 1904

Distribution:

cc: Hulcher & Associates
2114 Spencer Road
Richmond, Virginia 23230

Attention: Mr. Bob Gore

SINCE
F&R
1881

## C&R BATTERY WORKS

## F&R #K-55-221

| Hand Probe No. | Depth | Description | Sample No |
|---|---|---|---|
| HP-1 | 0.0-1.0' | Brown Silty CLAY with Metal and Plastic Debris | S-1 |
| | 1.0-2.0' | | S-2 |
| | Hand Auger Refusal due to debris (plastic)<br>S-2 offset 5' from S-1 | | |
| HP-1A | 0.0-1.0' | Gray Clayey Fine to Coarse SAND, Little Silt, Little Gravel | S-1 |
| | Auger Refusal @ 1.0' due to gravel | | |
| HP-2 | 0.0-0.5' | Gray Clayey Fine to Coarse SAND, Little Silt, Little Gravel with Plastic | S-1 |
| | Auger Refusal @ 0.5' due to gravel | | |
| HP-2A | 0.0-1.0' | Gray Clayey Fine to Coarse SAND, Little Silt, Little Gravel | S-1 |
| | 1.0-1.3' | | S-2 |
| | Auger Refusal @ 1.3' due to gravel | | |
| HP-3 | 0.0-1.0' | Brown Silty CLAY, Little Fine to Coarse Sand | S-1 |
| | 1.0-2.0' | | S-2 |
| | Probe Terminated @ 2.0' | | |
| HP-4 | 0.0-0.5' | Brown Silty CLAY with Hydrated Lime(?) | S-1 |
| | Auger Refusal @ 0.5' due to concrete | | |
| HP-5 | 0.0-0.8' | Gray-Brown Silty CLAY w/Plastic & Debris | S-1 |
| | Auger Refusal @ 0.8' | | |

C&R BATTERY WORKS CONTD.

| Hand Probe No. | Depth | Description | Sample N |
|---|---|---|---|
| HP-6 | 0.0-1.0' | Gray-Brown Silty CLAY, Little Fine to Coarse Sand with Hydrated Lime(?) Saturated 0-10" | S-1 |
| | 1.0-2.0' | | S-2 |
| | Probe Terminated @ 2.0' | | |
| HP-6A | 0.0-1.0' | Brown Silty CLAY, Little Fine to Coarse Sand | S-1 |
| | 1.0-2.0' | | S-2 |
| | Probe Terminated @ 2.0' | | |
| HP-7 | 0.0-0.3' | Gray to Brown Silty CLAY (wet) | S-1 |
| | 0.3-2.0' | Brown Fine Sandy CLAY | S-2 |
| | Probe Terminated @ 2.0' | | |
| HP-8 | 0.0-2.0' | Brown Fine Sandy CLAY w/Little Gravel | S-1<br>S-2 |
| | Probe Terminated @ 2.0' | | |
| HP-9 | 0.0-0.2' | Gray-Brown Silty CLAY w/Plastic | |
| | 0.2-1.1' | Brown Silty Fine SAND w/Some Clay | S-1 |
| | 1.1-2.0' | Brown Silty CLAY | S-2 |
| | Probe Terminated @ 2.0' | | |
| HP-9A | 0.0-0.8' | Gray-Brown Silty CLAY w/Plastic | S-1 |
| | 0.8-2.0' | Gray-Brown Mottled Silty CLAY | S-2 |
| | Probe Terminated @ 2.0' | | |
| HP-10 | 0.0-1.2' | Gray-Brown Silty CLAY w/Plastic & Metal Debris | S-1 |
| | 1.2-2.0' | Gray-Brown Mottled Clayey SILT | S-2 |
| | Probe Terminated @ 2.0' | | |
| HP-11 | 0.0-1.2' | Gray-Brown Silty CLAY w/Plastic & Metal Debris | S-1 |
| | 1.2-2.0' | Gray & Light Brown Clayey SILT | S-2 |
| | Probe Terminated @ 2.0' | | |

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December 30, 1983

No: K-52-397-12-A

Preleminary Analysis of Soil

Made For: Cobough Blanton Associates
P.O. Box 8822
Richmond, Virginia 23225

Re: C & R Battery Works
Chesterfield, County, Virginia

Void because units wrong. To be reis

0 - 0 - 0

| Sample No. | Sample I.D. | pH Value | Total Lead (pb), mg/1 |
|---|---|---|---|
| 1 | HP-1, 0 to 1.0' | 6.9 | 17,997 |
| 2 | HP-1, 1.0 to 2.0' | 5.7 | 22,000 |
| 3 | HP-1A, 0 to 1.0' | 6.7 | 4396 |
| 4 | HP-2, 0 to 0.5' | 7.0 | 43,569 |
| 5 | HP-2A, 0 to 1.0' | 7.2 | 3431 |
| 6 | HP-2A, 1.0 to 1,3' | 8.2 | 3233 |
| 7 | HP-3, 0 to 1.0' | 5.2 | 7857 |
| 8 | HP-3, 1.0 to 2.0' | 3.7 | 91.7 |
| 9 | HP-4, 0.0 to 0.5' | 11.8 | 25,755 |
| 10 | HP-5, 0.0 to 0.8' | 7.6 | 62,958 |
| 11 | HP-6, 0.0 to 1.0' | 10.6 | 13,366 |
| 12 | HP-6, 1.0 to 2.0' | 12.3 | 32,391 |
| 13 | HP-6A, 0.0 to 1.0' | 4.8 | 4589 |
| 14 | HP-6A, 1.0 to 2.0' | 4.5 | 292 |
| 15 | HP-7, 0.0 to 1.0' | 5.8 | 35,379 |
| 16 | HP-7, 1.0 to 2.0' | 4.6 | 6039 |
| 17 | HP-8, 0.0 to 1.0' | 5.5 | 29,595 |
| 18 | HP-8, 1.0 to 2.0' | 3.5 | 1114 |
| 19 | HP-9, 0.0 to 1.0' | 6.0 | 25,583 |

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CHARTER MEMBER CHARTER MEMBER ASTM MEMBER SINCE 19

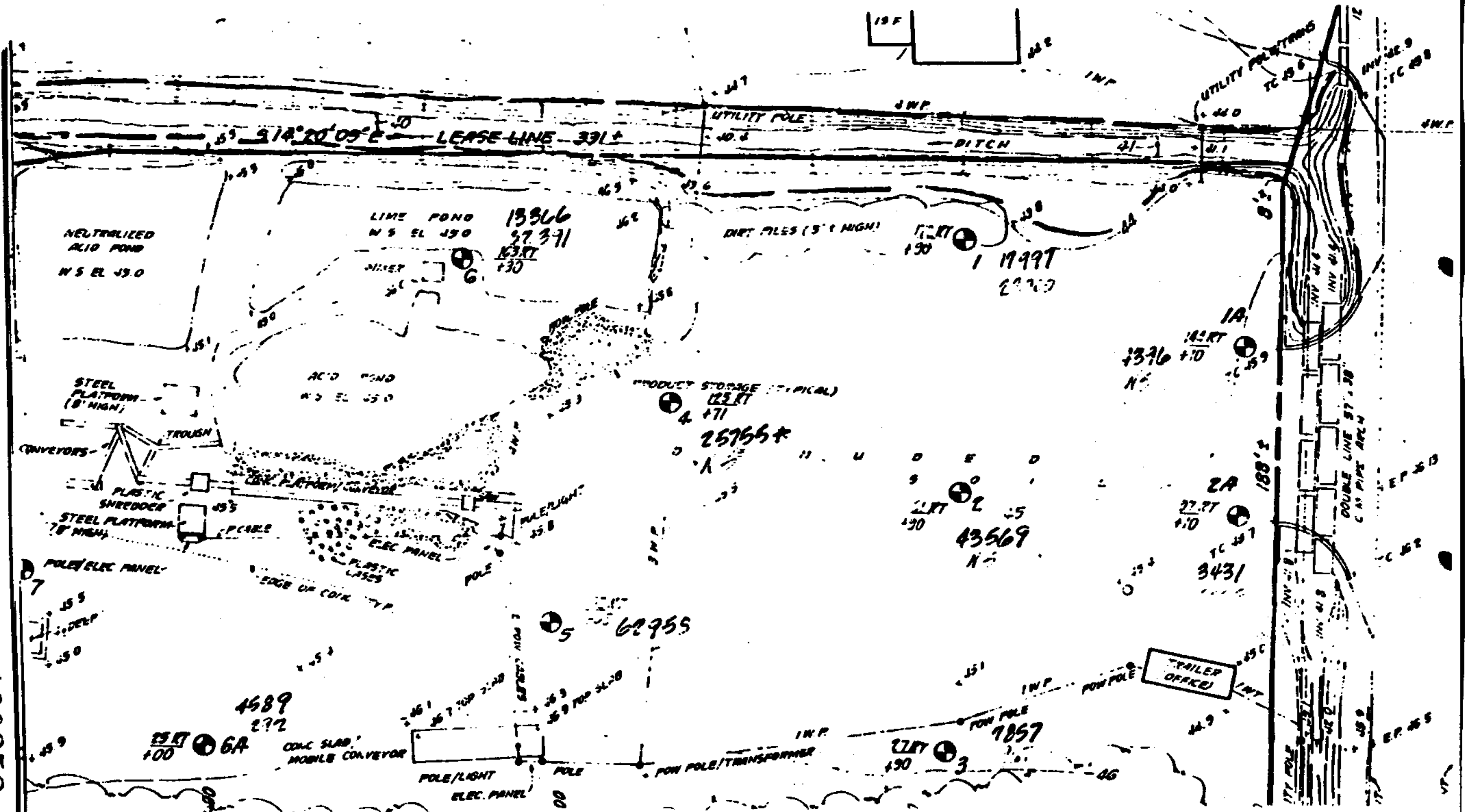
ORIGINAL
(Red)

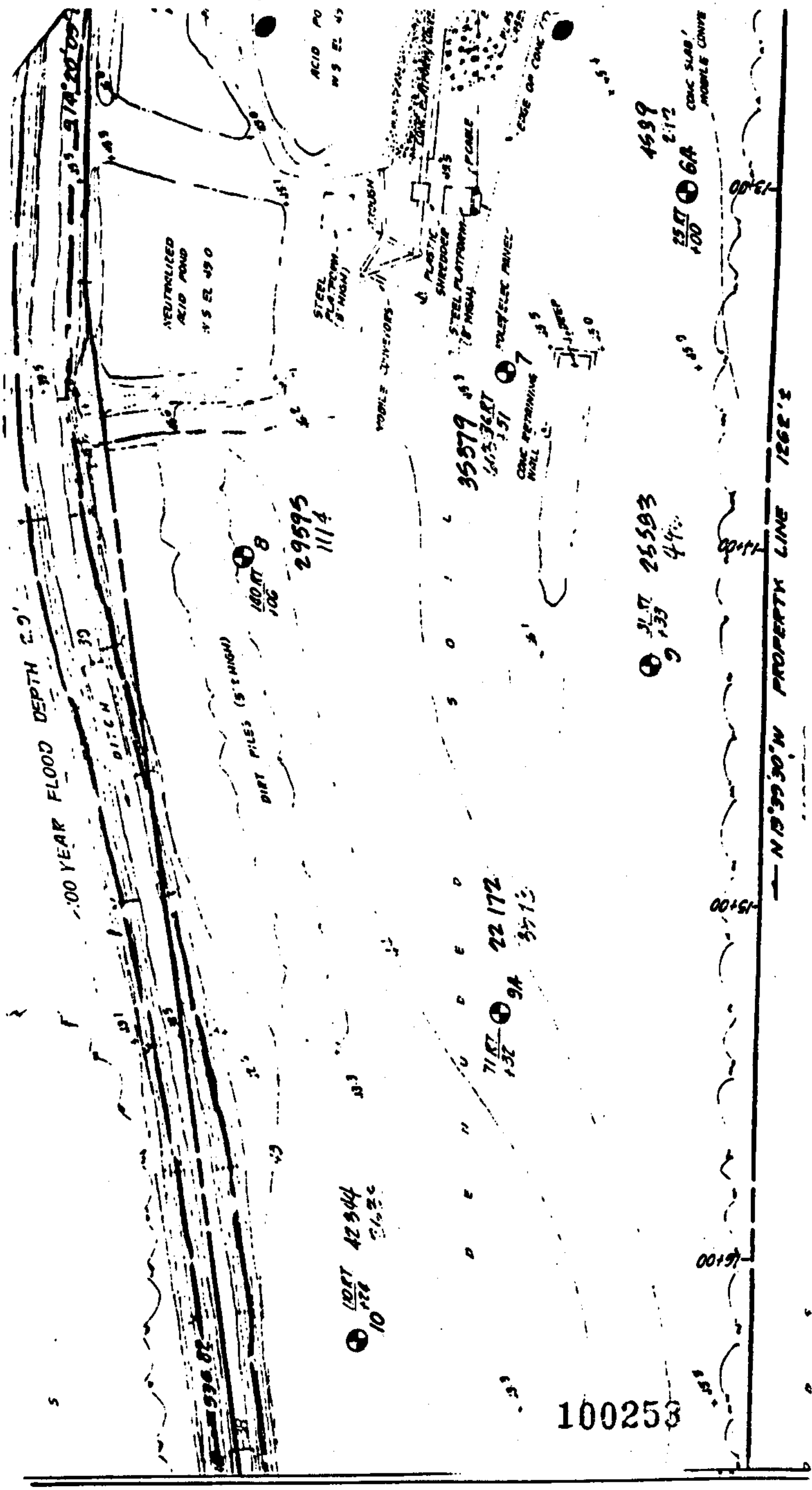
| Sample No. | Sample I.D. | pH Value | Total Lead (pb), mg/l |
|---|---|---|---|
| 20 | HP-9, 1.0 to 2.0' | 4.6 | 446 |
| 21 | HP-9A, 0.0 to 1.0' | 4.6 | 22,172 |
| 22 | HP-9A, 1.0 to 2.0' | 4.2 | 3598 |
| 23 | HP-10, 0.0 to 1.0' | 4.7 | 42,344 |
| 24 | HP-10, 1.0 to 2.0 | 3.8 | 2638 |
| 25 | HP-11, 0.0 to 1.0' | 4.9 | 60,635 |
| 26 | HP-11, 1.0 to 2.0' | 4.3 | 9331 |

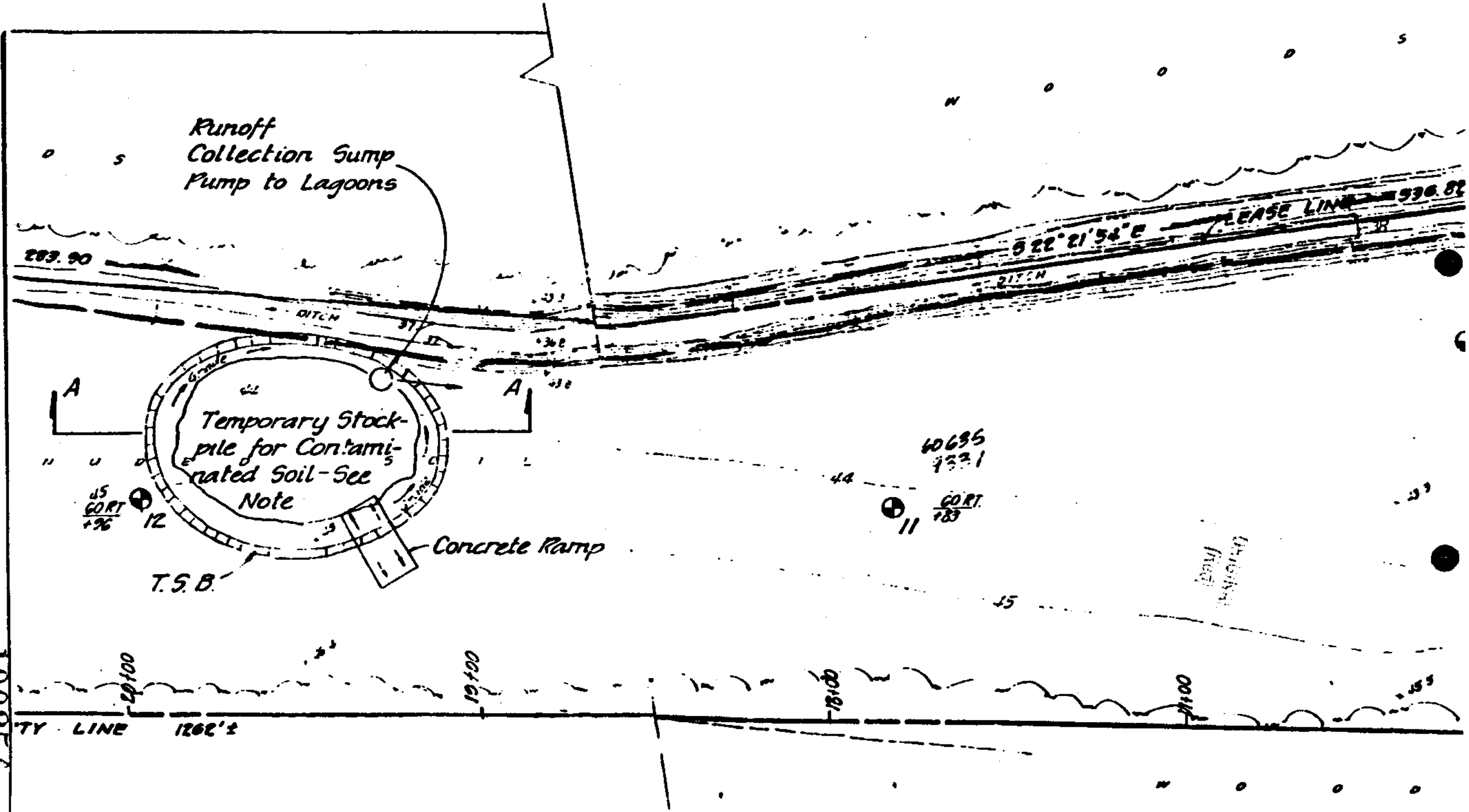
Respectfully,

August A. Thieme
Chief Chemist & Director
Chemical & Biological Services

Ray Showalter
Chemist

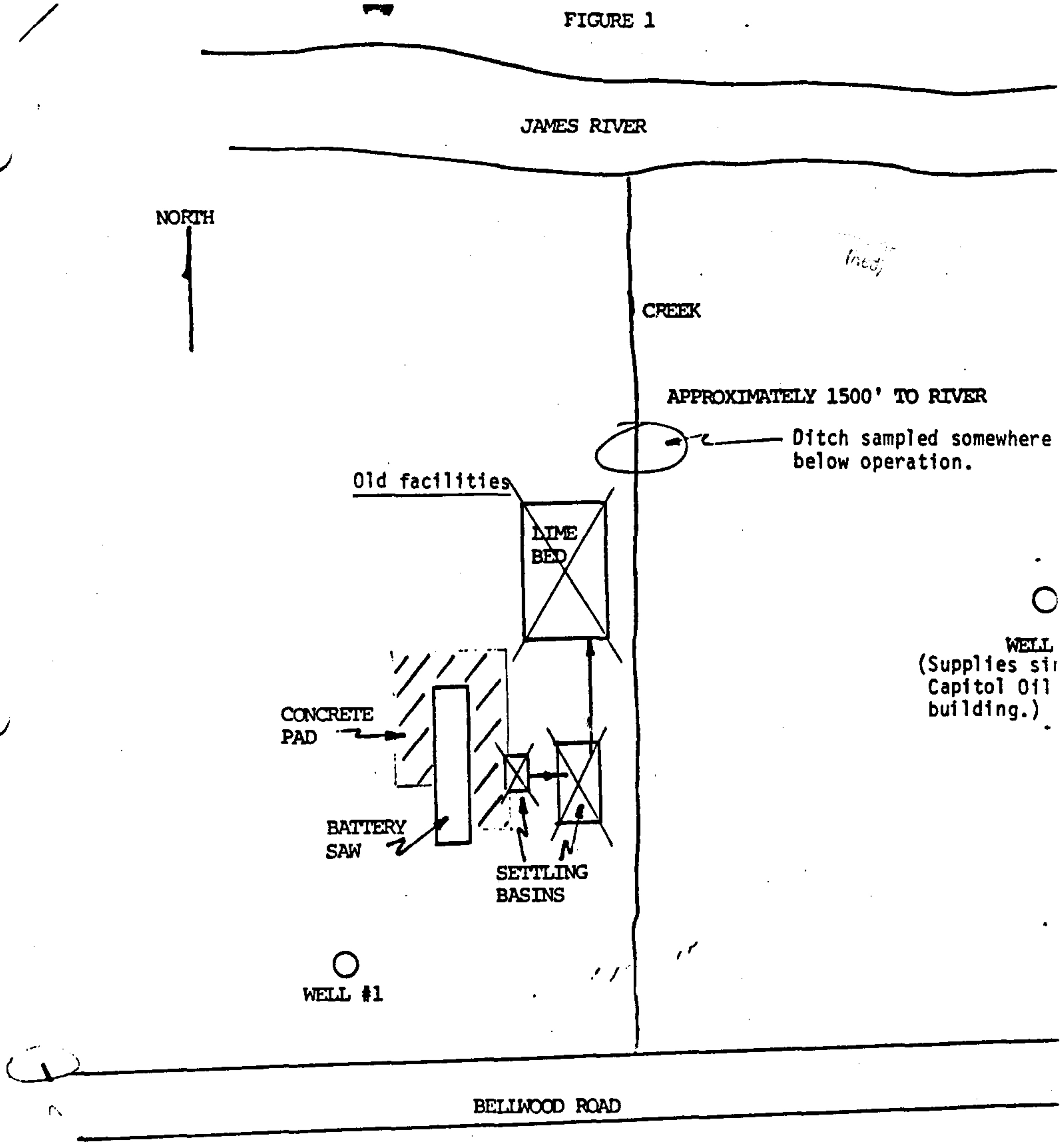

S14°20'05"E — LEASE LINE 331±
UTILITY POLE
DITCH
UTILITY POLE/TRANS
DIRT PILES (5'± HIGH)
NEUTRALIZED ACID POND W S EL 49.0
LIME POND W S EL 49.0
13366
37.371
163 RT +30
6
INLET
ACID POND W S EL 45.0
PRODUCT STORAGE (TYPICAL)
125 RT +71
4
25755*
1
11997
1A
142 RT +10
1376
2
43569
2A
3431
DOUBLE LINE 57.38
C M PIPE ARCH
188'±
STEEL PLATFORM (8' HIGH)
TROUGH
CONVEYORS
CONC. PLATFORM/CONVEYOR
PLASTIC SHREDDER
STEEL PLATFORM 78' HIGH
POLE/ELEC PANEL
7
POLE/LIGHT
ELEC PANEL
PLASTIC CASES
EDGE OF CONC TYP
POLE
5
62955
POW CABLES
4589
272
75 RT +00
6A
CONC SLAB, MOBILE CONVEYOR
POLE/LIGHT
ELEC. PANEL
POW POLE/TRANSFORMER
POW POLE
1857
77 RT +30
3
TRAILER OFFICE
IWP


100 YEAR FLOOD DEPTH 2.0'
DITCH
NEUTRALIZED ACID POND W S EL 49.0
ACID POND W S EL 49
DIRT PILES (5'± HIGH)
STEEL PLATFORM (8' HIGH)
TROUGH
PLASTIC SHREDDER
STEEL PLATFORM (8' HIGH)
MOBILE INJECTORS
POLE/ELEC PANEL
CONC RETAINING WALL
EDGE OF CONC
CONC SLAB/ MOBILE CONTE
8
29595
1114
7
35879
6A
4499
9
25593
9A
22172
10
42344
N 13°39'30" W PROPERTY LINE 1262'±
13+00
14+00
15+00
16+00
ROAD


Runoff Collection Sump Pump to Lagoons
Temporary Stockpile for Contaminated Soil-See Note
Concrete Ramp
T.S.B.
A
A
LEASE LINE
S 22°21'54" E
336.82
283.90
DITCH
DITCH
60 RT +96
12
60 RT. 183
11
60635
44
45
20+00
19+00
18+00
17+00
TY LINE
1262'±
W O O D S
W O O D S
W O O D

# APPENDIX E

FIGURE 1



Drainage ditch upstream of C&R site.

NOT TO SCALE

## C&R Battery

| | Well #1 mg/l | | Ditch | |
|---|---|---|---|---|
| | pH | Pb | pH | Pb |
| 10-3-78 | 3.01 | 1.38 | 2.76 | 2.77 |
| 7-17-78 | 2.95 | 1.16 | 2.20 | 3.96 |
| 4-24-78 | 3.00 | 2.51 | 1.50 | 4.64 |
| 1-20-78 | 6.20 | 0.20 | 3.9 | 4.26 |
| 10-3-77 | 2.70 | 3.44 | | |
| 8-30-77 | 3.80 | 4.21 | | |
| 7-14-77 | 3.80 | 4.25 | | |
| 6-23-77 | 4.40 | 3.35 | | |
| 5-19-77 | 4.40 | 3.54 | | |
| 4-26-77 | 4.25 | 2.66 | | |
| 3-21-77 | 3.35 | 2.19 | | |
| 2-15-77 | 4.5 | 1.59 | | |
| | | | Well #2 | |
| 7-30-76 | - | | 6.7 | 0.05- |
| 7-26-76 | 5.40 | 0.43 | - | |
| 6-25-76 | 4.20 | 1.88 | 6.5 | 0.05- |
| 5-14-76 | 5.95 | 1.05 | 6.7 | 0.05- |
| 4-6-76 | 4.8 | 1.38 | 6.3 | 0.05 |
| 3-23-76 | 6.0 | 0.05 | 6.4 | 0.05 |
| 3-8-76 | 6.5 | 0.05 | - | |
| 2-10-76 | 5.15 | 0.55 | - | |
| 2-3-76 | 4.72 | 0.89 | 6.65 | 0.05- |
| 1-27-76 | 6.05 | 0.05- | 6.25 | 0.05- |
| 1-20-76 | 5.62 | 0.05- | 6.40 | 0.05- |

**FROEHLING & RC ERTSON, INC.**
FULL SERVICE LABORATORIES • ENGINEERING/CHEMICAL
*"OVER ONE HUNDRED YEARS OF SERVICE"*
1881

RECEIVED
MAR 2 1982

PRO

No: J-52-061-2-A

February 23, 1982

cc: BAT
BE-Stitzer
AGD-Butcher

Sampling & Analysis of Water

Made For: C & R Battery Co.
P.O. Box 3715
Richmond, Va. 23234
Attn: Mr. Charles Guyton

Marked:
(1) Sample taken from well next to C & R Battery Co. office
(2) Sample taken from ditch running ghrough C & R Battery Co. property
(3) Sample taken from sink in Capitol Oil Co. building
(4) Sample taken from drainage ditch on the north side of Bellwood Road, approximately 60' west of C & R Battery Co. property line.

Samples taken 2/19/82

0 - 0 - 0

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| pH Value | 5.3 | 5.1 | 6.2 | 6.5 |
| Lead (Pb), mg/1. | 0.20 | 0.76 | <0.05 | 0.57 |

Respectfully,

FROEHLING & ROBERTSON, INC.

August A. Thieme
Chief Chemist & Director
Chemical & Biological Services

Ray Showalter
Chemist

SINCE F&R 1881
**FROEHLING & ROBERTSON, INC.**
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RECEIVED
JUN [illegible] 1982

PRO

No: J-52-061-5-A

May 26, 1982

cc: BAT-Alexander
BE-Stitzer
AGO-Butcher

ORIGINAL

Sampling & Analysis of Water

Made For: C. & R. Battery Co.
P.O. Box 3715
Richmond, Va. 23234
Attn: Mr. Charles Guyton

Marked:
(1) Sample from well next to C & R Battery Co. office.
(2) Sample taken from ditch running through C & R Battery Co. property.
(3) Sample taken from sink in Capitol Oil Co. building.
(4) Sample taken from drainage ditch on the north side of Bellwood Road, approximately 60' west of C.& R. Battery property line.

Samples taken 5/24/82

0 - 0 - 0

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| pH Value | * | 3.7 | 6.1 | 7.1 |
| Lead (Pb), mg/l | * | 3.446 | 0.05 | 5.97 |

* Unable to take sample No. 1 due to pump not being operational.

Respectfully,

FROEHLING & ROBERTSON, INC.

August A. Thieme
Chief Chemist & Director
Chemical & Biological Services

Ray Showalter
Chemist

HEADQUARTERS: 3015 DUMBARTON ROAD • BOX 27524 • RICHMOND, VA. 23261 • TEL (804) 264-2701
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F&R
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RECEIVED
AUG 30 1982
PRO

No: J-52-061-8-A

August 19, 1982

Sampling & Analysis of Water

Made For: C & R Battery Co.
P.O. Box 3715
Richmond, Va. 23234
Attn: Mr. Charles Guyton

Marked:
(1) Sample fakm well next to C. & R. Battery Co. office
(2) Sample taken from ditch running through C. & R. Battery Co. property.
(3) Sample taken from sink in Capitol Oil Co. building.
(4) Sample taken from drainage ditch on the north side of Bellwood Road, approximately 60' west of C. & R. Battery Co. property line.
Samples taken 8/16/82.

0 - 0 - 0

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| pH Value | * | 6.3 | 6.0 | 6.4 |
| Lead (Pb), mg/l | * | 0.10 | 0.05 | 0.10 |

Respectfully,

FROEHLING & ROBERTSON, INC.

August A. Thieme
Chief Chemist & Director
Chemical & Biological Services

Ray Showalter
Chemist

cc: BAT - Alexander
BE - Stitzer
AGO - Butcher

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F&R
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RECEIVED
OCT 13 1982

PRO

October 7, 1982

No: J-52-061-10-A

ORIGINAL
(Red

Sampling and analysis of water

Made For: C & R Battery Co.
P.O. Box 3715
Richmond, Virginia 23234
Attn: Mr. Charles Guyton

Marked: Sample taken from well next to C. & R. Battery Co. office, 10-5-82

0 - 0 - 0

| | |
|---|---|
| pH Value | 5.0 |
| Lead (Pb), mg/1 | 0.32 |

Respectfully,

August A. Thieme
Chief Chemist & Director
Chemical & Biological Services

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VA • LYNCHBURG, VA

CHARTER MEMBER CHARTER MEMBER MEMBER SINCE 1

SINCE F&R 1881

FROEHLING & ROBERTSON, INC.
MATERIALS TESTING & INSPECTION — ENGINEERS & CHEMISTS
CABLE ADDRESS — "FROEHLING"

MAIN OFFICE AND LABORATORIES
P. O. BOX 27524, 3015 DUMBARTON RD.
RICHMOND, VIRGINIA 23261
PHONE (804) 264-2701
BRANCH LABORATORIES
ASHVILLE, BALTIMORE, CHARLOTTE
CROZET, FAYETTEVILLE, GREENVILLE
NORFOLK, RALEIGH, ROANOKE

November 19, 1982

No: J-52-061-11-A

cc: BAT - Alexander
BE - Stitzer
AGO - Butcher

RECEIVE
MAR 1 1983
PRO

Sampling & Analysis of Water

Made For: C & R Battery Co.
P.O. Box 3715
Richmond, Va. 23234
Attn: Mr. Charles Guyton

Marked:
(1) Sample from well next to C & R Battery Co. office
(2) Sample taken from ditch running through C & R Battery Co. property
(3) Sample taken from sink in Capitol Oil Co. building.
(4) Sample taken from drainage ditch on the north side of Bellwood Road approximately 60' west of C & R Battery Co. property line

Samples taken 11-15-82

0 - 0 - 0

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| pH value | * | 4.4 | 6.1 | 6.4 |
| Lead (Pb), mg/l | * | 0.08 | <0.05 | <0.05 |

* unable to take Sample No. 1 due to pump not being operational

Respectfully,

August A. Thieme
Chief Chemist & Director
Chemical & Biological Services

Ray Showalter
Chemist

Please note that the pump is now in operation and samples are being taken. We will send you a copy of the results as soon as they are received by us.

Thank you.

Charles Guyton

SINCE 1881

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RECEIVED
MAY 6 1983
PRO

April 30, 1983

No: K-52-077-4-A

cc: BAT
BE-Stitzer
ACO-Butcher

Sampling and Analysis of Water

Made For: C & R Battery Co.
P.O. Box 3715
Richmond, Va. 23234
Attn: Mr. Charles Guyton

Marked:
(1) Sample taken from well next to C. & R. Battery Co. office.
(2) Sample taken from ditch running through C. & R. Battery Co. Property.
(3) Sample taken from sink in Capitol Oil Co. building.
(4) Sample taken from drainage ditch on north side of Bellwood Road, approximately 60' west of C. & R. Battery Co. property Line.

Samples taken 4-27-83

0 - 0 - 0

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| pH Value | 5.3 | 6.3 | 5.9 | 7.0 |
| Lead (pb), mg/l | 0.26 | 0.68 | <0.05 | 0.42 |

Respectfully,

August A. Thieme
Chief Chemist & Director
Chemical & Biological Services

Ray Showalter
Chemist

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CHARTER MEMBER CHARTER MEMBER ASTM MEMBER SINCE 1904

SINCE 1881
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*"OVER ONE HUNDRED YEARS OF SERVICE"*

October 31, 1983

No: K-52-077-10-A

cc: BAT
BE - stitzer
AGO - Butcher

NOV 14 1983

PRO

Sampling and Analysis of Water

Made For: C & R Battery Co.
P.O. Box 3715
Richmond, Virginia 23234
Attn: Mr. Chalres Guyton

Marked:
(1) Well next to C & R Battery Co. Office.
(2) Ditch running through C & R Battery Co. property.
(3) Sample taken from sink in Capitol Oil Co. building.
(4) Drainage ditch on North side of Bellwood Road, approximately 10' West of C & R Battery Co. property line.
Samples taken 10-31-83

0 - 0 - 0

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| pH Value | 3.6 | * | 6.2 | 6.7 |
| Lead (pb), mg/1 | 0.79 | * | ∠0.001 | 1.10 |

* Unable to take sample due to ditch being dry.

Respectfully,

August A. Thieme
Chief Chemist & Director
Chemical & Biological Services

Ray Showalter
Chemist

HEADQUARTERS: 3015 DUMBARTON ROAD • BOX 27524 • RICHMOND, VA. 23261 • TEL (804) 264-2701
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CHARTER MEMBER CHARTER MEMBER ASTM MEMBER SINCE 1904

SINCE F&R 1881

**FROEHLING & ROBERTSON, INC.**
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March 12, 1984

RECEIVED
MAR 16 1984

No: L-52-120-3-A

Sampling & Analysis of Water

PRO

cc: BAT - Alexander
DE - Stitzer
DES - Lunsford
AGO - Butcher

Made For: C & R Battery Co.
P.O. Box 3715
Richmond, Virginia 23234
Attn: Mr. Charles Guyton

Marked:
(1) Well next to C & R Battery Co. office.
(2) Ditch running through C & R Battery Co. property.
(3) Sample taken from sink in Capitol Oil Co. building.
(4) Drainage ditch on North side of Bellwood Road, approximately 60' West of C & R Battery Co. property line.

Samples taken 3-6-84

0 - 0 - 0

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| pH Value | 6.2 | 6.5 | 6.3 | 6.5 |
| Lead (pb), mg/l | 0.32 | 0.22 | <0.001 | 0.077 |

Respectfully,

August A. Thieme
Chief Chemist & Director
Chemical & Biological Services

Ray Showalter
Chemist

**HEADQUARTERS** 3015 DUMBARTON ROAD • BOX 27524 • RICHMOND,VA 23261 •
TEL (804) 264-2701
**BRANCHES:** ASHEVILLE, NC • BALTIMORE, MD • CHARLOTTE, NC • CROZET,VA •
FAYETTEVILLE, NC • GREENVILLE, SC • NORFOLK,VA • RALEIGH, NC • ROANOKE,
VA • LYNCHBURG,VA

CHARTER MEMBER CHARTER MEMBER ASTM

ORIGINAL
(Red)

# APPENDIX F

**NUS CORPORATION**

Page 1 of 1

DATE 7/8/85

CLIENT C+R BATTERY FILE NO. E3-8505-37 BY RJG

SUBJECT CALCULATION OF HAZARDOUS WASTE QUANTITY Checked By

ASSUME:

1) A SITE RECLAMATION PLAN FOR THE C+R BATTERY SITE HAS BEEN DEVELOPED BY COBAUGH, BLANTON ASSOCIATES. THE PLAN INCLUDED A DETAILED, SITE SPECIFIC LIME APPLICATION RATE FOR pH AND LEAD STABILAZATION OF CONTAMINATED AREAS ON SITE. THE BASIC CALCULATION REQUIRED FOR THE ESTABLISHMENT OF THE LIME APPLICATION RATE INCLUDED THE ESTIMATION OF SOIL VOLUMES ON SITE. AREAS FOR VOLUME ESTIMATION WERE ESTABLISHED BASED ON THE LOCATION OF SAMPLE POINTS WHICH REVEALED DOCUMENTED LEVELS OF LEAD CONTAMINATION. SUBSEQUENT DIMENSIONS (LENGTH, WIDTH AND DEPTH) ALONG WITH AVERAGE SOIL DENSITIES WERE THEN APPLIED TO ESTIMATE THE QUANTITIES OF SOIL WITHIN EACH AREA.

- FOR THE PURPOSES OF THIS REPORT, THE QUANTITIES FOR ALL AREAS AS REPORTED BY COBAUGH, BLANTON HAVE BEEN ADDED TOGETHER TO REPRESENT THE TOTAL QUANTITY OF CONTAMINATED SOIL ON SITE. BASED ON THIS CONSIDERATION, THE TOTAL QUANTITY OF CONTAMINATED SOIL AT THE SITE WILL BE ASSUMED AS APPROXIMATELY 9,545 TONS.

2) A DETAILED SOIL SAMPLING REPORT APPLICABLE TO THE C+R BATTERY SITE WAS PREPARED BY FROEHLING AND ROBERTSON, INC. FOR THE COBAUGH, BLANTON RECLAMATION PLAN. THE REPORT INCLUDED THE COLLECTION OF 26 SOIL SAMPLES FROM 15 LOCATIONS AT DEPTHS FROM 0 TO 2 FEET AT VARIOUS LOCATIONS ON SITE. THE REPORT INCLUDED THE RESULTS OF TOTAL LEAD ANALYSIS FOR ALL SAMPLE LOCATIONS. RESULTS WERE REPORTED IN PARTS PER MILLION.

○ FOR THE PURPOSES OF THIS REPORT, THE ANALYTICAL RESULTS FOR ALL SAMPLE LOCATIONS WERE AVERAGED AND CONVERTED TO PERCENTAGE BY VOLUME. THE AVERAGE LEVEL OF CONCENTRATION REPORTED WILL THEREFORE BE ASSUMED AS 18492.3 PPM OR 1.85 %

○ UTILIZING THE TOTAL QUANTITY OF CONTAMINATED SOIL CONTAINED ON SITE AND THE AVERAGE LEVEL OF CONTAMINATION BY PERCENTAGE, AN ESTIMATE CAN BE MADE OF THE QUANTITY OF CONTAMINATION ON SITE AS FOLLOWS:

☆ → 9,545 TONS OF CONTAMINATED SOIL ON SITE X 1.85 % LEAD CONTAMINATION = 171.8 TONS OF LEAD

Consulting & Design for Industry
P.O.Box 8822, Richmond, Va. 23225
Tel. (804) 271-9407

ISSUE DATE

✓ CIVIL
STRUCTURAL
MECHANICAL
ELECTRICAL
INSTRUMENTATION
✓ PROCESS

MADE BY: LRC DATE 5/8/84
SHEET NO. OF
CHECKED BY: DATE
PROJ. ENGR DATE

PROJECT C&R Battery SITE RECLAMATION
SUBJECT Lime Stabilization of Lead in Soil on Site.

Calculations Based on averages per sample & Volumes bounded by Median lines between sample points

| PLAN Point of Sample / LAB Sample | L ft | × D ft | = A ft² | × H ft | = V ft³ | Using soil @ 100 pcf × 1/20 (Tons) | × FACTOR | = Required TONS AG LIME | cuft ×100#/ / 2000#/ Notes |
|---|---|---|---|---|---|---|---|---|---|
| 1A / 3 | | | | | | | | — | pH 6.7 |
| 2A / 5,6 | | | | | | | | — | pH 7+ |
| 1 / 2 | 114' | AV. 50' | = 5700 | (2'-1') | 5700 | 265 | ,0055 | 1.57 | pH 5.7 (1'-2' |
| 2 / 4 | | | | | | | | — | pH 7.0 |
| 3 / 7 | AV 101 | 64 | = 6464 | TOP (1'-0) | 6464 | 323.2 | .0058 | 1.87 | pH 5.2 |
| 3 / 8 | | | 6464 | (2'-1') | 6464 | 323.2 | ,0153 | 4.95 | pH 3.7 |
| 4 / 9 | | | | | | | | — | pH 11.8 |
| 5 / 10 | | | | | | | | — | pH 7.6 |
| / 11,12 | | | | | | | | — | pH 10.6/12. |
| 6A / 13 | Δ 102 | 96/2 | 4896 | (1-0) | 4896 | 244.8 | 0.0144 | 3.53 | pH 4.8 |
| 6A / 14 | | | 4896 | (2-1) | 4896 | 244.8 | 0.0145 | 3.55 | pH 4.5 |
| 7 / 15 | ▽ 150 | AV 72 | 10,800 | (1'-0) | 10,800 | 540 | 0.0074 | 4.00 | pH 5.8 |
| 7 / 16 | | | 10,800 | (2'-1') | 10,800 | 540 | 0.0147 | 7.94 | pH 4.6 |
| 8 / 17 | 135<br>193 | 45/2<br>50 | 12,688 | (1'-0') | 12,688 | 634.4 | 0.0073 | 4.63 | pH 5.5 |
| 8 / 18 | | | 12,688 | (2'-1') | 12,688 | 634.4 | 0.0155 | 9.83 | pH 3.5 |
| 9 / 19 | 128 | 75 | 9,600 | (1'-0') | 9,600 | 480 | (0.0073 interp) | 3.50 | pH 6.0 |
| 9 / 20 | | | 9,600 | (2'-1') | 9,600 | 480 | 0.0138 | 6.63 | pH 4.6 |
| 9A / 21 | | | 15,269 | (1'-0') | 15,269 | 763.4 | 0.0138 (interp) | 10.54 | pH 4.6 |
| 9A / 22 | | | 15,269 | (2'-1') | 15,269 | 763.4 | 0.0083 | 6.34 | pH 4.2 |
| 10 / 23 | 221 | $\frac{32+68}{2}$ | 11,050 | (1'-0') | 11,050 | 552.5 | 0.0130 | 7.18 | pH 4.7 |
| 10 / 24 | | | 11,050 | (2'-1') | 11,050 | 552.5 | 0.0155 | 8.56 | pH 3.8 |
| 11 / 25 | 265<br>220 | (85+80)/2<br>48/2 | 21,842.5 | (1'-0') | 21,842 | 1092 | 0.0068 | 7.43 | pH 4.9 |
| 11 / 26 | | | 21,842 | (2'-1') | 21,842 | 1092 | 0.0080 | 8.74 | pH 4.3 |
| | | | | | TOTAL | 9545.6 | | | |

Σ 100.79 TONS AG. LIM

Use 150 tons Burnt Lime.

SINCE
F&R
1881

**FROEHLING & ROBERTSON, INC.**
FULL SERVICE LABORATORIES • ENGINEERING/CHEMICAL
*"OVER ONE HUNDRED YEARS OF SERVICE"*

December 30, 1983

No: K-52-397-12-A

Preleminary Analysis of Soil

Made For: Cobough Blanton Associates
P.O. Box 8822
Richmond, Virginia 23225

Re: C & R Battery Works
Chesterfield, County, Virginia

0 - 0 - 0

| Sample No. | Sample I.D. | pH Value | Total Lead (pb), mg/1 |
|---|---|---|---|
| 1 | HP-1, 0 to 1.0' | 6.9 | 17,997 ppm* |
| 2 | HP-1, 1.0 to 2.0' | 5.7 | 22,000 |
| 3 | HP-1A, 0 to 1.0' | 6.7 | 4396 |
| 4 | HP-2, 0 to 0.5' | 7.0 | 43,569 |
| 5 | HP-2A, 0 to 1.0' | 7.2 | 3431 |
| 6 | HP-2A, 1.0 to 1.3' | 8.2 | 3233 |
| 7 | HP-3, 0 to 1.0' | 5.2 | 7857 |
| 8 | HP-3, 1.0 to 2.0' | 3.7 | 91.7 |
| 9 | HP-4, 0.0 to 0.5' | 11.8 | 25,755 |
| 10 | HP-5, 0.0 to 0.8' | 7.6 | 62,958 |
| 11 | HP-6, 0.0 to 1.0' | 10.6 | 13,366 |
| 12 | HP-6, 1.0 to 2.0' | 12.3 | 32,391 |
| 13 | HP-6A, 0.0 to 1.0' | 4.8 | 4589 |
| 14 | HP-6A, 1.0 to 2.0' | 4.5 | 292 |
| 15 | HP-7, 0.0 to 1.0' | 5.8 | 35,379 |
| 16 | HP-7, 1.0 to 2.0' | 4.6 | 6039 |
| 17 | HP-8, 0.0 to 1.0' | 5.5 | 29,595 |
| 18 | HP-8, 1.0 to 2.0' | 3.5 | 1114 |
| 19 | HP-9, 0.0 to 1.0' | 6.0 | 25,583 |

* 7/5/85 TELECON WITH RAY SHOWALTER, VERIFYING THAT ANALYSIS WAS REPORTED IN PPM !

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T. (804) 264-2701
ANCHES: ASHEVILLE, NC • BALTIMORE, MD • CHARLOTTE, NC • CROZET, VA •
'ETTEVILLE, NC • GREENVILLE, SC • NORFOLK, VA • RALEIGH, NC • ROANOKE, VA • LYNCHBURG, VA

| Sample No. | Sample I.D. | pH Value | Total Lead (pb), mg/1 PPM |
|---|---|---|---|
| 20 | HP-9, 1.0 to 2.0' | 4.6 | 446 |
| 21 | HP-9A, 0.0 to 1.0' | 4.6 | 22,172 |
| 22 | HP-9A, 1.0 to 2.0' | 4.2 | 3598 |
| 23 | HP-10, 0.0 to 1.0' | 4.7 | 42,344 |
| 24 | HP-10, 1.0 to 2.0 | 3.8 | 2638 |
| 25 | HP-11, 0.0 to 1.0' | 4.9 | 60,635 |
| 26 | HP-11, 1.0 to 2.0' | 4.3 | 9331 |

$$\text{AVERAGE} = \frac{480799.7}{26}$$

$$= 18492.29 \text{ PPM}$$

$$= \underline{\underline{1.85\%}}$$

Respectfully,

August A. Thieme
Chief Chemist & Director
Chemical & Biological Services

Ray Showalter
Chemist

# APPENDIX G

# HYDROGEOLOGIC FRAMEWORK OF THE VIRGINIA COASTAL PLAIN

Original
[illegible]

By Andrew A. Meng III and John F. Harsh

---

Open-File Report 84-728

Richmond, Virginia

1984

100272

UNITED STATES DEPARTMENT OF THE INTERIOR

WILLIAM P. CLARK, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

---

For additional information
write to:

Gary S. Anderson, Chief
Virginia Office
U.S. Geological Survey, WRD
200 W. Grace Street, Room 304
Richmond, Virginia 23220

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## CONTENTS

# ILLUSTRATIONS

(Plates are in back of report)

# CONVERSION FACTORS

Factors for converting inch-pound units to the International System (SI) of units are given below:

| Multiply | By | To obtain |
|---|---|---|
| ft (feet) | 0.3048 | m (meters) |
| mi (miles) | 1.609 | km (kilometers) |
| mi2 (square miles) | 2.590 | km2 (square kilometers) |
| ft/mi (feet/mile) | 0.18943 | m/km (meter per kilometer) |

[illegible]

# HYDROGEOLOGIC FRAMEWORK OF THE VIRGINIA COASTAL PLAIN

by A. A. Meng III and J. F. Harsh

## ABSTRACT

This report defines the hydrogeologic framework of the Virginia Coastal Plain and is a product of a comprehensive regional study to define the geology, hydrology, and geochemistry of the northern Atlantic Coastal Plain aquifer system extending from North Carolina to Long Island, New York.

The Virginia Coastal Plain consists of an eastward-thickening wedge of generally unconsolidated, interbedded sands and clays, ranging in age from Early Cretaceous to Holocene. These sediments range in thickness from more than 6,000 feet beneath the northeastern part of the Eastern Shore Peninsula to nearly 0 feet along the Fall Line. Eight confined aquifers, eight confining beds, and an uppermost water-table aquifer are delineated as the hydrogeologic framework of the Coastal Plain sediments in Virginia. The nine regional aquifers, from oldest to youngest, are lower, middle, and upper Potomac, Brightseat, Aquia, Chickahominy-Piney Point, St. Marys-Choptank, Yorktown-Eastover, and Columbia. The Brightseat is a newly identified and correlated aquifer of early Paleocene age. This study is one of other, similar studies of the Coastal Plain areas in North Carolina, Maryland-Delaware, New Jersey, and Long Island, New York. These combined studies provide a system of hydrogeologic units that can be identified and correlated throughout the northern Atlantic Coastal Plain.

Data for this study were collected and analyzed from October 1979 to May 1983. The nine aquifers and eight confining beds are identified and delineated by use of geophysical logs, drillers' information, and stratigraphic and paleontologic data. By correlating geophysical logs with hydrologic, stratigraphic, and paleontologic data throughout the Coastal Plain, a comprehensive multilayered framework of aquifers and confining beds, each with distinct lithologic properties, was developed.

Cross-sections show the stratigraphic relationships of aquifers and confining beds in the hydrogeologic framework of the Virginia Coastal Plain. Maps show confining-bed thicknesses and altitudes of aquifer tops, provide the basis for assigning aquifers to screened intervals of observation and production wells, and are used for the development of a comprehensive observation well network in the Virginia Coastal Plain.

# INTRODUCTION

In 1977, Congress appropriated funds for a series of ground-water-assessment studies titled the "Regional Aquifer-System Analyses" (RASA) program; this program was designed to identify and evaluate the water resources of major aquifer systems on a regional scale in the United States. In 1979, the U.S. Geological Survey began a comprehensive regional investigation, as part of the RASA program, to define the hydrogeology and geochemistry, and to simulate ground-water flow, in the northern Atlantic Coastal Plain that extends from North Carolina to Long Island, New York (fig. 1). Subsequently, the northern Atlantic Coastal Plain RASA investigation was subdivided into five state-level RASA studies. The Virginia RASA, headquartered in the Virginia Office, Mid-Atlantic District, of the Geological Survey, was assigned the responsibility of defining a regional hydrogeologic framework and of simulating ground-water flow in the Coastal Plain province of Virginia (fig. 1). This report describes the hydrogeologic framework developed as part of the Virginia RASA study. Companion RASA studies were also conducted for the Coastal Plain areas of North Carolina, Maryland-Delaware, New Jersey, and Long Island, New York (fig. 1). Collectively, these individual studies form a regional system of hydrogeologic units that can be identified and correlated between adjoining states throughout the northern Atlantic Coastal Plain.

## Purpose and Scope

This report is the result of part of the Virginia RASA study to (1) identify and define the regional hydrogeologic framework of the Coastal Plain sediments of Virginia; and (2) further understand the subsurface Coastal Plain geology and hydrology. The description of the hydrogeologic framework presented herein provides the basis for the RASA modeling study in Virginia.

Specific objectives of this report are to: (1) identify and divide the sediments of the Virginia Coastal Plain into regional hydrogeologic units; (2) delineate and describe the boundaries, stratigraphic relationships, and characteristics of the hydrogeologic units; (3) provide data to construct a digital model to simulate ground-water flow in the Virginia Coastal Plain; and (4) provide data to generate the regional hydrogeologic framework and to construct a regional ground-water flow model of the entire northern Atlantic Coastal Plain from North Carolina to Long Island, New York.

The scope of this study is to define a system of hydrogeologic units for the Virginia Coastal Plain that correlates with a regional hydrogeologic framework. The regional hydrogeologic framework is composed of ten aquifers and nine confining beds and based on published literature describing the hydrogeology in the Coastal Plain areas of New Jersey and Maryland. The Virginia Coastal Plain hydrogeologic units, as presented in this report, have been divided into nine regional aquifers with eight confining beds, encompassing nine geochronologic epochs that range in age from Early Cretaceous to Holocene. This hydrogeologic framework correlates areally and hydrologically with units in adjoining States. The hydrogeologic units in the Virginia Coastal Plain are described in terms of age, lithology, stratigraphic position, configuration, areal extent, depositional environment, regional correlations, and their characteristic geophysical log signatures; beginning with the oldest stratigraphic unit and ending with the youngest. Also, the aquifer-unit descriptions briefly refer to the general use and availability of ground

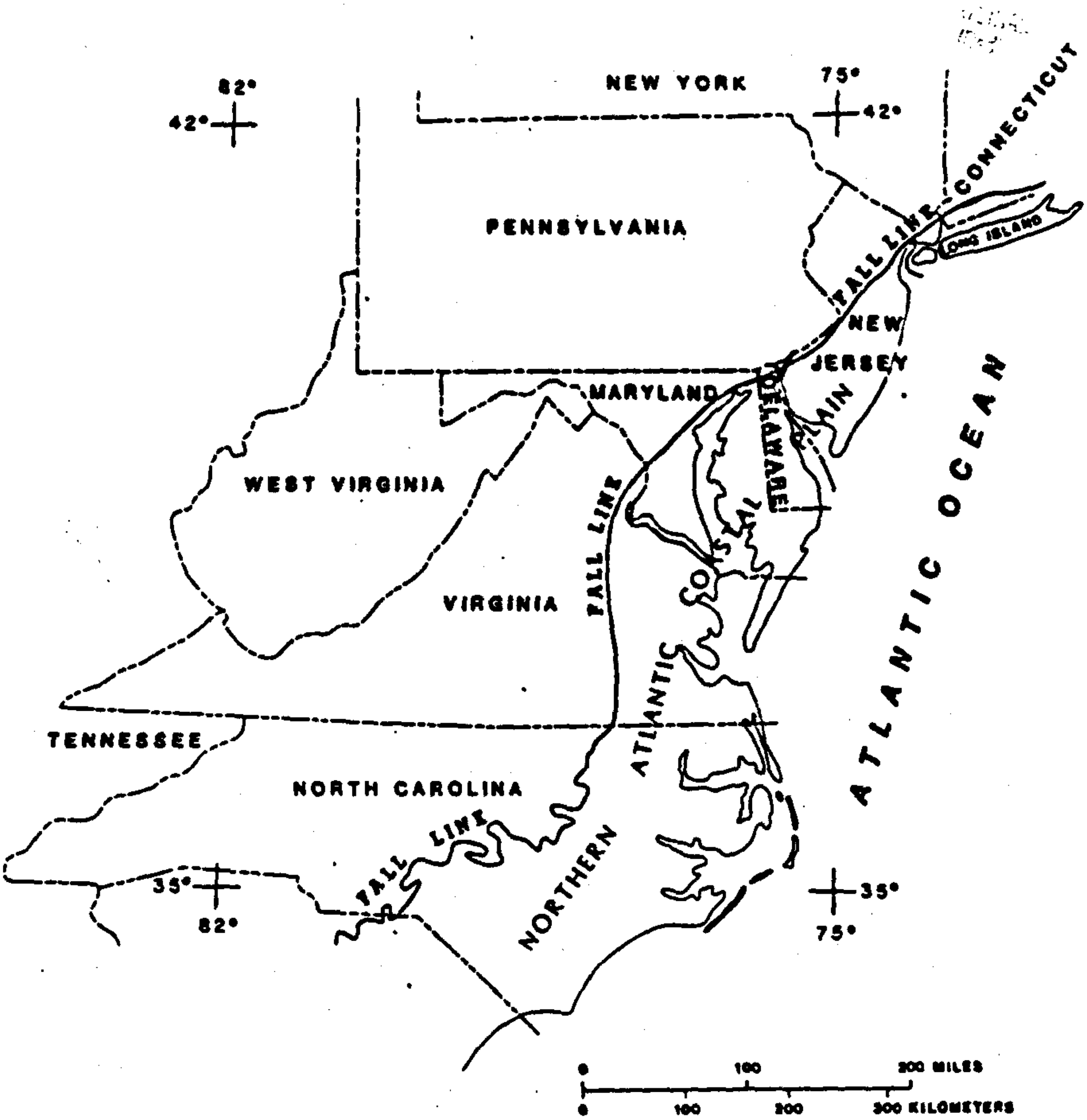


Figure 1.--Location of northern Atlantic Coastal Plain.

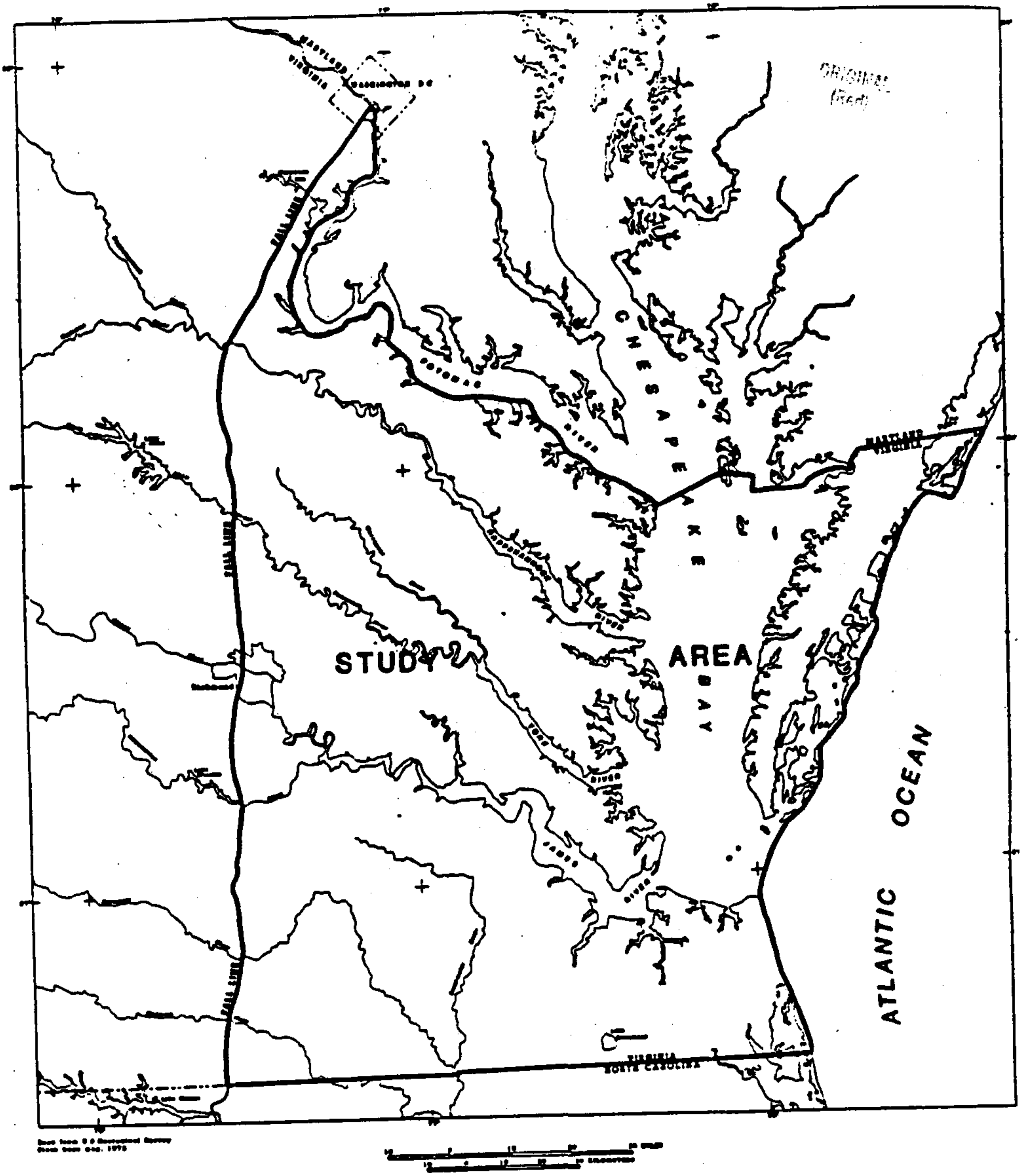
water, but a detailed discussion of water supply and water quality is beyond the scope of this report.

## Location and Extent

The study area (fig. 2) comprises all of the Coastal Plain physiographic province of Virginia. It encompasses the eastern third of the State and consists of about 13,000 square miles. The study area is approximately 125 miles wide across the northern section, and 165 miles long along the western section. It is bounded on the west by the Fall Line, a physiographic boundary that separates the Piedmont province from the Coastal Plain province. The Fall Line runs generally north-south near or through the cities of Alexandria, Fredericksburg, Richmond, Petersburg, and Emporia (fig. 2), and closely corresponds to the present route of Interstate 95. The study area is also bounded by Maryland on the north, North Carolina on the south, and by the Atlantic Ocean on the east. For the purpose of this report, the study area is informally divided into five principal geographic regions: the western, central, eastern, northern, and southern. For more precise geographical orientations, the five principal regions are further subdivided into more specific parts, such as the northwestern, north-central, northeastern, west-central, east-central, southwestern, south-central, southeastern. The above areas and regions are referred to throughout the text so that explanations of the interrelationships and areal extent of the hydrogeologic units can be related to specific parts of the Virginia Coastal Plain.

## Previous Investigations

Many reports describe specific aspects of the geology or ground-water resources in the Coastal Plain of Virginia, but none describe the hydrogeologic framework as a whole. Clark and Miller (1912) provide the first comprehensive view on the geology and physiography of the Coastal Plain in Virginia. Sanford (1913) presents the first integrated view of geology and ground-water resources throughout the Virginia Coastal Plain. Cederstrom (1945a, 1957) describes the hydrogeology of southeastern Virginia and the York-James Peninsula. Sinnott and Tibbitts (1954, 1957, 1968) define the availability of ground water and the uppermost stratigraphy in the Eastern Shore Peninsula of Virginia. The investigation by Brown and others (1972) correlates 17 chronostratigraphic rock units and depicts regional permeability-distribution maps based on the 17 delineated time-rock units for the northern Atlantic Coastal Plain sediments. The Virginia State Water Control Board (1970, 1973, 1974), Siudyla and others (1977, 1981), and Fennema and Newton (1982) present data on ground-water conditions in various county and peninsula-wide areas in the Virginia Coastal Plain. A stratigraphic-data report published by the Virginia Division of Mineral Resources (1980) on a U.S. Geological Survey corehole at Oak Grove, Virginia, supplies invaluable information on subsurface geology in the northwestern part of the Virginia Coastal Plain. Numerous reports prepared by consultants describe the ground-water conditions and potential yields of important aquifers in various parts of the Virginia Coastal Plain, especially the southeastern area. In addition to the information cited above, other important data sources include works by: Cederstrom (1943, 1945b); Richards (1945, 1948, 1967); Spangler and Peterson (1950); Hack (1957); Brenner (1963); Nogan (1964); Drobnyk (1965); Glaser (1969); Hazel (1969); Johnson and Goodwin (1969); Cushing, Kantrowitz, and Taylor (1973); Onuschak



Base from U.S. Geological Survey
State base map, 1970

Figure 2.--Location of study area.

(1972); Oaks and Coch (1973); Blackwelder and Ward (1976); Doyle (1977); Doyle and Robbins (1977); Hansen (1978); Blackwelder (1980); Gleason (1980); Ward and Blackwelder (1980); Ward (1980); Meisler (1981); Larson (1981); and Gibson (1982).

## Methods of Study

Data used in this study were collected, analyzed, and interpreted during the period from October 1979 to May 1983. Literature pertinent to the lithology, stratigraphy, and ground-water resources of the study area and the adjoining States was reviewed and synthesized. Water-well and stratigraphic test-hole data consisting of borehole-geophysical logs, drillers' logs, well completion reports, geologic logs, and paleontologic and core-sample analyses were compiled. This information, together with hydrogeologic interpretations provided by adjoining northern Atlantic Coastal Plain RASA studies, supplies the data used to define the regional hydrogeologic framework of the Virginia Coastal Plain.

Borehole-geophysical logs and drillers' information, supported by pertinent stratigraphic and hydrologic data, were used to provide the basis for the identification, correlation, and definition of the areally comprehensive hydrogeologic framework of the Virginia Coastal Plain. Borehole-geophysical logs are a qualitative, graphic representation of the subsurface environment penetrated by drilling. These logs portray a continuous, scaled record of the character of the subsurface sediments, and are used to identify formations and the relative salinity of formation waters. Details on the interpretation, correlation, and application of borehole geophysics to hydrogeologic investigations are given by Keys and MacCary (1971). The types of borehole-geophysical logs most commonly used in this study consist primarily of electric resistivity and natural-gamma logs. Spontaneous potential (S.P.) and single-point and multi-point electric resistivity logs identify lithologic contacts, determine gross sand-to-clay ratios in each hydrogeologic unit, and indicate the relative quality of water in the aquifer units. Natural-gamma logs define regional lithologic facies changes in units and dip directions of strata that contain particularly high gamma-emitting lithologies or marker beds. Drillers' information includes sample logs, commonly called drillers' logs or cuttings logs, and well-completion reports. Sample logs describe the physical properties of sediments penetrated during drilling operations. Well-completion reports provide information on depths to screened intervals and water levels in finished wells. Geologic logs provide a detailed, usually microscopic, description and identification of the lithology of cuttings collected from the drilled holes. Paleontologic analyses of cuttings and core samples provide biostratigraphic data on the ages of sediments. Core-sample analyses also provide information on specific lithologic and depositional characteristics of the subsurface sediments not otherwise obtainable from drill cuttings.

Lithologic trends in the type and distribution of sediments are apparent from analysis of stratigraphic, borehole, and water-well information. These trends were identified on the basis of stratigraphic and lithologic relationships obtained from different drilled holes over large areas and areally extensive lithologic and geophysical marker beds. Log signatures depicting sand lithologies are identified and labeled as aquifers on the geophysical logs; in contrast, log signatures depicting clay lithologies are identified and labeled as confining beds (fig. 3). A regional correlation of aquifers and confining beds in the Virginia Coastal Plain was developed by comparing geophysical logs and chronostratigraphic and lithostratigraphic units across adjoining State boundaries.

## Well-numbering System

The well-numbering system used by the Geological Survey in Virginia is based on the "Index to Topographic Maps of Virginia" (U.S. Geological Survey, 1978). Topographic map quadrangles covering 7 1/2-minutes of latitude and longitude, published at a scale of 1:24,000, or 1 inch = 2,000 feet, are identified by numbers and letters starting in the southwest corner of the State. The quadrangles are numbered 1 through 69 from west to east beginning at 83°45' west longitude, and lettered A through Z (omitting letters I and O) from south to north, beginning at 36°30' north latitude. The area covered by the Coastal Plain includes generally the quadrangles numbered from 50 to 69 containing the letters from A to V. Wells are identified and numbered serially within each 7 1/2-minute quadrangle. As an example, figure 4 shows the south-central section of the study area. Well 53A2 is in quadrangle 53A and is the second well in that quadrangle for which the location and other data were recorded by the Geological Survey. All wells selected as controls for this hydrogeologic framework are listed by increasing well number in the Appendix of this report.

## Acknowledgments

Acknowledgment is given to the Bureau of Surveillance and Field Studies and the Tidewater Regional Office of the Virginia State Water Control Board, for furnishing well information, selected stratigraphic cores, and geophysical logs. The authors wish to thank R. L. Magette Co., Gammon Well Co., and Layne-Atlantic Co. for providing single point electric-resistivity geophysical logs and well data, and to the many drillers in the Virginia Coastal Plain who have supplied valuable information concerning the nature of sediments and their water-bearing properties. Special thanks goes to Sydnor Hydrodynamics, Inc. for providing comprehensive well data, multipoint electric-resistivity and natural-gamma geophysical logs, and for their conscientious and continuous efforts in obtaining subsurface hydrogeologic information.

The authors express appreciation to the Virginia Division of Mineral Resources for providing a preliminary revised surficial geologic map of the Virginia Coastal Plain sediments. The authors also wish to convey appreciation to L. W. Ward, L. E. Edwards, R. B. Mixon, J. P. Owens, L. McCarten, and T. G. Gibson, of the U.S. Geological Survey, for providing valuable and timely stratigraphic information and analysis.

## GENERAL GEOLOGY

The study area is part of the Atlantic Coastal Plain province that extends from Cape Cod, Massachusetts, southward to the Gulf of Mexico. The Coastal Plain province of Virginia consists of an eastward-thickening sedimentary wedge (fig. 5) composed principally of unconsolidated gravels, sands, silts, and clays, with variable amounts of shells. This sedimentary wedge generally is devoid of hard rocks, although calcareous cementations are present locally, forming thin lithified strata. The unconsolidated deposits rest on a rock

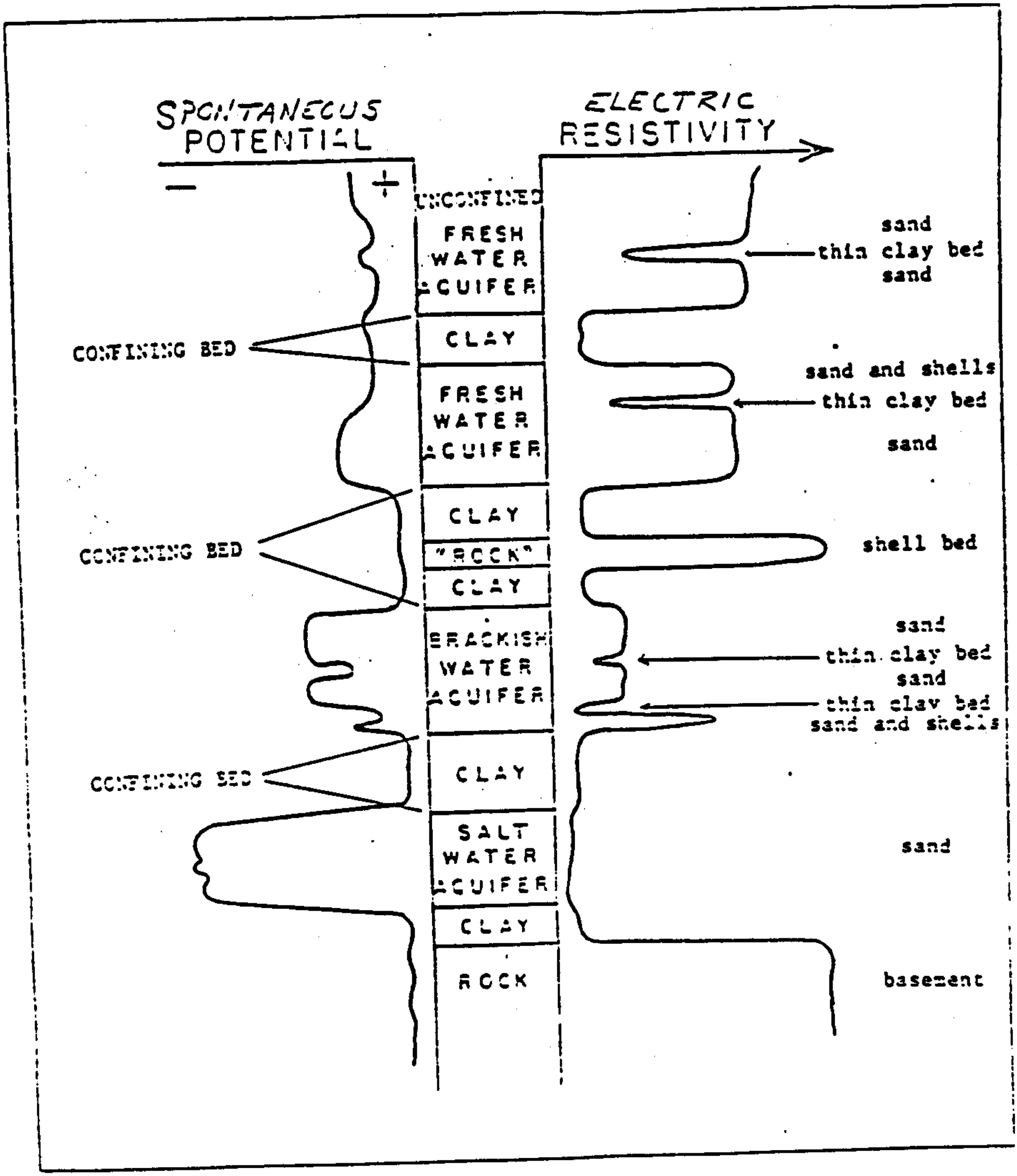
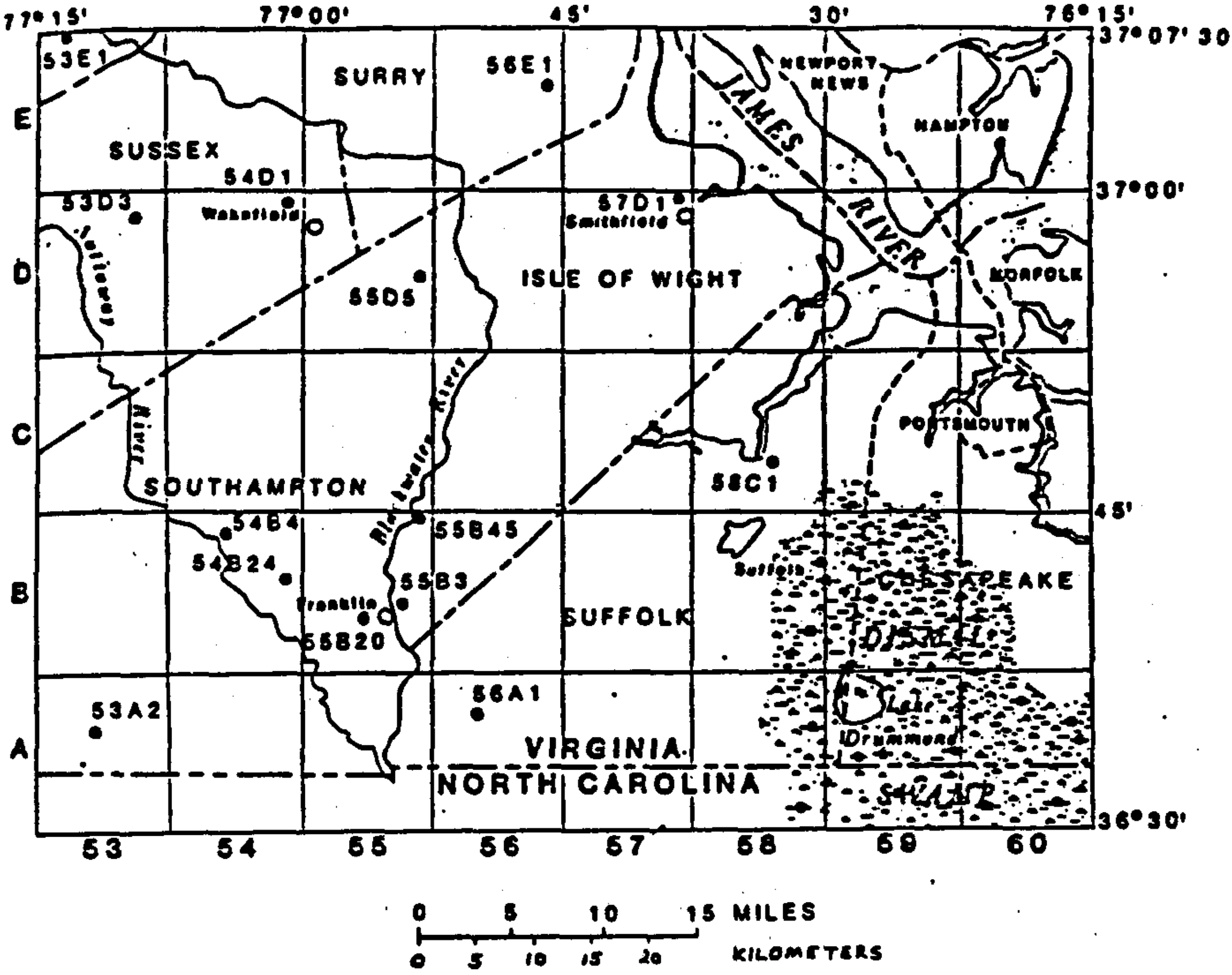


Figure 3.--Idealized geophysical log showing aquifers and confining beds and characteristic electric and spontaneous potential traces.

ORIGINAL
(Red)



EXPLANATION

● 53A2 Control well location and well number

Figure 4.--Example of Virginia well-numbering system.

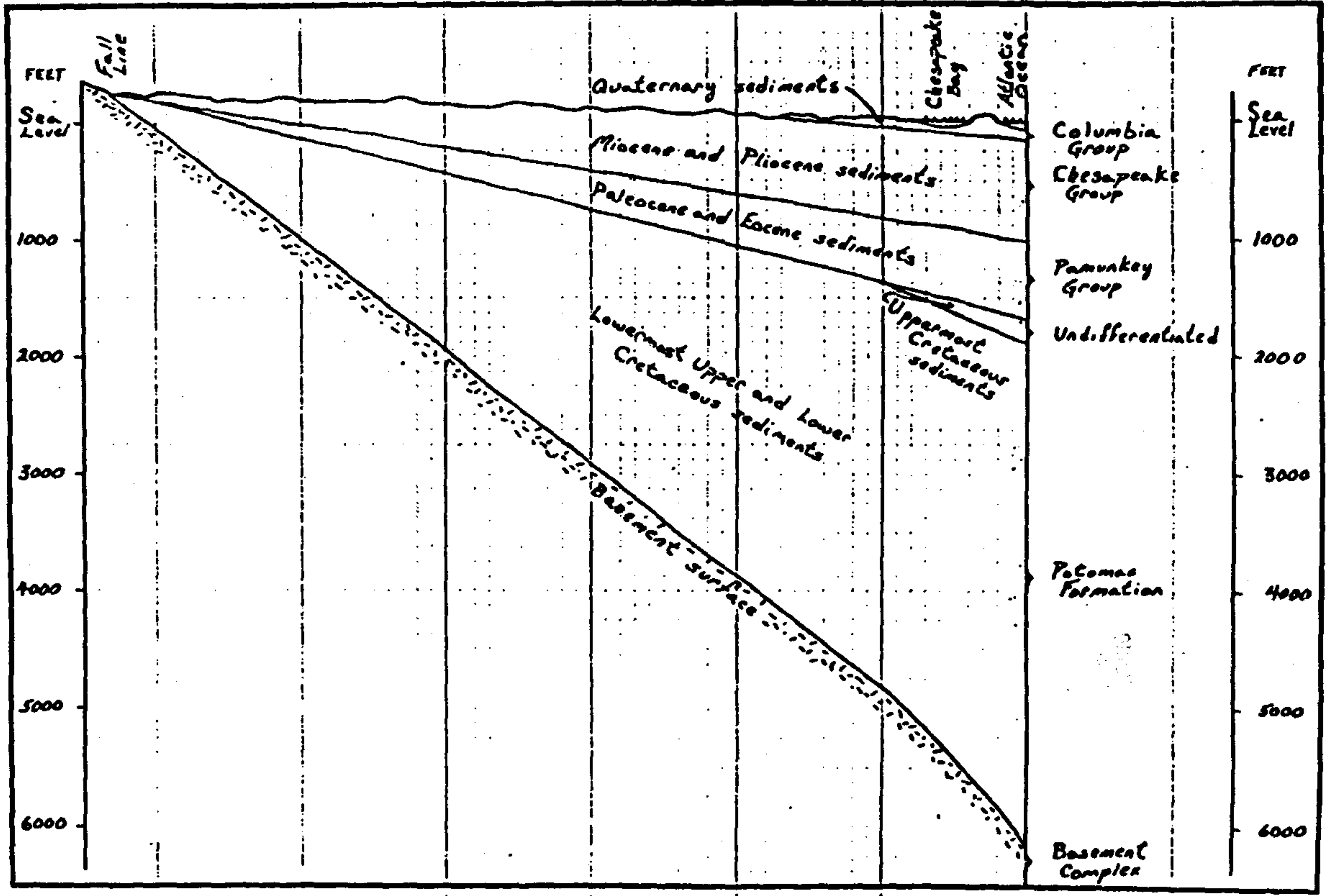


Figure 5.--Generalized geologic section showing eastward-thickening sedimentary wedge of Virginia Coastal Plain.

surface, commonly referred to as the "basement," that slopes gently eastward. The sediments attain a maximum thickness of over 6,000 ft in the northeastern part of the study area. Onuschak (1972) reports that the sediments are 6,186 ft thick beneath the Eastern Shore Peninsula at Temperanceville, Virginia (fig. 5). Coastal Plain sediments thin westward to nearly zero thickness at the Fall Line and are highly dissected by streams throughout the western region. Small, isolated erosional remnants of Coastal Plain deposits are common, just west of the main sedimentary wedge, in the Fall Line area. The surface of the Virginia Coastal Plain consists of a series of broad gently sloping, highly dissected terraces bounded by seaward-facing, ocean-cut escarpments extending generally north-south across the province. Most of the study area is less than 100 ft in altitude and one-fifth is covered by water, principally the Chesapeake Bay. The land surface is highest along the Fall Line, especially in the northwestern part of the study area. The sedimentary section, in general, consists of a thick sequence of nonmarine deposits overlain by a much thinner sequence of marine deposits. These deposits are, for the most part, undeformed throughout, except for slight warping and tilting, with associated local faulting. All depositional units strike approximately parallel, or subparallel, to the Fall Line. The average dip of each successively younger depositional unit decreases upward, with the oldest deposits dipping nearly the same as the basement-rock surface (about 40 ft/mi) and the youngest deposits dipping less than 3 ft/mi. Sediments range in age from Early Cretaceous to Holocene, and have a complex history of deposition and erosion.

## Depositional History

Many different depositional environments existed during the formation of the Virginia Coastal Plain. Numerous marine transgressions and regressions, punctuated by varying periods of erosion, produced an assorted, but ordered, array of sediments in the study area. The shoreline has occupied positions far to the east of the present shoreline, as evidenced by offshore submerged Pleistocene barrier beach deposits, and positions at least as far west as the Fall Line, as evidenced by marine deposits at the Fall Line.

Ages of sediments exposed at the surface within the study area consist of Early Cretaceous, Paleocene, Eocene, Oligocene, Miocene, Pliocene, Pleistocene, and Holocene. Sediments of Late Cretaceous age are overlain by younger sediments, and are not exposed at the surface in the study area. Sediments of Early Cretaceous and Paleocene age crop out extensively between the Fall Line and the Potomac River in the northwestern part of the study area. Sediments of Eocene, Oligocene, and Miocene age are exposed principally along the major stream valleys throughout the western and central regions of the study area. The uppermost sediments of Pliocene, Pleistocene, and Holocene age crop out extensively in broad areas throughout the eastern and southern regions, and, to a lesser extent, in the central and north-central parts of the study area. The Coastal Plain deposits of Virginia can be divided into five principal lithostratigraphic groups based primarily on their mode of deposition. These five groups, from oldest to youngest, are (1) Lower to lowermost Upper Cretaceous Potomac Formation; (2) Uppermost Cretaceous deposits; (3) lower Tertiary Pamunkey Group; (4) upper Tertiary Chesapeake Group; and (5) Quaternary Columbia Group.

Throughout the Early Cretaceous, the land area now comprising the study area was elevated in relation to sea level, and thick sequences of fluvial-deltaic continental and marginal marine sediments were deposited on a broad rock surface. These sediments, at first, were deposited by high-gradient streams, which formed large subaerial deltas that prograded into the Cretaceous seas. As the deltas developed, the depositional pattern gradually changed to a lower-gradient, subaqueous environment throughout the latter half of the Early Cretaceous. Early in the Late Cretaceous, the first major marine transgression occurred, which inundated the eastern half of the study area with shallow seas and broad estuaries. A marine regression soon followed that resulted in a long period of nondeposition which lasted throughout most of the remaining Late Cretaceous. Toward the end of the Late Cretaceous, marine seas once again transgressed into the study area, but only marginally along the northeastern and southeastern sections, where a very thin veneer of clays, sandy clays, and marls was deposited. Throughout the following Tertiary period, interbasinal marine seas covered the study area to varying degrees and deposited relatively thin, but areally extensive, sediments that consisted primarily of glauconite, diatoms, sands, silts, clays, and shells. These Tertiary marine deposits represent two major lithologically distinct groups: the glauconitic sands, silts, and clays of the Pamunkey Group; and the shelly clays, silts, and sandy clays of the Chesapeake Group. Sediments of Quaternary age, which compose the Columbia Group, overlie most of the Tertiary deposits. The Columbia Group includes fluvial and marine deposits that reflect Pleistocene sea-level fluctuations.

## Structural Setting

Crustal deformation along the Atlantic continental margin has produced the regionally downwarped Atlantic Coastal Plain province, and the adjoining regionally uplifted Piedmont province. Weathered rock debris eroded from the uplifted areas were transported and deposited into the downwarped areas as Coastal Plain sediments. The Coastal Plain's thin western edge, defined by the Fall Line, marks the limit of the overlapping unconsolidated sediments onto the crystalline rocks of the Piedmont highlands. The Coastal Plain sediments thicken and extend eastward to the submerged margin of the Continental Shelf approximately 65 miles offshore of Virginia. Within the regionally downwarped area, local differential subsidence produced a series of structural highs and lows, commonly referred to as arches and embayments (basins). Thick accumulations of sediments were deposited within the embayments, with thinner accumulations over the arches. The arches, in effect, separated each of the basins, and together with other environmental factors, produced basins with characteristic depositional sequences. Deposition in the Virginia Coastal Plain was affected by three major structural deformation features. These structural features are, from north to south, the Salisbury embayment, the Norfolk arch, and the Albemarle embayment (fig. 6).

The Coastal Plain of northern and central Virginia forms the southern flank of the Salisbury embayment (Richards, 1948)--an eastward-plunging, open-ended sedimentary basin with an axis that trends across southern Maryland. Structure contours of the top of the basement rocks (fig. 6) bend noticably toward the northwest as they approach the axis of the Salisbury embayment. This structural low has had a pronounced influence on the deposition of sediments throughout the northern and central sections of the study area. Lower Cretaceous fluvial-deltaic deposits thicken considerably toward the axis of the embayment; Glaser (1968) reports that more than 70 percent of the sedimentary section in southern Maryland and northern Virginia is composed of Lower

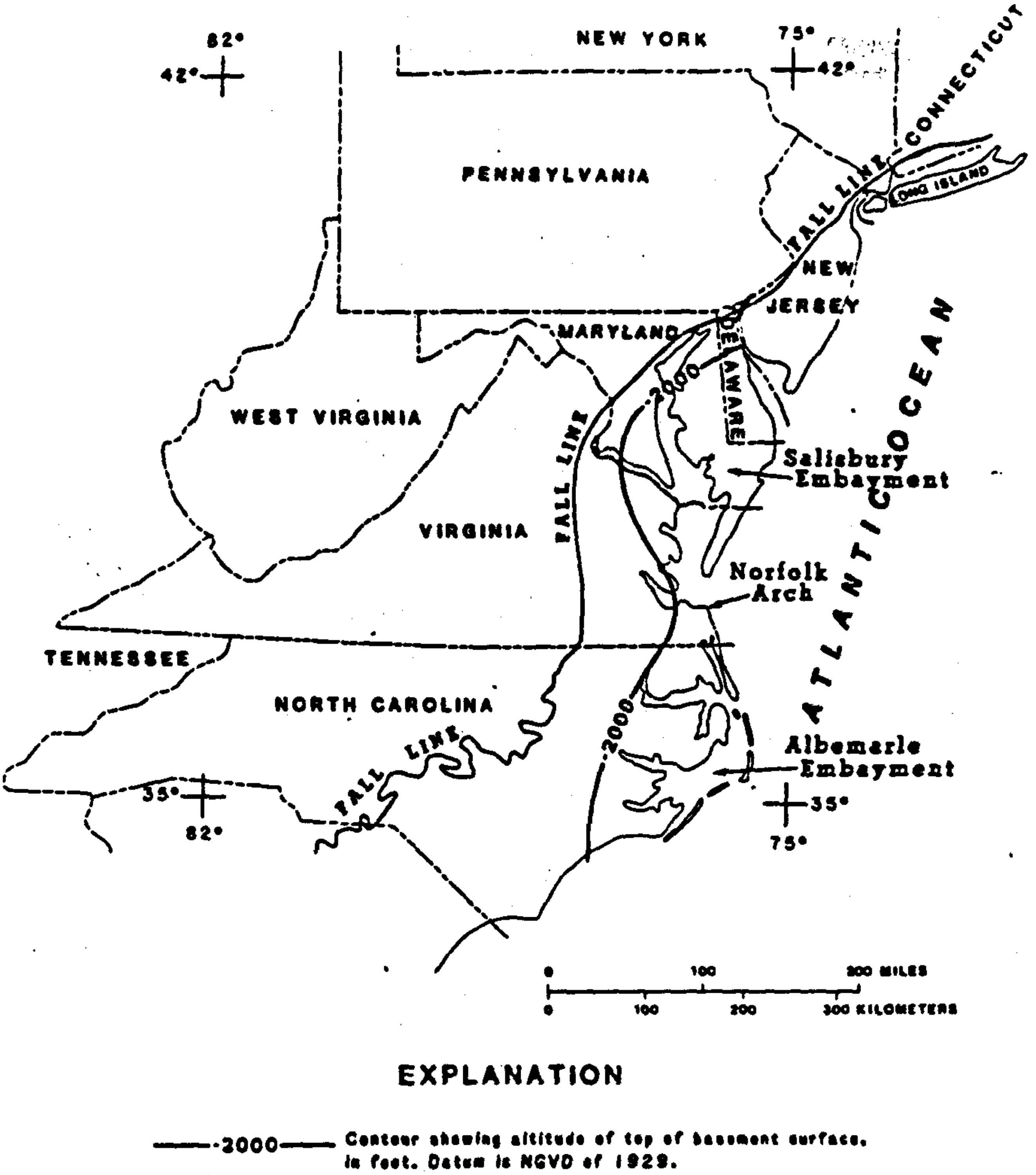


Figure 6.--Map showing major structural deformation basement features of the Virginia Coastal Plain and adjoining areas.

Cretaceous sediments. Lower to middle Tertiary marine deposits also thicken toward the axis of the embayment in this area, but the uppermost Tertiary marine and overlying Quaternary fluvial and marine deposits seem not to be affected by the embayment structure.

In contrast to the structural low that flanks the northern and central sections, a structural high is located midway in the southern section of the study area. This structural high was originally termed the "Fort Monroe High," by Richards and Straley (1953), and now is more commonly referred to as the "Norfolk Arch" (Gibson, 1967). The axis of this structural high dips gently eastward beneath the Coastal Plain sediments (fig. 6). This arch has had a strong control on the deposition of some sediments in the southern part of the study area. Stratigraphic evidence indicates that the Norfolk arch was most active throughout Late Cretaceous and Paleogene time (J. P. Owens, U.S. Geological Survey, oral commun., 1983), which greatly influenced the deposition of these sediments. Generally, these sediments thin drastically as they approach the arch from both the north and south, and some sediments are missing from the area because of nondeposition or erosion. Like the Salisbury embayment, this arch has not noticably affected the deposition of upper Tertiary marine and Quaternary fluvial and marine deposits.

The Norfolk arch separates two distinct sedimentary basins that are characterized by their Paleogene deposits--the glauconite-rich Salisbury embayment to the north from the limestone-rich Albemarle embayment to the south. The arch is probably the controlling structural feature responsible for the general lack of limestone-type deposits in the Coastal Plain areas to the north. Being relatively higher than the surrounding basinal areas, this arch modified the the depositional environment to the south and restricted the northward migration of southern limestone-depositing seas across the arch. Generally, the sediments north of the arch dip to the northeast and sediments south of the arch dip to the southeast into basinal lows.

South of the Norfolk arch, deposition in the Virginia Coastal Plain was influenced by yet another basement low in central North Carolina, and named the "Albemarle Embayment" by Straley and Richards (1950). This embayment, also referred to as the "Hatteras Low" by Johnson and Straley (1953), is a broad open-ended sedimentary basin that dips gently eastward. The south flank of the Norfolk arch is the northern limit of the limestone-rich Albemarle embayment. Sediments in the lowermost part of the study area (south of the structural basement high), are generally much finer grained than sediments to the north. In this area, limestone-stringers and limey-matrix deposits of Paleogene age are common. These limey deposits become more numerous and thicker in the northern North Carolina Coastal Plain (M. D. Winner, Jr., Geological Survey, oral commun., 1982), and eventually thicken into the extensive limestone beds of Eocene, Oligocene and Miocene age in the central North Carolina Coastal Plain.

## HYDROGEOLOGIC FRAMEWORK

The regional hydrogeologic framework described in this report identifies and delineates eight major confined aquifers, eight major confining beds, and an uppermost water-table aquifer. Recognition of the nine aquifers and eight confining beds is based on lithologic and hydrologic characteristics of geologic formations, and is supported by analysis of water-level data.

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Hydrogeologic units are defined on the basis of their water-bearing properties and not necessarily on stratigraphic boundaries. A formation may contain more than one hydrogeologic unit, or may be an aquifer in one area and a confining bed in another. Therefore, the hydrogeologic units commonly consist of combinations or divisions of geologic formations.

The hydrogeologic names of aquifers and confining beds used in this report are based on the name of the predominant geologic formation, or formations, that comprise each unit. Geologic names are used so that a clear and concise relationship is developed between stratigraphic formations and their hydrologic properties. With this geologically orientated nomenclature, the hydrogeologic unit name will immediately indicate a qualitative description and relative position to those familiar with Virginia Coastal Plain stratigraphy. For those not familiar with the Virginia Coastal Plain, each hydrogeologic unit is described in the following sections of this report and delineated on maps and hydrogeologic sections in the back of this report. Regional correlations of hydrogeologic units in the Virginia Coastal Plain with those in adjoining States are included in the description of each aquifer and confining bed based on written and oral communications with D. A. Vroblesky (U.S. Geological Survey, 1984) in Maryland and M. E. Winner (U.S. Geological Survey, 1984) in North Carolina. The correlative aquifer unit names in adjoining States are terms applied by the RASA studies in the respective States and usually reflect the name of the predominant geologic formation, or formations, that compose each aquifer unit. However, the correlative confining beds in adjoining States were not given hydrogeologic names, as was done for the Virginia Coastal Plain. These correlative confining beds are commonly denoted as "the confining bed overlying..." a particular aquifer and in Maryland, the confining beds are numbered serially 1 through 9, from oldest to youngest.

For the purposes of continuity and clarity, only one set of geologic names is used exclusively throughout the study area, even though the study area includes parts of two distinct sedimentary-basin systems--the Salisbury and Albemarle embayments. The geologic formations that developed within the Salisbury basin are the predominant depositional units throughout most of the study area; therefore, these formation names are used. The much smaller, lowermost part of the study area, in which sediment depositional history was controlled primarily by the Albemarle basin system, is similar in deposition and stratigraphy to the study area to the north, and, therefore, these units are denoted accordingly.

The regional hydrogeologic units identified in this study and the corresponding hydrogeologic units of adjoining RASA studies are illustrated on plate 1. Also illustrated are diagnostic and correlative ages, stages, pollen zones, corresponding group names and formation names, lithologies, origins, and areal distribution of each framework unit, together with a combined idealized single-point electric resistivity and lithologic log representative of the total hydrogeologic section. This plate provides a quick reference for the characteristics and correlations associated with the regional hydrogeologic units identified throughout the Virginia Coastal Plain. Table 1 provides an overview of significant Virginia Coastal Plain stratigraphic nomenclature, from a review of present and past literature, relative to the hydrogeologic units identified in this study and the corresponding modeling units used in the ground-water flow model developed under the Virginia RASA study (Harsh and Laczniak, 1983, p. 592).

Table 1.--Significant stratigraphic nomenclature in relation to hydrogeologic framework units and modeling units of Virginia Coastal Plain RASA study.

| PERIOD | EPOCH | STAGE | STRATIGRAPHIC FORMATION | VIRGINIA RASA HYDROGEOLOGIC UNIT | VIRGINIA RASA MODEL UNIT | RADER 1983 | TEIFKE 1973 | CEDERSTROM 1957 | CLARK AND MILLER 1912 | BROWN, MILLER AND SWAIN 1972 |
|---|---|---|---|---|---|---|---|---|---|---|
| QUATERNARY | HOLOCENE | POST-GLACIAL | Holocene deposits (Columbia Group) | Columbia Aquifer | AQ 10 | alluvial deposits<br>Tabb Formation | Columbia Group | Columbia Group | Talbot Formation<br>?<br>Wicomico Formation<br>?<br>Sunderland Formation<br>(Columbia Group) | Rocks of Post Miocene Age |
| | PLEISTOCENE | WISCONSIN TO NEBRASKAN | Undifferentiated | | | Norfolk Formation<br>Windsor Formation | | | | |
| TERTIARY | PLIOCENE | PIACENZIAN | Yorktown Formation (Chesapeake Group) | Yorktown Confining Bed | CB 9 | Bacons Castle Formation | | ▨ | Lafayette Formation | |
| | | ZANCLIAN | | Yorktown-Eastover Aquifer | AQ 9 | Yorktown Formation & Eastover Formation (undifferentiated) (Chesapeake Group) | | | | |
| | MIOCENE | MESSINIAN<br>TORTONIAN | Eastover Formation | | | | Yorktown Formation | Yorktown Formation<br>?—?<br>(Chesapeake Group) | Yorktown Formation<br>?—?<br>(Chesapeake Group) | Rocks of Late Miocene Age |
| | | SERRAVALLIAN | St. Marys Formation | St. Marys Confining Bed | CB 8 | St. Marys Formation, Choptank Formation, & Calvert Formation (undifferentiated) | | St. Marys Formation<br>?—? | St. Marys Formation<br>?—? | Rocks of Middle Miocene Age |
| | | | Choptank Formation | St. Marys-Choptank Aquifer | AQ 8 | | | | | |
| | | LANGHIAN<br>BURDIGALIAN<br>AQUITANIAN | Calvert Formation | Calvert Confining Bed | CB 7 | | Calvert Formation | Calvert Formation | Calvert Formation | |
| | OLIGOCENE | CHICKASAWHAYAN 1/ | Old Church Formation | Chickahominy-Piney Point Aquifer | AQ 7 | ▨ | ▨ | ▨ | ▨ | ▨ |
| | | VICKSBURGIAN 1/ | Not Present in Study Area | ▨ | ▨ | | | | | |
| | EOCENE | JACKSONIAN 1/ | Chickahominy Formation (Pamunkey Group) | Chickahominy-Piney Point Aquifer | AQ 7 | Nanjemoy Formation (Pamunkey Group) | Calvert Formation (continued) | Chickahominy Formation | Nanjemoy Formation (Pamunkey Group) | Rocks of Jackson Age |
| | | CLAIBORNIAN 1/ | Piney Point Formation | | | | | Nanjemoy Formation | | Rocks of Claiborne Age |
| | | SABINIAN 1/ | Nanjemoy Formation | Nanjemoy-Marlboro Clay Confining Bed | CB6 | Marlboro Clay | Nanjemoy Formation | ?—?<br>Aquia Formation | ?—?<br>Aquia Formation | Rocks of Sabine Age |
| | PALEOCENE | | Marlboro Clay | | | | | | ▨ | |
| | | MIDWAYAN 1/ | Aquia Formation | Aquia Aquifer | AQ 6 | Aquia Formation | Mattaponi Formation | Mattaponi Formation | | Rocks of Midway Age |
| | | | Brightseat Formation | Brightseat Confining Bed | CB 3 | Brightseat Formation | | | | |
| | | | | Brightseat Aquifer | AQ 3 | ▨ | | | | |
| CRETACEOUS | LATE CRETACEOUS | MAASTRICHTIAN | undifferentiated Sediments | Upper Potomac Confining Bed | CB3 | Unit A | | | | Rocks of Unit A |
| | | CAMPANIAN | | | | Unit B | | | | Rocks of Unit B |
| | | SANTONIAN<br>CONIACIAN | | | | Unit C | | | | Rocks of Unit C |
| | | TURONIAN | | | | Unit D | | | | Rocks of Unit D |
| | | CENOMANIAN | Potomac Formation | Upper Potomac Aquifer | AQ 3 | Unit E | "Unnamed beds" | ?—? | | Rocks of Unit E |
| | EARLY CRETACEOUS | ALBIAN | | Middle Potomac Confining Bed | CB 2 | Unit F | | Potomac Group | Patapsco Formation (Potomac Group) | Rocks of Unit F |
| | | | | Middle Potomac Aquifer | AQ 2 | Unit G | | | ?—? | Rocks of Unit G |
| | | APTIAN<br>BARREMIAN<br>HAUTERIVIAN<br>VALANGINIAN<br>BERRIASIAN | | Lower Potomac Confining Bed | CB 1 | Unit H | | | | Rocks of Unit H |
| | | | | Lower Potomac Aquifer | AQ 1 | | Patuxent Formation | | Patuxent Formation | |

1/ Commonly used Stages in Atlantic Coastal Plain Province

Stratigraphic test-well and water-well data from more than 600 sites throughout the study area were compiled, analyzed, and interpreted. Of these, 185 control wells were selected as being representative of the hydrogeologic framework of the Virginia Coastal Plain. Control-well identifiers and their locations are shown on plate 2 together with the lines of hydrogeologic sections (plates 3-13) that were developed to illustrate the stratigraphic relationships of the hydrogeologic units. These control wells were selected on the basis of location and quality of the geophysical, hydrologic, and stratigraphic data.

Stratigraphic- and geophysical-log data necessary for the identification and correlation of each hydrogeologic unit are not available for some parts of the study area. Generally, the areas from the western shore of the Chesapeake Bay to the Fall Line, and south of the James River, contain the most complete data required for hydrogeologic correlations. In areas where data are not available, or where borehole information does not extend deeply enough, hydrogeologic units are correlated by projecting dips of the units from known data points, commonly from the updip sections, into those areas that lack sufficient data. Two major areas that commonly lack data are the Chesapeake Bay and the Eastern Shore Peninsula.

Hydrogeologic correlations of the lower hydrogeologic units beneath the Chesapeake Bay are, for the most part, approximate due to the general lack of borehole information. There are no wells that extend to the basement in this area. Water wells located on Tangier Island (63L1, plate 2) and the water-test well (62O2, plate 2) located at milemarker 3.7 on the Chesapeake Bay Bridge-Tunnel provide only partial borehole information to depths of 1,000 ft and 1,500 ft, respectively. The uppermost hydrogeologic units beneath the Chesapeake Bay and its tributaries were studied in detail because of interest in the erosional effects induced by sea-level lowering during Pleistocene glaciations. This erosion created deeply incised stream channels in the Coastal Plain sediments (Hack, 1957; Harrison and others, 1965), which caused a disruption in aquifer and confining-bed continuity and a change in the distribution of hydraulic heads within the affected aquifers.

The hydrogeology of the sediments beneath the Eastern Shore Peninsula have been previously investigated to a depth of approximately 450 ft (Sinnott and Tibbitts, 1954, 1957, 1968; Fennama and Newton, 1982). This area only has three wells--the J&J Taylor oil-test well, the Coast Guard Cobb Island well, and the New York, Philadelphia, and Norfolk Railroad Co. well--which were drilled to 1,000 ft or greater. Only the J&J Taylor well (66M1, plate 2) has either geophysical and geologic information available for analysis. The general lack of deeper hydrogeologic data throughout the Eastern Shore Peninsula area makes correlations of most hydrogeologic units only tentative south of well 66M1.

The information obtained from the interpretation and correlation of geophysical logs, as illustrated in the hydrogeologic sections, was then used to construct sets of hydrogeologic unit maps (plates 14-30) delineating thicknesses of confining beds and altitudes of aquifer tops. For the most part, the hydrogeologic sections and maps can be used to determine the relative positions of, and depths to, the major aquifers and confining beds. However, these hydrogeologic sections and maps are to be used only as a guide, and, because of the variable nature of subsurface sediments, should not be a substitute for test-hole drilling, especially in areas where data are sparse. Outcrop areas of the geologic formation, or formations, that form hydrogeologic units are illustrated on the Geologic Map of Virginia (Milici, Spiker, and Wilson, 1963). It is important to note that, in many cases, the hydrogeologic units constitute only the sandy or clayey facies of specific geologic formations and, therefore, represent an undefined part of the geologic outcrop areas.

Identification of each hydrogeologic unit is based on biostratigraphic and lithostratigraphic analysis obtained from literature describing outcrops, core samples and/or cuttings. A test hole (well 58H4, plate 2) was drilled, in cooperation with the Virginia State Water Control Board's Bureau of Surveillance and Field Studies, to obtain stratigraphic and hydrologic data by analyses of core samples, cuttings, water-level measurements, water samples, and geophysical logs. Correlation and delineation of the identified hydrogeologic units are based on compiled data in combination with the interpretation of geophysical logs, drillers' logs, and water-level data.

## Basement Complex

The basement, which is overlain unconformably by the unconsolidated deposits of the Virginia Coastal Plain, generally consists of a gently eastward-dipping erosional surface of warped, crystalline rocks (plate 14). This basement rock emerges along the Fall Line and extends westward forming the Piedmont province. The exposed Piedmont complex consists mainly of massive igneous and highly deformed metamorphic rocks that range in age from Precambrian to Lower Paleozoic (Milici, Spiker, and Wilson, 1963), but also includes unmetamorphosed, consolidated sediments and igneous intrusives of probable Triassic age within isolated grabens and half grabens (plate 14). It seems reasonable to assume that basement rocks underlying the Coastal Plain in Virginia are similar to the adjacent exposed rocks of the Piedmont terrain. It should be noted that evidence is conflicting (Brown and others, 1972; Doyle and Robbins, 1977) concerning the presence of consolidated Jurassic sediments within the study area. If, in fact, these consolidated sediments are present, they would be considered as part of the basement complex in this report.

The slope of the basement-rock surface ranges from 50 to 100 ft per mile near the Fall Line and then decreases in slope to about 40 ft per mile to the Atlantic Coast (plate 14). Data from wells that penetrate basement rock in the Coastal Plain (plate 14) indicate an irregular, undulating surface composed of the aforementioned variable lithologies. Many authors document these irregularities in the basement surface beneath the Coastal Plain and suggest various origins. Cederstrom (1945b) interprets many of the local steep-sided basement features common throughout the Coastal Plain to be stream-cut channels and erosional scarps. Other studies, however, (Minard and others, 1974; Mixon and Newell, 1977) suggest that major breaks in slope of the basement surface can be attributed more to faulting and warping than to erosion. In wells that penetrate the basement, drillers' logs indicate that a saprolitic mantle overlies the basement surface in many places, which suggests that not all of the underlying basement surface was eroded. The basement surface forms the basal limit of the study area and is overlain principally by sediments of the lower Potomac aquifer. The basement surface is overlain by younger-age deposits only near the Fall Line.

## Lower and lowermost Upper Cretaceous Potomac Formation

Fluvial-deltaic continental and marginal-marine deposits of Early to early Late Cretaceous age constitute the basal lithostratigraphic section known as the Potomac Formation (R. B. Mixon and A. J. Froelich, U.S. Geological Survey, oral commun., 1982). This stratigraphic section comprises the six lowermost hydrogeologic units and consists of three aquifers and three confining beds in the hydrogeologic framework of the Virginia Coastal Plain. These hydrogeologic units are the lower, middle, and upper Potomac aquifers and the corresponding lower, middle, and upper Potomac confining beds. The Potomac Formation, as used in this report, is commonly referred to in the literature as the Potomac Group. The Potomac sediments consist of a massive, eastward-thickening wedge of interlensing gravels, sands, silts, and clays. Throughout the study area, the Potomac Formation rests nonconformably upon the basement rock surface and is separated by major regional unconformities from the overlying latest Cretaceous and various Tertiary deposits.

The Potomac sediments crop out just east of the Fall Line in the major river valleys of the study area and in an extensive arcuate band extending from the northwestern part of the study area northeastward through Maryland. Clark and Bibbins (1897) divided the Potomac sediments into four formations based on characteristic lithofacies recognized in outcrops between Washington, D.C., and Baltimore. The four formations consist of, from oldest to youngest: the Patuxent Formation, Arundel Clay, Patapsco Formation, and rocks of the former "Maryland Raritan" now assigned to the Patapsco. Corresponding associated lithologies of these four formations consist of massively bedded, light-colored coarse arkosic clayey sands and sandy clays that commonly contain gravels; massively bedded clays and finely laminated carbonaceous clays, commonly light to dark in color; interbedded medium, lenticular sands and well-bedded, highly colored clays; and interbedded fine, blanket sands and thinly to thickly bedded, dark-colored clays. Similar lithologic units have been recognized (Cederstrom, 1945a; Spangler and Peterson, 1950; Richards, 1967) in the Potomac section throughout the study area, although they are not generally mapped as such because of their seemingly similar and discontinuous nature. Lack of definitive age relationships for the various Potomac sediments in the subsurface has, in the past, also hindered areal correlation of major lithic units owing to the sparsity of readily apparent guide fossils associated with these continental-deltaic deposits.

In Virginia, the Potomac sediments have not been as extensively studied as those in Maryland. Early studies of the Virginia Coastal Plain (Darton, 1901; Clark and Miller, 1912; Sanford, 1913) divided the Potomac sediments into the Patuxent and Patapsco Formations based primarily on lithologic and stratigraphic similarities with the type formations in Maryland. Later studies, however, generally have not recognized these formal divisions. These later studies can be divided into two basic groups: those that refer to the Potomac sediments as "Potomac Group undifferentiated" (primarily Cederstrom's works); and those that recognize the "Patuxent" with overlying "transitional beds" (Onuschak, 1972; Teifke, 1973; Daniels and Onuschak, 1974). The "Patuxent," as recognized and delineated by these later studies, is not correlative with the type Patuxent Formation of Maryland because it generally includes all Potomac sediments of Early Cretaceous age in the study area. This "Patuxent" should more properly be referred to as "Potomac Group undifferentiated," in comparison with other lithologic and stratigraphic studies (Brenner, 1963;

Glaser, 1969; Robbins, Perry, and Doyle, 1975; Doyle and Hickey, 1976; Christopher and Owens, 1980).

The characteristically variable lithologies and sparse macrofossils have made past stratigraphic correlation of these sediments as formations difficult, especially in the subsurface. The study of palynology, (pollens and spores) has recently produced a systematic zonation scheme that qualitatively identifies and correlates the age relationships of sediments. This zonation is based on the analysis and identification of index microfossil flora that resulted from the evolution of land plants and are recognized world-wide as age indicators. Palynologic studies of the Potomac sediments provide, for the first time, a comprehensive stratigraphic zonation that can be used to identify equivalent-age deposits of continental and marginal-marine origins that normally contain few other diagnostic fossils.

Brenner's (1963) analysis of Lower Cretaceous pollens in the Potomac section of Maryland and Virginia resulted in the development of the first comprehensive palynostratigraphic zonation that definitively correlates the ages of sediments in outcrop with the ages of sediments in the subsurface. Other detailed palynological studies by Groot, Penny, and Groot (1961), Brenner (1967), Doyle (1969), Wolf and Pakiser (1971), Sirkin (1974), and Doyle and Hickey (1976), have led to important modifications and a more complete zonation of the total Potomac section. Robbins, Perry, and Doyle (1975) recently refined Brenner's zonation based on palynologic analysis of samples from four deep oil test wells located within the Salisbury Embayment. The palynostratigraphic zonation scheme developed by the above studies is now recognized and used to define the standard stages of the Cretaceous Potomac Formation. Combined palynostratigraphic analyses (Brenner, 1963; Robbins, Perry, and Doyle, 1975; Doyle and Hickey, 1976; Doyle and Robbins, 1977; Reinhardt, Christopher, and Owens, 1980; L. A. Sirkin, Adelphi University, written commun., 1983) have identified five major pollen zones in the Cretaceous Potomac Formation of Virginia. These major pollen zones and their corresponding ages are: pre-Zone I, Berriasian to Barremian; Zone I, Barremian to early Albian; Zone II, middle to late Albian; Zone III, early Cenomanian; and Zone IV, middle to late Cenomanian (plate 1). Other studies (Glaser, 1969; Hansen, 1969a; Brown and others, 1972; Hansen, 1983) have proposed that correlatable lithological and depositional patterns are related to most of the major pollen zones and their corresponding "formations." In this study, the hydrogeologic units identified within the Potomac section of Virginia are based on palynostratigraphic zonation, mode of deposition, lithologic characteristics, and hydrologic data. These units are then correlated and delineated throughout the study area by interpreting of geophysical logs, drillers' logs, and water-level data. In general, all Cretaceous units strike approximately north-south and dip and thicken eastward. The delineated aquifer units are wedge shaped in cross section and consist of a series of interbedded sands and clays. The delineated confining bed units are highly variable in thickness and consist of a series of areally interlayered silty and clayey deposits.

## Lower Potomac Aquifer

The lower Potomac aquifer, by definition, consists of sandy palynostratigraphic pre-Zone I and Zone I sediments of the Potomac Formation. These sediments are early to middle Early Cretaceous (Berriasian through early

Albian) in age and correlate with the Patuxent aquifer of Maryland, and the Lower Cretaceous aquifer of North Carolina (plate 1). The lower Potomac aquifer is the lowermost confined aquifer in the hydrogeologic framework. It rests entirely on the basement surface and is overlain throughout its extent by the lower Potomac confining bed, except where it crops out along the Fall Line in the northwestern part of the study area (plate 15). This aquifer attains a maximum thickness, 3,010 ft at well 66M1, in the northeastern part of the study area and thins to a featheredge along its western limit near the Fall Line. It dips eastward at about 30 ft per mile throughout the area. The lower Potomac aquifer consists predominantly of thick, interbedded sequences of angular to subangular coarse sands, clayey sands, and clays. This aquifer unit is equivalent to the Patuxent Formation of Maryland, of which numerous descriptions have been written concerning its characteristics.

From outcrops in Virginia, Berry (in Clark and Miller, 1912, p. 63) describes the Patuxent Formation as medium to coarse, light-colored quartz sands containing lenses and beds of interstratified yellow, gray, and brown clays. Berry also reports that, in general, the sands are highly arkosic, cross-bedded and clayey, commonly with micaceous and lignitic material, and that the Patuxent also contains varying amounts and sizes of gravels, either in beds, or sometimes interspersed through strata of finer materials. Analysis of the Lower Cretaceous deposits from the Oak Grove core (well 54P3, plate 2), by Reinhardt, Christopher, and Owens (1980), reveals that sediments of Cretaceous pollen zone I contain a massive lower interval of thickly bedded coarse sands and associated clay-clast conglomerates. This lower interval of pollen zone I sediments is herein identified in the hydrogeologic framework of the Virginia Coastal Plain as the lower Potomac aquifer. Typically, the sands of this series are composed of medium to very coarse subangular quartz, with abundant weathered potassium feldspar and some plagioclase. Reinhardt, Christopher, and Owens (1980) also note that the well-bedded clays of this lower interval are typically mixed-layer illite/smectite, whereas the interstitial and laminated clays are predominantly kaolinitic.

Few wells drilled in the study area penetrate the lower Potomac aquifer (plate 15). Generally, only deep stratigraphic test wells and high-capacity production wells provide data required to correlate this aquifer. The lower Potomac aquifer is capable of producing large quantities of water, but generally lie too deep for all but large industrial applications. The overlying middle and upper Potomac aquifers supply much of the water used for smaller industrial, municipal, and domestic purposes. In addition, this aquifer contains increasingly higher chloride concentrations in the downdip direction, which further restricts its usage as a potable source of water.

Typical electric-resistivity log patterns of the lower Potomac aquifer sediments are best illustrated in geophysical logs of wells 54P3, plate 4; 55H1, plates 7 and 8; 58F3, plate 8; 54G10, plates 7 and 8; 58A2, plates 9 and 14; and 53A3, plate 13. Generally, these resistivity patterns are characteristically "blocky" in profile, indicating massively bedded sequences with relatively sharp lithologic contacts among sands, clayey sands, and clays. Very few patterns of gradational, fining-upwards sequences are observed on resistivity logs of the lower Potomac aquifer. However, where these patterns occur, they are usually restricted to the uppermost part of the sand beds. Resistivity logs also characteristically show low resistance values for the sandy sediments. The low resistance values are probably caused by the high percentage of interstitial clays commonly found in the aquifer sands, or by the higher chloride concentrations generally associated with the eastern half of this aquifer unit. Corresponding natural-gamma log patterns commonly reflect a high interstitial clay content also characteristic of the aquifer sands. Drillers commonly refer to the lower Potomac aquifer sediments as "coarse gray sands" that may contain "gravels," and "light to drab-colored clays." Most of the larger gravels encountered in the drilling process are too heavy to be brought to the surface by the drilling fluid and are pushed away from the borehole by the drill bit. Drillers also commonly describe the sands as "hard" or "tough" and the clays as "tight" or "hard." Either of these conditions result in noticeably increased drilling resistance and drilling time. Commonly, the drilled clays reach the surface as small, angular pieces.

The lithologic heterogenity and discontinuous nature of the sediments in this unit makes correlation of individual sand and clay bodies extremely difficult, even over relatively short distances. The contour map delineating the top of this aquifer unit (plate 15) is based on the tops of the uppermost sands in the unit. Because of the sparse data base available and the large distances between control wells, this map should only be used as a guide to indicate the approximate altitude at any specific site. Also, the uppermost part of this aquifer, as it is presently delineated, may include sediments of younger age. As more definitive data becomes available, especially from pollen analysis and water-level information, structure contours that depict the top of the lower Potomac aquifer can be refined accordingly.

Numerous studies (Glaser, 1969; Hansen, 1969; Reinhardt, Christopher, and Owens, 1980; Hansen, 1982) of the lower Potomac sediments (pre-Zone I to middle Zone I) postulate that the paleoenvironment consisted of a subaerial high-gradient fluvial flood plain dominated by braided streams. Their interpretations are based on the predominance of coarse materials, the general lack of sorting, and overall bedding characteristics. Reinhardt, Christopher, and Owens (1980) observed glauconite and illitic clays in the lower Potomac sediments of the Oak Grove core (well 54P3). From this, they suggested that deposition occurred in a broad alluvial plain that was occasionally inundated by marine seas. The presence of glauconite was also observed by Anderson and others (1948) among alluvial sediments in cores from the lower Patuxent Formation at two deep oil test wells, the Hammond and J. D. Bethards, located in eastern Maryland, and a similar hypothesis was suggested. When viewed as a whole, sediments of the lower Potomac aquifer appear to represent the development of a continental delta (Reinhardt, Christopher, and Owens, 1980).

## Lower Potomac Confining Bed

The lower Potomac confining bed is defined by the major clayey strata directly above the lower Potomac aquifer. These clay beds are predominantly restricted to upper palynostratigraphic zone I, but may also include younger sediments (basal pollen zone II). For the most part, this confining bed is middle Early Cretaceous (late Aptian to early Albian) in age. The lower Potomac confining bed correlates with confining bed 1 of Maryland and with the confining bed overlying the Lower Cretaceous aquifer of North Carolina (plate 1). This confining bed crops out in the northwestern part of the study area between the Fall Line and the Potomac River just east of the outcropping lower Potomac aquifer, and in the major stream valleys just east of the Fall Line (plate 15). It overlies and transgresses the lower Potomac aquifer throughout the study area, except where the aquifer crops out and is overlain by the middle Potomac aquifer. It attains a maximum known thickness of 173 ft (well 66M1) in the northeastern part of the study area and thins to a featheredge along its western limit near the Fall Line. The lower Potomac confining bed is usually the thickest bedded clay or, interbedded clay and sandy clay sequence, of pollen zone I sediments. Most of this sequence of clayey sediments correlates with the Arundel Clay of Maryland, although the Arundel Clay is not generally recognized as a continuous unit in the subsurface. From outcrops in Maryland, Clark and Bibbins (1897, p. 485) originally identified and defined the Arundel Clay as a series of large and small lenses of drab colored, tough clays, that are commonly highly carbonaceous and ferruginous. Analysis of the Cretaceous section in the Oak Grove core (well 54P3) by Reinhardt, Christopher, and Owens (1980), and Estabrook and Reinhardt (1980) provides the most definitive lithologic data for the lower Potomac confining bed. These studies identify and describe an upper interval of pollen zone I sediments as a massive clay-dominated interval composed of thick sequences of finely-laminated, carbonaceous clays interbedded with thin sandy clay beds. This upper interval of pollen zone I sediments is herein identified as the lower Potomac confining bed in the hydrogeologic framework described in this report. Typically, the thickly-bedded clays and sandy clays of this interval are mixed-layer illite/smectite that also contain a high percentage of expandable clays; while the laminated carbonaceous clays are predominantly kaolinitic (Reinhardt, Christopher and Owens, 1980; Estabrook and Reinhardt, 1980).

As with the underlying lower Potomac aquifer, few wells drilled in the study area penetrate the lower Potomac confining bed. Generally, only data from deep stratigraphic test wells and high-capacity production wells can be used to correlate this unit.

Clay beds comprising the lower Potomac confining bed are not a continuous, and areally extensive layer. Instead, these clays are a series of interlensing clayey deposits. Water-level measurements from observation wells indicate that these deposits act locally as confining beds and when viewed collectively, represent a single confining unit, as shown by the thickness map of the lower Potomac confining bed (plate 16). In some areas, such as in the western and central regions, the confining bed is relatively thin, ranging from 15 to 30 ft in thickness; in other areas, such as in the northern region, it attains a thickness of more than 200 ft.

Typical electric-resistivity log patterns of the lower Potomac confining bed sediments are best illustrated in geophysical logs of wells 51R5, plate 4; 53P4, plates 4 and 5; 54P3, plate 4; 52N16, plate 5; 57J3, plate 7; 58F3, plate 8, 54G10, plates 6 and 8; 53D3, plate 10; 55C12, plates 10 and 11; and 58A2, plates 10, 11 and 14. Generally, these resistivity patterns are "blocky" in profile, indicating relatively sharp lithologic contacts between the thickly-bedded confining clays with the overlying and underlying aquifer sands. Corresponding natural-gamma log patterns reflect the massively-bedded nature of these clays; few interbedded sands are present. Drillers often refer to the lower Potomac confining bed clays as "hard" or "tough" and as "gray, red, or brown clay." Like the underlying interbedded clays of the lower Potomac aquifer, drillers commonly observe an increase in drilling time and resistance when penetrating these sediments, and the resulting cuttings are commonly small, angular pieces. Also, the underlying interbedded clays of the lower Potomac aquifer usually contain significantly more interbedded sands and sandy clays than are present at this horizon.

Studies (Brenner, 1963; Glaser, 1969; Hansen 1969, 1982; Reinhardt, Christopher, and Owens, 1980) of correlative strata to the lower Potomac confining bed suggest a change in the paleoenvironment from that of the lower Potomac aquifer. These studies indicate that the depositional environment and drainage patterns changed from a high-gradient to a lower-gradient, fluvial flood plain, based on the predominance of finer grained clayey materials and their associated bedding characteristics. These studies also suggest that the resulting paleoenvironment consisted of quiet, shallow, discontinuous backswamp basins with little sediment input.

## Middle Potomac Aquifer

The middle Potomac aquifer, by definition, consists of sandy palynostratigraphic zone II sediments of the Potomac Formation. These sediments are late Early Cretaceous (middle to late Albian) in age and correlate with Patapsco sediments of the Raritan-Patapsco aquifer in Maryland and the lower Cape Fear aquifer of North Carolina (plate 1). The middle Potomac aquifer is the second lowest and thickest confined aquifer in the hydrogeologic framework. This aquifer crops out just east of the lower Potomac confining bed in the northwestern region of the study area and in a small area along the James and Appomattox Rivers near the Fall Line (plate 17). It overlies the lower Potomac confining bed and is overlain by the middle Potomac confining bed. The middle Potomac aquifer attains a maximum known thickness of 929 ft (well 66M1) in the northeastern part of the study area and thins to a featheredge along its western limit near the Fall Line. It dips eastward at approximately 15 ft per mile in the western half of the study area and at 25 ft per mile in the eastern half. The middle Potomac aquifer consists of interlensing medium sands, silts, and clays of differing thickness. This aquifer is equivalent to the Patapsco Formation in Maryland as defined by Brenner (1963).

From outcrops in Maryland, Glaser (1968, p.8) describes the Patapsco Formation as a thick sequence of interbedded variegated silty clay and fine to medium, gray to yellow sand. Glaser (1968) also reports that the clay lenses are typically thick, internally massive, and brightly mottled in red, yellow, gray, and purple, whereas the sands, occasionally with gravels, are similar to those in the Patuxent Formation, although they tend to be finer grained, more uniform, and more argillaceous. Berry (in Clark and Miller, 1912, p. 67) describes "Patapsco" sediments in Virginia much the same as Glaser describes them in Maryland, although Berry notes that the outcropping Virginia deposits are generally much more evenly colored than those in Maryland. Analysis of the Oak Grove core (well 54P3, plate 2) by Reinhardt, Christopher, and Owens (1980, p. 41) reveals that sediments of Cretaceous pollen zone II contain a lower sand-dominated interval characterized by distinct fining-upwards sand sequences interbedded with laminated or massive clays. This lower interval of pollen zone II strata is herein identified in the hydrogeologic framework of the Virginia Coastal Plain as the middle Potomac aquifer. Typically, the sands of these fining-upwards sequences are composed of coarse to fine, angular to subangular quartz, and some plagioclase. These sands are also commonly micaceous and contain abundant heavy minerals. Reinhardt, Christopher, and Owens (1980) also note that the laminated and massive clays of this sequence are composed of mixed kaolinite and highly expandable illite/smectite.

More wells drilled in the study area penetrate this aquifer (plate 17) than the underlying lower Potomac aquifer. Generally, most industrial and municipal wells throughout the western half of the study area use this aquifer, sometimes in combination with the underlying or overlying Potomac aquifers. This aquifer is capable of producing large quantities of high quality water in the western half of the study area, but, like the underlying lower Potomac aquifer, it contains increasingly higher chloride concentrations in the downdip direction, which restricts its use as a source of potable water. In addition, the middle Potomac aquifer generally lies too deep for all but large industrial users in the eastern half of the study area.

Typical electric-resistivity log patterns of the middle Potomac aquifer sediments are best illustrated in geophysical logs of wells 53Q9, 53P4, and 54P3, plate 3; 52N16, 53P8, 53P4, 54Q11, and 54R3, plate 4; 52J5, plate 5; 52K6, 54J4, 55H1, and 58F3, plate 7; 54G10, 57E10, and 60C7, plate 8; 53D3, plate 9; and 53A3, 58B115, and 59C28, plate 12. Generally, these resistivity log patterns are both "triangular" and "saw-toothed" in profile. The "triangular" profiles indicate the fining-upwards sequences characteristically associated with the aquifer sands. The "saw-toothed" profiles indicate the extensively interbedded sequences of sands, silts, and clays also characteristic of these sediments. These electric-resistivity patterns are also both massive and narrow in profile and the sands usually contain sharp, lower lithologic contacts. Resistivity logs of the middle Potomac aquifer also characteristically show high resistance values for the sandy sediments that helps distinguish this aquifer from the underlying lower Potomac aquifer. The high resistance values are indicative of the relatively "clean" sands common to this aquifer and the relatively low concentrations of dissolved solids common of the water from this unit. Corresponding natural-gamma logs show pronounced "saw-toothed" clay and sand patterns with sharp lower and gradational upper lithologic contacts. The clay patterns of natural-gamma logs of the middle Potomac aquifer are more distinct than the sand patterns, indicating the well-bedded and massive nature of the clays. Drillers commonly refer to the middle Potomac aquifer sediments as "medium or coarse gray sands" with "red, brown, or multicolored clays." Drillers also commonly refer to the sands as "water sands" or "artesian sands." Generally, these sediments drill easily and the clays reach the surface as small, cohesive clay balls. The individual sand and clay beds of the middle Potomac aquifer, like the underlying lower Potomac aquifer, are also difficult to correlate between geophysical logs. The contour map delineating the top of this aquifer (plate 17) is based on the tops of the uppermost sand beds. This map should only be used as a guide to indicate the approximate altitude to the top of this aquifer between control wells because of the interlensing nature of these sediments, the large distances between control points in some areas, and the general lack of data in the eastern half of the study area.

Studies (Glaser, 1969; Hansen, 1969; Reinhardt, Christopher, and Owens, 1980) of Potomac strata herein defined as the middle Potomac aquifer and the correlative Patapsco strata in Maryland suggest that the paleoenvironment consisted of a low gradient, subaerial, fluvial flood plain dominated by meandering streams. These deposits, which represent multiple fluvial processes, are dominated by channel sands, point bars, levees, flood plains, and backswamps. Reinhardt, Christopher, and Owens (1980, p. 41) note that no glauconite was observed in the cored sediments of the middle Potomac aquifer strata in the Oak Grove core and suggest that these deposits represent a more landward sedimentary assemblage than do the sediments of the underlying lower Potomac aquifer strata (p. 48). They also note (p. 47) that these deposits are distinctly continental in origin and together with the underlying lower Potomac aquifer sediments, appear to represent the development of a continental delta.

## Middle Potomac Confining Bed

The middle Potomac confining bed is defined by the major clayey strata directly above the middle Potomac aquifer. These clay beds are predominantly restricted to upper palynostratigraphic zone II, but may also consist of younger sediments (basal zone III), especially in the eastern half of the study area. The middle Potomac confining bed correlates with the western half of confining bed 2 of Maryland and with the confining bed that overlies the lower Cape Fear aquifer of North Carolina (plate 1). This confining bed crops out in the northwestern part of the study area between the middle Potomac aquifer and the Potomac River, and in the stream valleys of the Rappahannock, Pamunkey, James, and Appomattox Rivers just east of the outcropping middle Potomac aquifer (plate 18). It overlies the middle Potomac aquifer and is overlain by the upper Potomac aquifer, except in the western part of the study area where it is transgressed by the Aquia aquifer. This confining bed attains a maximum known thickness of 203 ft at well 66M1 (plate 2) in the northeastern part of the Eastern Shore Peninsula and thins to nearly zero thickness along its western limit near the Fall Line (plate 18). Its thickness is highly variable, but the middle Potomac confining bed is commonly the thickest-bedded clay or interbedded clay and sandy clay sequence of pollen zone II sediments.

Definitive lithologic data are obtained from analysis of the Cretaceous section in the Oak Grove core (well 54P3) by Reinhardt, Christopher, and Owens (1980), and Estabrook and Reinhardt (1980). Reinhardt, Christopher, and Owens (1980, p. 41) identify and describe an upper interval of pollen zone II sediments as a clay-dominated sequence characterized by highly sheared and locally mottled montmorillonitic red clay. This upper interval of pollen zone II sediments in the Oak Grove core (well 54P3) is herein identified as the middle Potomac confining bed in the hydrogeologic framework of the Coastal Plain of Virginia. Typically, the clays of this confining bed are massive to thick bedded, but are also finely laminated in places. These clays are similar in composition to the clays of the lower Potomac confining bed in that they consist primarily of mixed kaolinite and highly expandable illite/smectite (Reinhardt, Christopher, and Owens, 1980, p. 41). The laminated clays are silty, sandy, micaceous, and highly carbonaceous, whereas the massive clays are mottled, highly oxidized, and highly fractured. The middle Potomac confining bed is commonly characterized by a thick sequence of brightly-colored, variegated, plastic clays. These variegated clays are used to identify this confining bed on drillers' logs.

Numerous water wells drilled in the western and central regions of the study area penetrate this confining bed. In areas where the upper Potomac aquifer overlies this unit, drillers commonly cease drilling upon reaching this thick variegated clay horizon. The clays identified as the middle Potomac confining bed are not a single, continuous and areally extensive layer, but rather, are a series of interfingering deposits. Water-level data indicate that these clays act locally as confining beds and, when viewed collectively, constitute a single confinement, as shown by the thickness map of the middle Potomac confining bed (plate 18).

Typical electric-resistivity log patterns of the middle Potomac confining bed sediments are best illustrated in geophysical logs of wells 51R5, 54P3, 56N7, plate 3; 52N16, 54R3, plate 4; 52K6, 54J4, 54H11, 55H1, plate 7; 53D3, 54D2, 55C8, plate 9; and 52A1, 53A3, 54A3, 55A1, 56B9, plate 12. Generally, these resistivity patterns are "blocky" in profile, indicating thickly bedded clays in relatively sharp lithologic contact with the aquifer sands above and in gradational lithologic contact with the aquifer sands below. The lithologies indicated by the resistivity patterns range from massive clays, as in wells 54P3, plate 3, and 56N7, plate 5, to thick clays interbedded with thin sands and sandy clays, as in well 55A1, plate 10. Corresponding natural-gamma log patterns also commonly indicate massively-bedded clays with few interbedded sands or sandy clays. Drillers commonly refer to the middle Potomac confining bed clays as "slick or sticky" and as "multicolored or mixed colored clays." These multicolored clays, which are commonly red, purple, gray, brown, olive, and yellow, are also referred to as mottled clays.

Studies on the paleoenvironment of the Potomac strata suggest that deposition of the middle Potomac confining bed occurred on broad, low-gradient, fluvial deltaic plains containing extensive flood plains and swampy interfluves (Glaser, 1969, p. 73). Reinhardt, Christopher, and Owens (1980, p. 47) note that this clay-dominated upper pollen zone II interval is a product of overbank deposition that was modified by weathering and diagenesis, and that these backswamp and flood basin deposits are distinctly continental in origin.

## Upper Potomac Aquifer

The upper Potomac aquifer, by definition, consists of sandy palynostratigraphic zone III and zone IV sediments of the Potomac Formation. These sediments are early Late Cretaceous (Cenomanian) in age and correlate with the Raritan sediments of the Raritan-Patapsco aquifer in Maryland and the upper Cape Fear aquifer in North Carolina (plate 1). This aquifer is restricted to the subsurface; it overlies most of the middle Potomac confining bed and is overlain by the upper Potomac confining bed. The upper Potomac aquifer dips eastward at approximately 15 ft per mile, attains a maximum known thickness of 425 ft at well 66M1 in the northeastern part of the study area, and pinches out along its western subsurface limit throughout the west-central part of the study area. The upper Potomac aquifer, like the other underlying Potomac aquifers, is a multizone unit consisting of stratified sands and clays.

The presence of lower Upper Cretaceous sediments at the top of the Potomac Formation in the study area has been alluded to by many investigators (Cederstrom, 1945, 1957; Spangler and Peterson, 1950; Dorf, 1952; Richards, 1967), but the actual presence of these sediments in Virginia was not verified until the use of pollen analysis as a stratigraphic indicator. Palynostratigraphic analyses by Robbins, Perry, and Doyle (1975), Doyle and Robbins (1977), and L. A. Sirkin (Adelphi University, written commun., 1982, 1983) have indicated the presence of pollen zones III and IV as the top of the Potomac Formation throughout the eastern half of the study area. These sediments are correlatable with the Raritan Formation of New Jersey and comprise the uppermost aquifer of the Potomac Formation in the study area.

The sands of the upper Potomac aquifer, as described from drillers' logs, are characteristically white, micaceous, very fine to medium quartz, and commonly contain carbonaceous material. Gravel is uncommon, and very coarse sand is rare. The interbedded clays of this aquifer, as described from drillers' logs, are characteristically dark, silty, highly micaceous, and commonly contain carbonaceous material. Little data are available that describe the lithologic characteristics of the upper Potomac aquifer in the study area; only one set of core samples from this unit has ever been analyzed. These core samples were obtained as part of the "Artificial Recharge" project conducted by the Geological Survey in cooperation with the city of Norfolk at the Moore's Bridge Water Treatment facility, and are represented by well 61C1 on plate 2. Brown and Silvey (1977, p. 4) report that this unit consists of moderately sorted, angular to subangular, micaceous, fine to medium quartz sands that contain wood fragments and minor interstitial clays. Typical onsite core descriptions (D. L. Brown, U.S. Geological Survey, written commun. 1971) of the sandy intervals indicate that they are light yellow to greenish gray, clayey to "clean," micaceous, slightly calcareous, poor to well sorted, subangular to subrounded, and very fine to medium grained. Similarly, the interbedded silty-clay intervals are described as yellow green to dark greenish gray, glauconitic, calcareous, micaceous, plastic, locally sandy, and containing shell fragments. More wells drilled in the study area penetrate the upper Potomac aquifer (plate 19) than the underlying middle and lower Potomac aquifers. Generally, most light industrial and municipal ground-water users throughout the central part of the study area use this aquifer. This aquifer is capable of producing large quantities of generally good quality water suitable for most uses, but like the underlying Potomac aquifers, this aquifer contains water having high chloride concentrations that increase downdip, thus precluding the use of the aquifer as a potable source of water.

Typical electric-resistivity log patterns of the upper Potomac aquifer sediments are best illustrated in geophysical logs of wells 58J11, 58J5, plate 6; 57G25, 57F2, plate 7; 56F42, 57E10, 58D9, 60C7, plate 8; 55D5, 55E3, plate 10; 58B115, 58C51, plate 11; and 54A3, 55A1, 59C28, 60C25, plate 12. Generally, these resistivity patterns are very similar to the resistivity patterns of the underlying middle Potomac aquifer, but they are characteristically more massive and rounded in profile and are more easily correlated among logs. Also, the characteristic massively-bedded sand sequences are commonly separated by thinner interbedded clays, as shown by the logs of well 59C28 (plate 12). Corresponding natural-gamma logs commonly indicate the presence of interbedded sands and clays.

Drillers commonly refer to the upper Potomac aquifer sediments as "fine, white micaceous sands" and "dark micaceous clays," that commonly contain "wood fragments." Drillers also note that these sediments are penetrated easily. On drillers' logs, sediment descriptions of the upper Potomac aquifer are noticeably absent of the "variegated clay" and "red, brown and yellow clay" descriptions commonly used to describe the underlying Potomac clays.

The contour map delineating the top of the upper Potomac aquifer (plate 19) is based on the tops of the uppermost sand bodies identified at the control wells. Therefore, this map should only be used as a guide to indicate the approximate altitude of the top of this aquifer between control wells because of the interlensing nature of these sediments, the large distances between control points in some areas, and the general lack of data in the northern and eastern sections of the study area.

Sediments of the upper Potomac aquifer represent the effects of the first major marine transgression that inundated the study area. As the seas progressively encroached onto the delta complex, deposition occurred in ever-widening estuaries and intertidal basins. Brown and Silvey (1977) postulate that, based on grain size, deposition of the lower Upper Cretaceous sediments at well 61C1 (Moore's Bridge Water Treatment facility) took place in a littoral environment, possibly a tidal flat, with a semiprotected shoreline. Other studies of equivalent sediments in Maryland (Glaser, 1969; Hansen, 1969) note the absence of typical marine transgressive strandline features, such as barrier beach and dune sediments, and suggest that deposition occurred in a marginal marine outer-delta environment with a vegetated, swampy shoreline.

## Upper Potomac Confining Bed

The upper Potomac confining bed is defined by the major clayey strata directly above the upper Potomac aquifer. These clay beds are predominantly restricted to upper palynostratigraphic zone IV, but also include clay beds of palynostratigraphic zone III in the west-central parts of the study area and undifferentiated clays of latest Cretaceous age in the eastern regions of the study area. The upper Potomac confining bed correlates with part of confining bed 2 (that which overlies the Raritan aquifer strata of the Raritan-Patapsco aquifer) in Maryland and the confining bed that overlies the upper Cape Fear aquifer in North Carolina (plate 1). This confining bed is restricted to the subsurface; it overlies the upper Potomac aquifer and is overlain by the Brightseat aquifer in the north-central and northeastern regions of the study area, and by the Aquia aquifer throughout the remainder of its extent (plate 20). It attains a maximum known thickness of 126 ft at well 66M1 in the northeastern part of the study area and pinches out along its western subsurface limit in the west-central part of the study area. The thickness of this confining bed is variable, but generally it thickens and dips to the northeast.

As in the case for the underlying upper Potomac aquifer, detailed lithologic data is available to the authors only from core samples obtained at well 61C1 located at the City of Norfolk during the "Artificial Recharge" project. The core information indicates (Brown and Silvey, 1977, p. 7) that the confining bed clays consist of highly expandable silty-clay to clayey-silt mixed-layer illite and montmorillonite, and minor amounts of kaolinite. Onsite core descriptions (D. L. Brown, U.S. Geological Survey, written commun., 1971) describe this confining bed as a dark greenish-gray, micaceous, calcareous, slightly glauconitic and sandy, silty clay.

Numerous water wells drilled throughout the central and east-central regions of the study area penetrate and provide information on this confining bed. The clay beds identified as the upper Potomac confining bed are not a single, areally extensive layer, but rather, a series of interlayered clayey deposits. These individual clay layers are more extensive than the clayey deposits of the underlying middle and lower Potomac confining beds and, therefore, are more easily correlated between wells. Water-level data indicate that individual clay units act locally as confining beds and when viewed collectively, they constitute a single confining bed as depicted by the thickness map of the upper Potomac confining bed (plate 20).

Typical electric resistivity log patterns of the upper Potomac confining bed sediments are best illustrated in geophysical logs of wells 58J11, 58J5, plate 6; 57G22, 57G25, plate 7; 57A1, plate 9; and 60B1, plate 13. Generally, these resistivity logs show broad U-shaped profiles that commonly contain numerous thin, interbedded sequences of sands and sandy clays. These thin interbedded sequences of sands and sandy clays produce an erratic appearance to resistivity logs of the thick clay deposits of the upper Potomac confining bed. Drillers commonly refer to the upper Potomac confining bed sediments as "dark micaceous clays" or "dark sandy clays," that may contain "shells" or "wood."

Like the underlying sediments of the upper Potomac aquifer, these confining beds also result from the first major marine transgression in the sedimentary section. The depositional environment was similar to that of the upper Potomac aquifer, but was a lower-energy regime in a broad, low-lying outer delta.

## Uppermost Cretaceous Sediments Undifferentiated

Marine deposits of latest Cretaceous age represent the next distinctive group of sediments in the sedimentary section. These deposits are sparsely presented in the eastern part of the study area. Uppermost Cretaceous sediments typically form relatively thin veneers of glauconitic clays, sandy clays, and chalky marls. The sediments attain a maximum known thickness of 70 ft at well 66M1 in the northeastern part of the study area and approximately 50 ft at well 61C1 in the southeastern part. These sediments are included as part of the upper Potomac confining-bed sequence and are not further differentiated in this report because of their restricted areal extent and their predominantly clayey composition.

After the region-wide Turonian erosional period, marine seas extensively covered the downwarped Coastal Plain areas of Maryland and North Carolina, depositing thick, extensive Upper Cretaceous marine sediments in the structural lows of the Salisbury and Albemarle embayments. Based on lithologic and paleontologic evidence, it appears that most of the Virginia Coastal Plain was elevated, in relation to sea level, throughout this time. Hansen (1978) proposes basement faulting along the southern limb of the Salisbury embayment as the mechanism responsible for the truncation or nondeposition of the uppermost Cretaceous deposits in the north-central and northwestern parts of the study area.

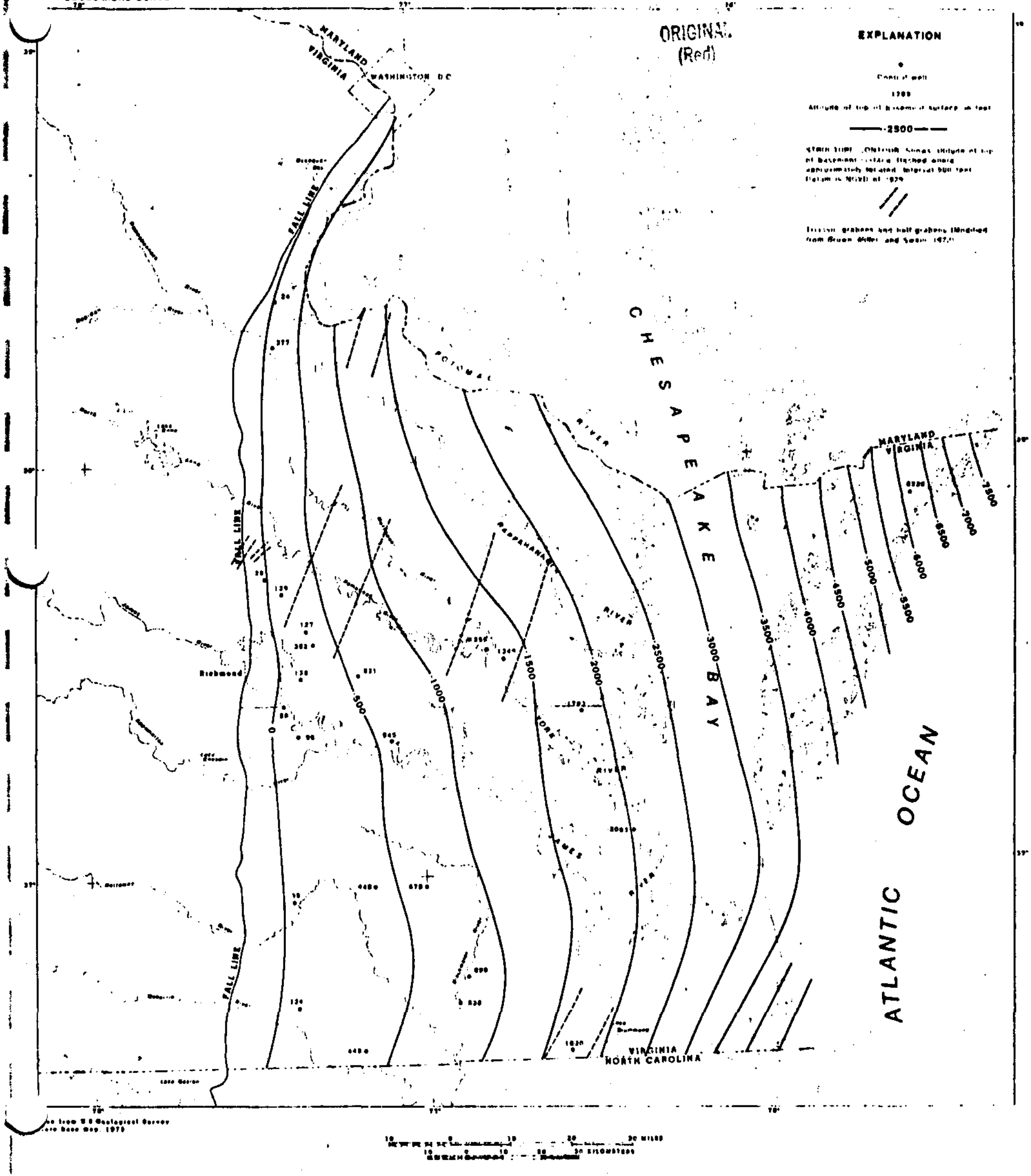
Cederstrom (1945a) suggests a Late Cretaceous age for deposits in the southeastern part of the study area based on paleontological analysis of well cuttings. These sediments are reported to range from 10 to 100 ft thick and consist predominantly of clays and sandy clays. From correlation of geophysical logs and recent stratigraphic data, the authors determined that the thickness is 10 to 30 ft in southeastern Virginia. Brown and others (1972) also found the uppermost Cretaceous deposits in the southernmost part of the study area and, like Cederstrom, determined that the deposits are thin, predominantly clayey sediments, interbedded with a few thin sands. The Norfolk arch is undoubtedly the predominant controlling influence for the northern limit of these Upper Cretaceous deposits in southeastern Virginia.

## Paleocene and Eocene Pamunkey Group

Marine deposits of Paleocene and Eocene age constitute the lower Tertiary (Paleogene) stratigraphic section known as the Pamunkey Group. From oldest to youngest, six formations consisting of the Brightseat, Aquia, Marlboro Clay,

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

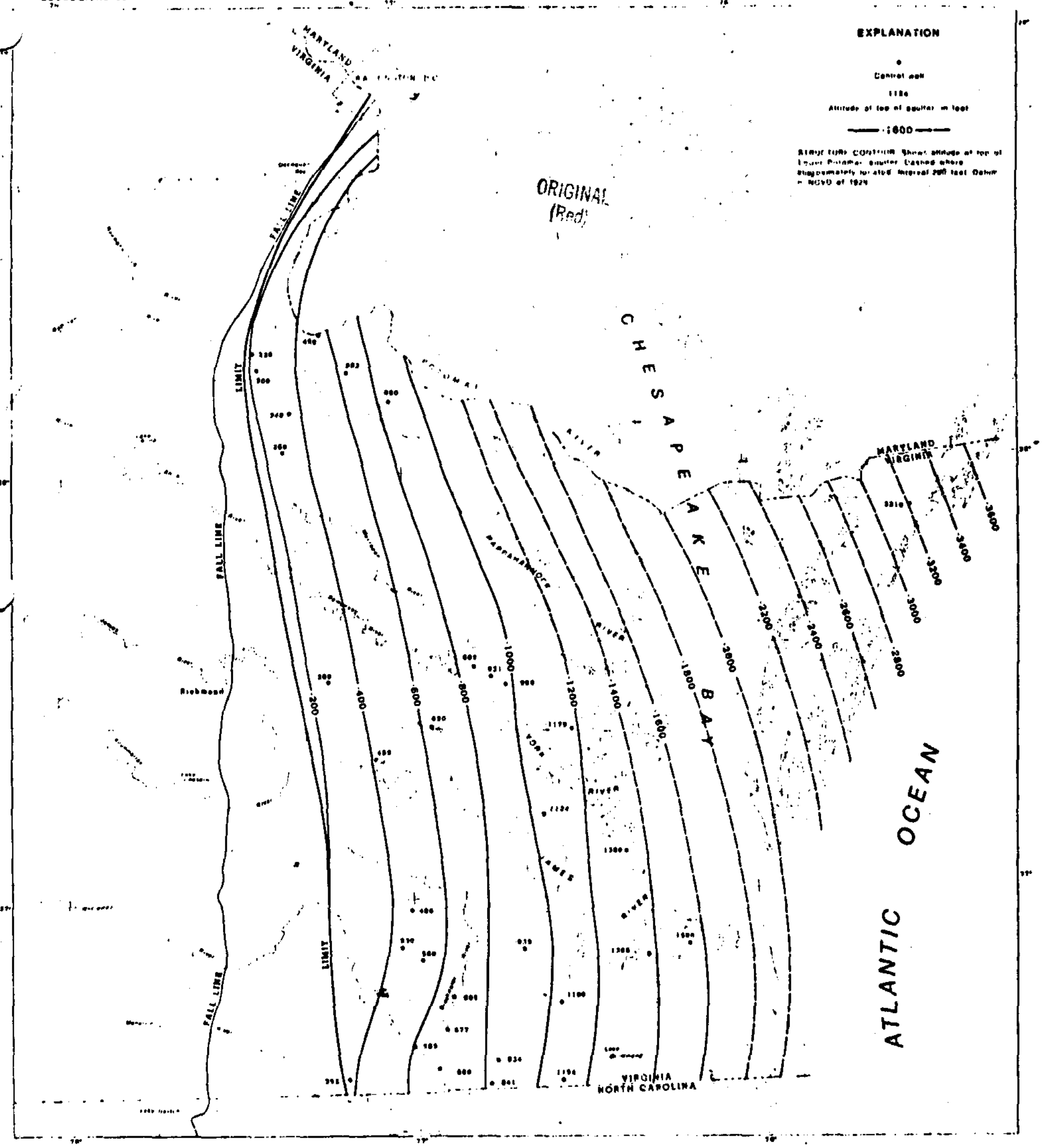
OPEN-FILE REPORT 84-728
PLATE 14



ALTITUDE OF TOP OF BASEMENT SURFACE

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

OPEN-FILE REPORT 84-728
PLATE 16

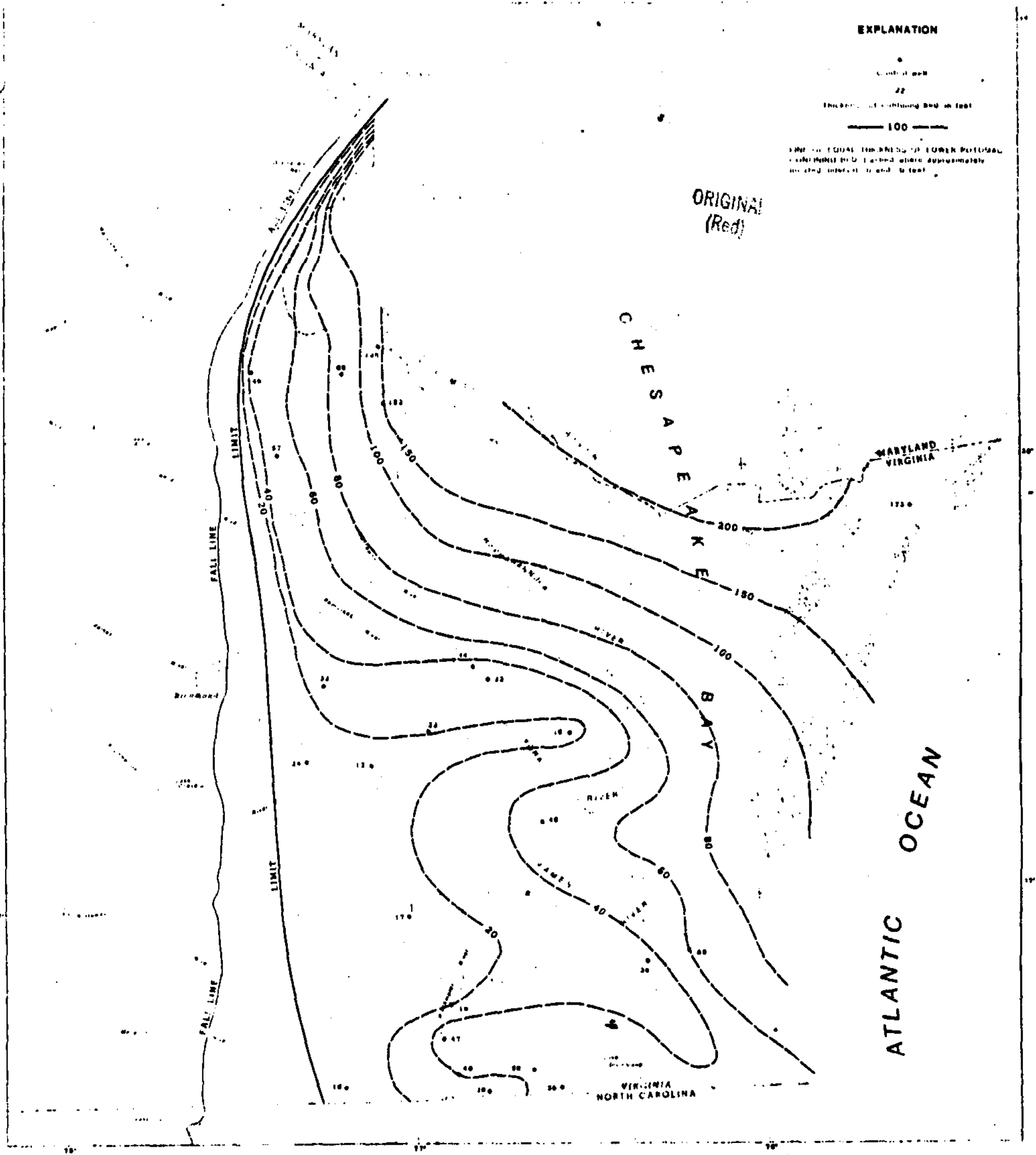


Base from U.S. Geological Survey
State base map, 1972

ALTITUDE OF TOP OF LOWER POTOMAC AQUIFER

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

OPEN-FILE REPORT 84-728
PLATE 16



Base from U.S. Geological Survey
State base map, 1973

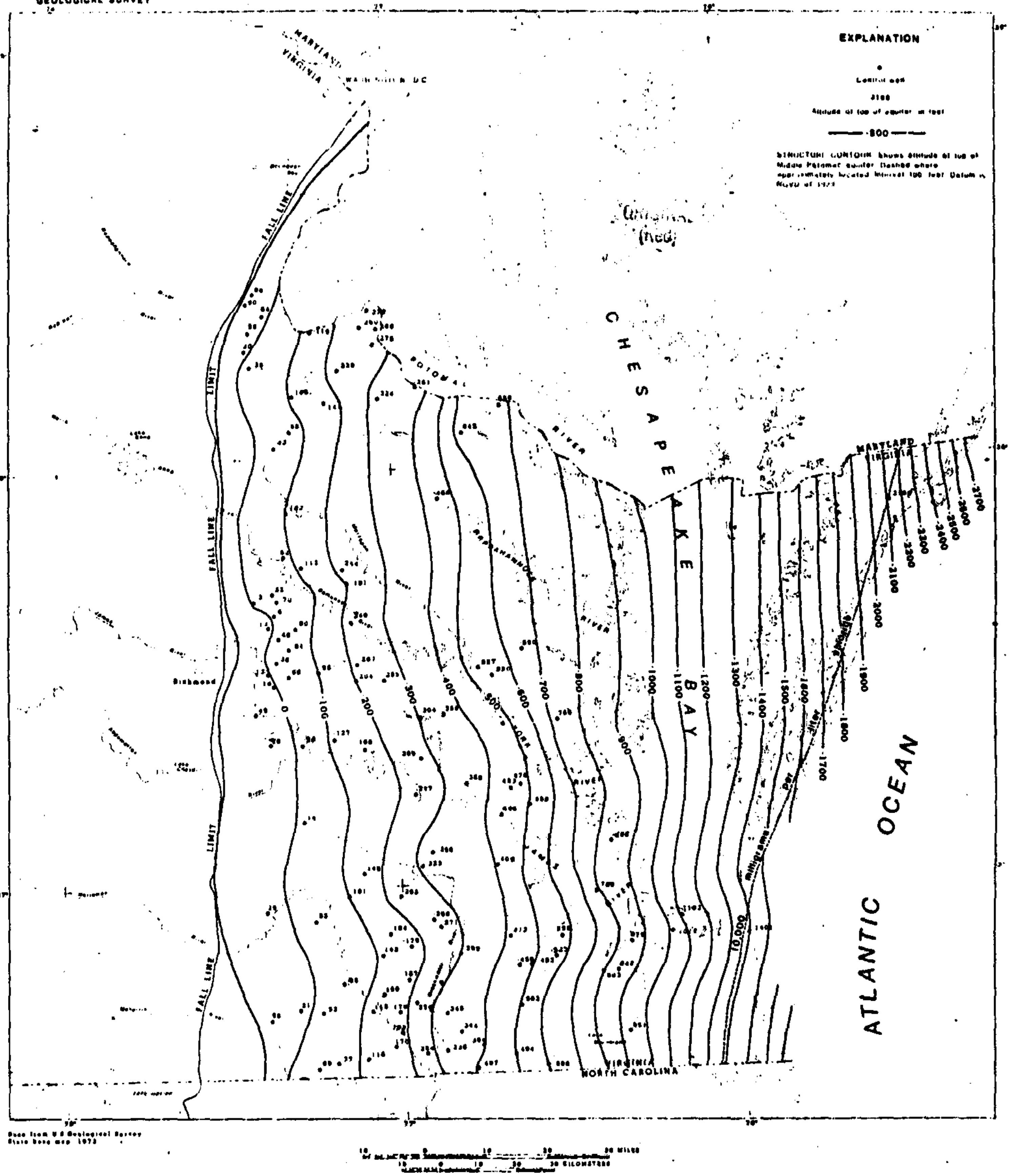
10 5 0 10 20 30 MILES
10 5 0 10 20 30 KILOMETERS

THICKNESS OF LOWER POTOMAC CONFINING BED

100310

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

OPEN-FILE REPORT 84-728
PLATE 17

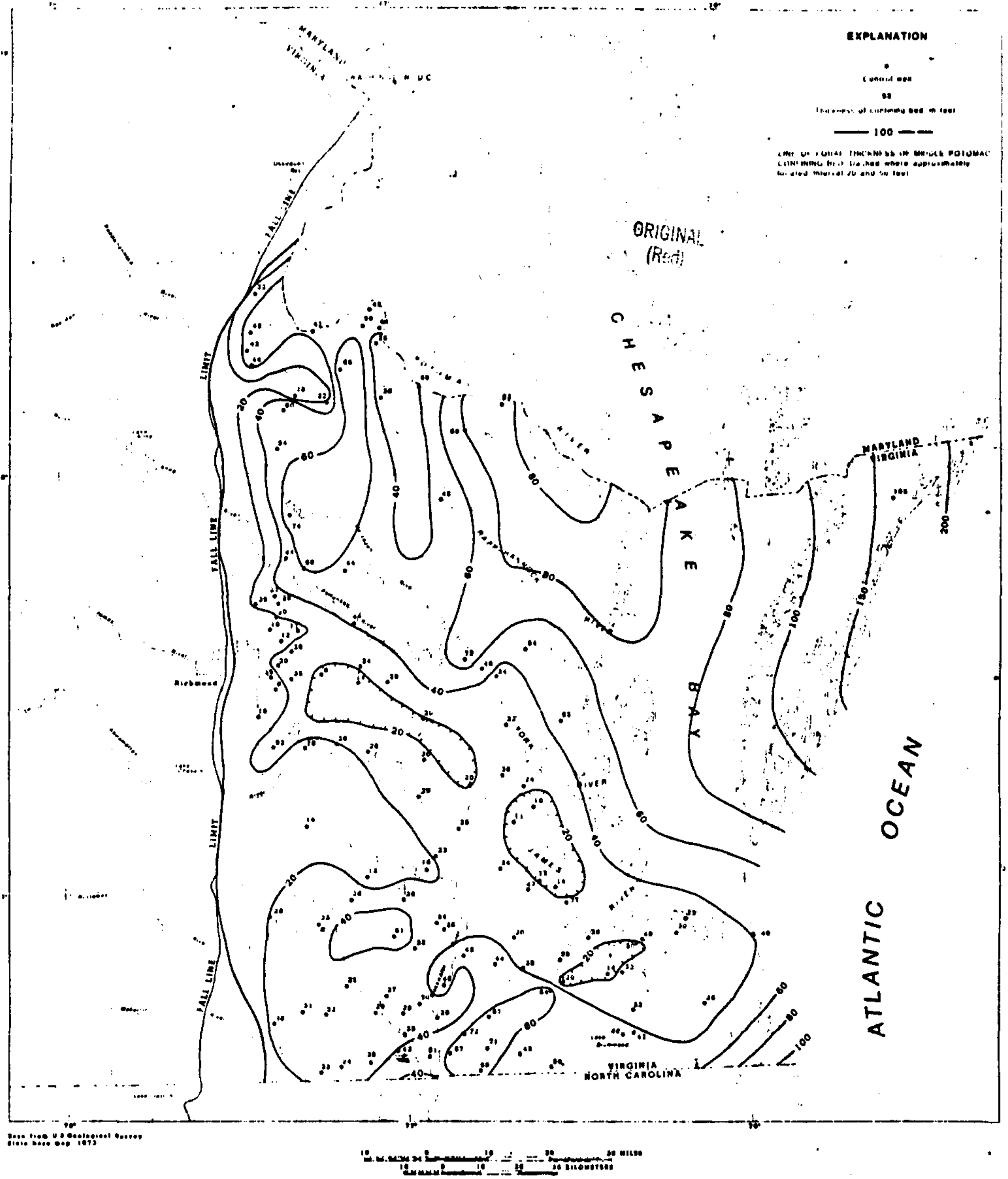


ALTITUDE OF TOP OF MIDDLE POTOMAC AQUIFER

100311

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

OPEN-FILE REPORT 84-7
PLATE 18



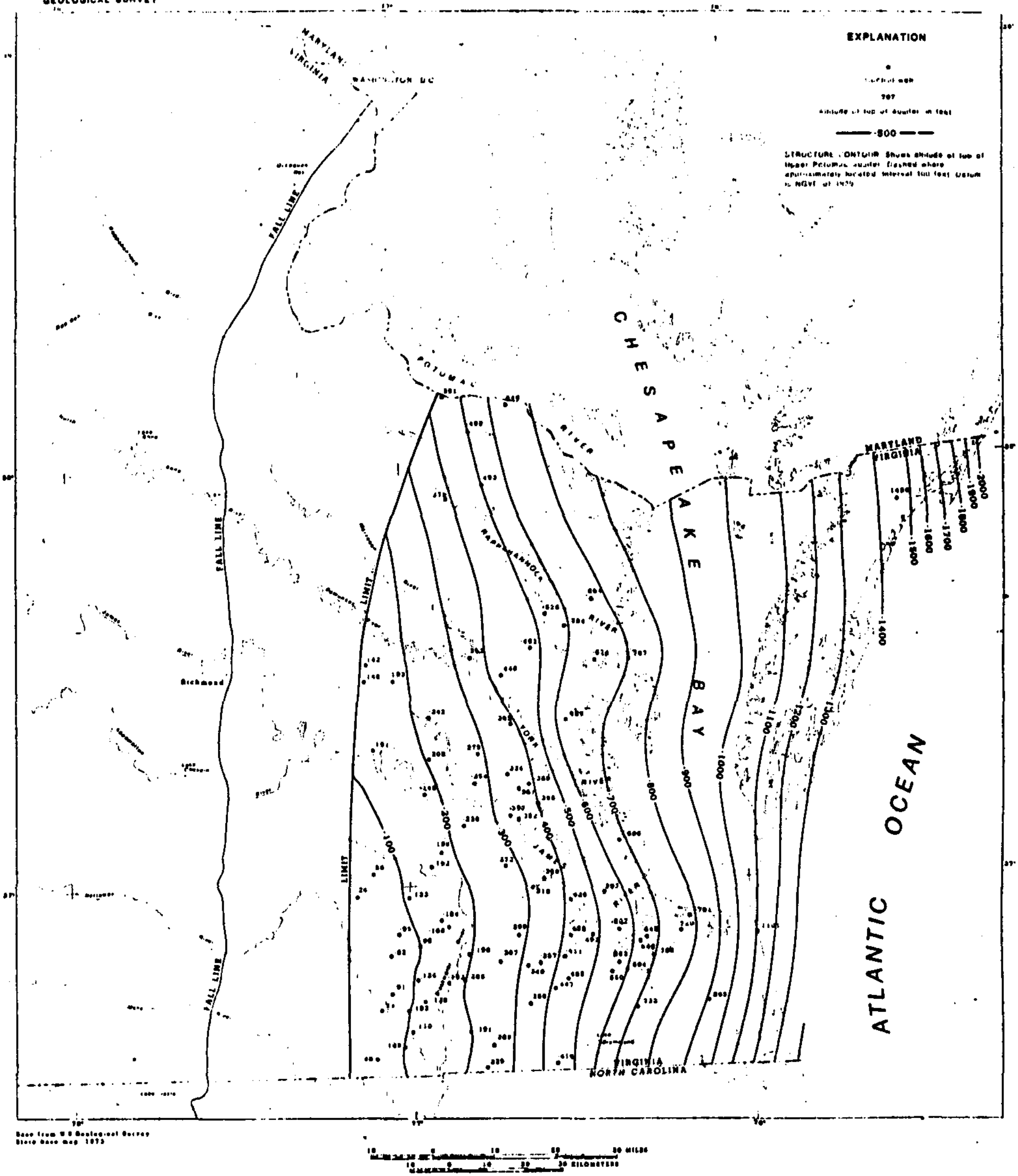
ORIGINAL
(Red)

Base from U.S. Geological Survey
State base map, 1973

THICKNESS OF MIDDLE POTOMAC CONFINING BED

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

OPEN-FILE REPORT 84-728
PLATE 18



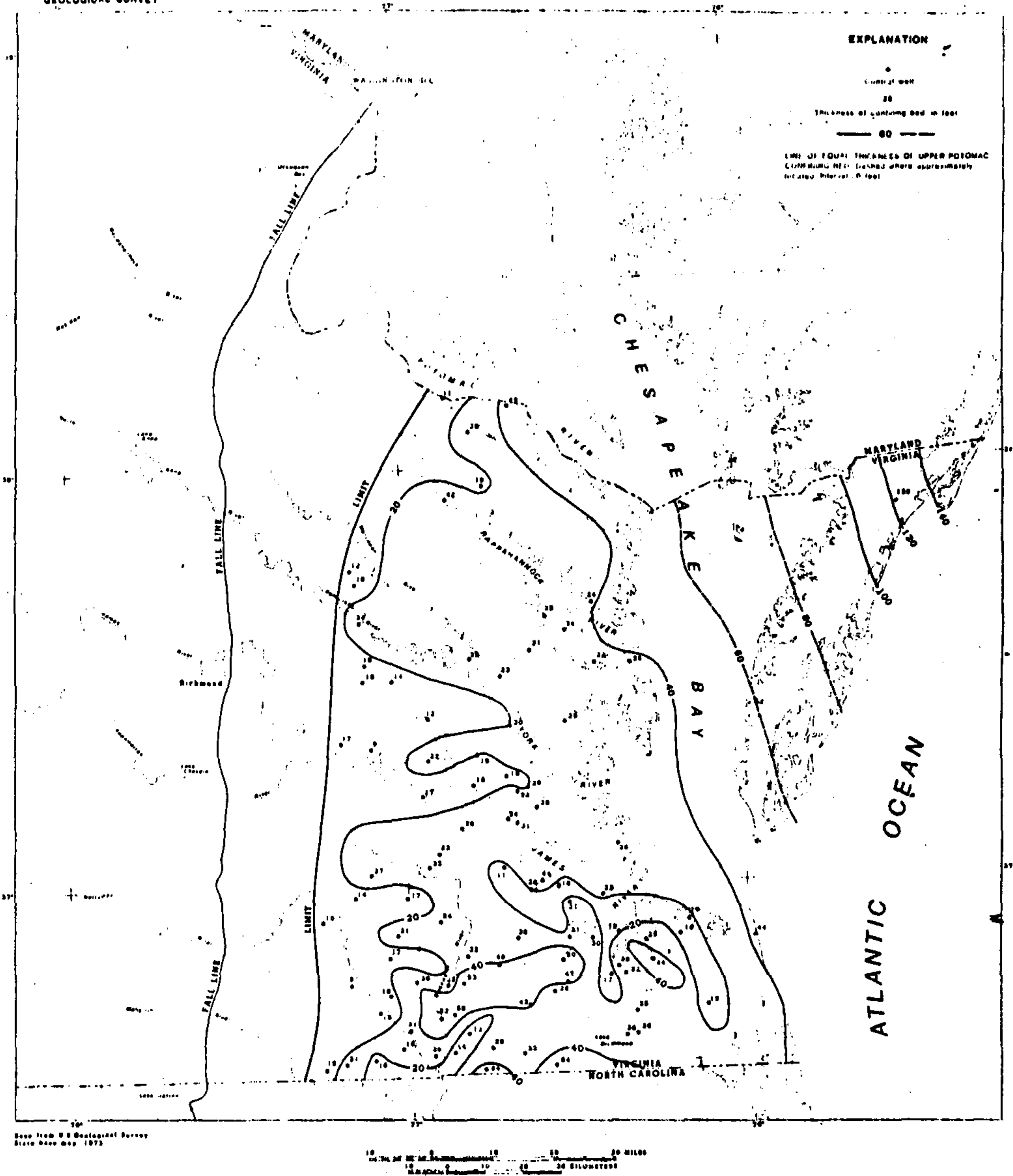
Base from U.S. Geological Survey
State base map 1972

ALTITUDE OF TOP OF UPPER POTOMAC AQUIFER

100313

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

OPEN-FILE REPORT 84-72
PLATE 20



EXPLANATION

●
Control well

38
Thickness of confining bed in feet

—— 60 ——
LINE OF EQUAL THICKNESS OF UPPER POTOMAC CONFINING BED. Dashed where approximately located. Interval 20 feet

Base from U.S. Geological Survey State base map, 1973

THICKNESS OF UPPER POTOMAC CONFINING BED

100314

# APPENDIX H

SYDNOR HYDRODYNAMICS, INC.

ORIGINAL
(Red)

WELL TEST INFORMATION SHEET

CUSTOMER: FORT DARLING - DATE STARTED: 11/30/76

NATIONAL PARK SERVICE DATE COMPLETED: 11/30/76

LOCATION: CHESTERFIELD CO., VIRGINIA WELL TEST NO.: 1

JOB NUMBER: 43763-7

**WELL DESCRIPTION:** Sand or Screened Well (XXX) Rock Well ( )

Total Depth 205 Ft. Size 11" to 184 ' and 6 " to

Casing Depth 0-90 105-184 Ft. Screens 90-105

Construction: Domestic ( ) Class 11-B (XX) 11-A ( ) 1 (

Static Water Level 32'6" Ft. Measured 11/30/76 D

Description of Formations: yellow, gray, green and white clay ---

gravel, sand and rock mixed

**TEST PUMP:** Turbine ( ) Sumo (xxx) Piston ( ) Air ( ) Bailer (

Pump Intake 90 Ft. Below Ground; Air Line electric tape Ft. Below Gro

Size Pump Discharge ___ Ft. Metering Device 5/8" water meter

Description of Pump 1/3 H.P. with 1" pipe and driven with 220 generator

**TEST DATA:** Static Level Before Installing Pump 32'6" Ft.

Air Line electric tape PSI Before Starting Pump; Time of Measurement 6:45

Time Test Pump Started 7:00 a.m.; Time Test Pump Stopped 3:0C

Total Hours Pumped 8 Final Capacity 3 GPM @ 59'6 1/2" F

Static Level Ft., 33'9" Ft., 1 Hr. 30 Min. After Pump Stoppe

**INSTRUCTIONS:** For the first hour of pumping, take readings at least ever 5 minutes and thereafter at least every 15 minutes. Obtain two 1 gallon representative samples of water near the end of the test. If possible, measure recovery for time equal to 1/3 length of the test. Sample to F & R 12/1/76

| m | To | TYPE OF ROC R SOIL PENETRATED (gravel, clay, etc.; hardness, color, etc.) | REMARKS (water, caving, shot, screen, samp |
|---|---|---|---|
| 0 | 1 | Top Soil | |
| 1 | 9 | Yellow Clay | |
| 9 | 20 | Gravel | ORIGINAL (Red) |
| 20 | 43 | Gravel, White and Gray Clay Mixed | |
| 43 | 49 | Rock and Gravel Mixed | |
| 49 | 60 | Yellow, Gray, White Clay and Gravel Mixed | |
| 60 | 70 | Some Gray Sand and Gravel with Streaks of Clay | |
| 70 | 86 | Green and Gray Clay with Streaks of Gravel | |
| 86 | 104 | Brown, Green, White, Sandy Clay with Gravel | |
| 104 | 116 | Coarse Gravel with White, Gray and Pink Clay | |
| 116 | 127 | Red, Gray and White Clay with Gravel and Rock Streaks | [illegible] |
| 127 | 131 | White Clay and Gravel | |
| 131 | 136 | Gray and White Clay | |
| 136 | 138 | Rock and Gravel | |
| 138 | 141 | Gray Clay | |
| 141 | 146 | Rock . | |
| 146 | 155 | Red and Gray Clay with Rock Mixed | |
| 155 | 174 | Gray Clay with Some Red Clay | Basement |
| 174 | 176 | Streaks of Rock and Gray Clay | |
| 176 | 184 | Red and Gray Granite | |
| 184 | 205 | Red Granite | |

P. O. Box 11143, 2111 North Hamilton Street
Richmond, Virginia 23230
Phone (804) 770-1411

## WATER WELL COMPLETION REPORT
(Certification of Completion)
(For use in all groundwater areas)

PERMIT NUMBER ______ 1-10
BWCM WELL NO. ______ 11-19

DATE REC'D ______
TRUCK TAG NO. WD1075

### LOCATION (Card 1)

COUNTY: Chesterfield

WELL IS LOCATED APPROX. 900 feet/XXXXs East (direction) of I-95 and 2500 feet/XXXXs North (direction) of Rt. 656.

WELL IS NEWLY CONSTRUCTED ✓ 26 OR IS AN ALTERATION, REHABILITATION, OR EXTENSION OF AN EXISTING WELL ___ 27. NUMBER OF CERTIFICATE OF GROUNDWATER RIGHT OF EXISTING WELL, IF APPLICABLE ______ 28-37.

FOR OFFICE USE:

VA. PLANE COORDINATES: ______ 38-43 N ______ 44-50 E

TOPOGRAPHIC MAP NUMBER: ______ 51-53

### OWNER (Card 2)

NAME: Richmond National Battlefield
STREET: 3215 E. Broad Street
CITY: Richmond
STATE: Va. 73-74 ZIP: 23223 75-79

### DRILLER (Card 3)

NAME: Earl Seay, Jr.
STREET: 2111 Magnolia St.
CITY: Richmond
STATE: Va. 73-74 ZIP: 23223 75-79

### CONTRACTOR (Card 4)

SIGNATURE:
NAME (type): Sydnor Hydrodynmics, Inc.
STREET: P.O. Box 27186
CITY: Richmond
STATE: Va. 73-74 ZIP: 23261 75-79

### BASIC DATA (Card 5)

DATE STARTED: 10/27/76 11-16 DATE COMPLETED: 11/19/76 17-22 DEPTH DRILLED: 205 23-26

DEPTH OF COMPLETED WELL: 205 27-30 STATIC WATER LEVEL: 32'6" 31-33 feet below land surface.

YIELD TEST submersible pump 34-35 method; Drawdown 27' 36-38 feet; Yield 3 39-42 gpm; Duration 8 43-44 hours.

WAS THE WELL LOGGED? Yes/~~No~~ 45; If Yes, BY WHOM? Sydnor-USGS 46-55; TYPE OF LOG(S): Elect Gamma 56-58

WAS THE WATER ANALYZED? ~~Yes~~/No 59; If Yes, BY WHOM? ______ 60-66. TYPE OF RIG: Rotary 69-71

WELL TO SUPPLY: XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX/Other Park (circle which) 72 73 74 75 76 77 78

WERE WELL DRILLINGS SAVED? Yes/~~No~~ 79 (Well cuttings should be collected at 10-foot intervals and shipped express collect to this office in a shipping container. Sample bags are furnished free of charge upon request).

### PUMP DATA (Card 6)

BRAND NAME: ______ 11-30
TYPE: ______ 31-45
MODEL NUMBER: ______ 46-60
RATED CAPACITY: ______ 61-63 gpm at ______ 64-68 feet of head.
DEPTH OF INTAKE: ______ 69-71
RATED HORSEPOWER: ______ 72-74

### CONSTRUCTION DATA (Card 7)

HOLE SIZE: 11-12 12 inches from 0 to 184 feet
21-22 6 inches from 184 to 205 feet
31-32 ___ inches from ___ to ___ feet

CASE SIZE: 41-42 6 inches from +6" to 90 feet
51-52 6 inches from 105 to 184 feet
61-62 ___ inches from ___ to ___ feet

GROUTING? Yes/~~No~~ 71; from surface to 55 72-74 feet.

100318

## ꓛREEN DATA (Card 8)

DOES THE WELL HAVE SCREENS? Yes/XXo; OR 11
DOES THE WELL HAVE SLOTTED OR PERFORATED PIPE? Yes/No 12

LOCATION OF SCREENS: Give the diameter and depth of all screens or sections of sl
or perforated pipe.

| | |
|---|---|
| 6 (13-14) inches from 90 (15-18) to 105 (19-22) feet | ___ (43-44) inches from ___ (45-48) to ___ (49-52) feet |
| ___ (23-24) inches from ___ (25-28) to ___ (29-32) feet | ___ (53-54) inches from ___ (55-58) to ___ (59-62) feet |
| ___ (33-34) inches from ___ (35-38) to ___ (39-42.) feet | ___ (63-64) inches from ___ (65-68) to ___ (69-72) feet |

## QUALITY DATA (Card 9)

DID ANY STRATUM CONTAIN WATER WHICH WAS UNUSUABLE? XXX/No; 11 TYPE OF WATER ___ (12-22)

DEPTH OF STRATUM: from 90 (23-26) to 105 (27-30) feet; from ___ (31-34) to ___ (35-38) feet. WATER TEMPERATURE:

If a permit was not issued for this well and a USGS topographic map is not availab
a written description and sketch map of well location will suffice.

## DRILLER'S LOG

| DEPTH (feet) | | TYPE OF ROCK OR SOIL PENETRATED (gravel, clay, etc.; hardness, color, etc.) | REMARKS (water, caving, s screen, samples, |
|---|---|---|---|
| From | To | | |
| | | | |

| H. | ORIFICE READING INCHES | TIME [illegible] FILL CONT. MIN. SEC. | AIR LINE PSI | TAPE READING FEET | PUMP DISCHARGE GPM | PUMPING LEVEL FEET | REMARKS – (e. g., water clear, cloudy, taking air, etc.) |
|---|---|---|---|---|---|---|---|
| 05 a.m. | | 5 | | | 3 | 40'1" | Clear |
| 7:10 | | 10 | | | " | 44'5" | " |
| 7:15 | | 15 | | | " | 48'1/2" | " |
| 7:20 | | 20 | | | " | 50'9" | " |
| 7:25 | | 25 | | | " | 52'4 1/2" | " |
| 7:30 | | 30 | | | " | 53'9", | " |
| 7:35 | | 35 | | | " | 54'8" | " |
| 7:40 | | 40 | | | " | 55'3 1/2" | " |
| 7:45 | | 45 | | | " | 55'8" | " |
| 7:50 | | 50 | | | " | 56'1" | " |
| 7:55 | | 55 | | | " | 56'4 1/2" | " |
| 8:00 | | 60 | | | " | 56'7 1/2" | " |
| 8:10 | | 70 | | | " | 56'11" | " |
| 8:20 | | 80 | | | " | 57'3 1/2" | " |
| 8:30 | | 90 | | | " | 57'7 1/4" | " |
| 8:40 | | 100 | | | " | 57'9 3/4" | " |
| 8:50 | | 110 | | | " | 57'11 1/2" | " |
| 9:00 | | 120 | | | " | 58'2 1/2" | " |
| 9:15 | | 135 | | | " | 58'5 1/2" | " |
| 9:30 | | 150 | | | " | 58'7" | " |
| 9:45 | | 165 | | | " | 58'8 3/4" | " |
| 10:00 | | 180 | | | " | 58'10 1/2" | " |
| 10:30 | | 210 | | | " | 59' | " |
| 11:00 | | 240 | | | " | 59'1" | " |
| 12:00 noon | | 300 | | | " | 59'2 1/2" | " |
| 1:00 | | 360 | | | " | 59'4" | " |
| 2:00 | | 420 | | | " | 59'5 3/4" | " |
| 3:00 | | 480 | | | " | 59'6 1/2" | " |

ATE: 11/30/76 DATA BY: E.S. & K.B. DATA SHEET NO. 1

| G MIN. | ORIFICE READING INCHES | TIMF FILL T. MIN. SEC. | AIR LINE PSI | TAPE READING FEET | PUMP DISCHARGE GPM | PUMPING LEVEL FEET | REMARKS – (e. water clear, clou taking air, etc.) |
|---|---|---|---|---|---|---|---|
| RECOVERY | TEST | | | | | | |
| | | | | | | | |
| 3:05 | | | | 50'10" | | | |
| 3:10 | | | | 46'1 1/2" | | | |
| 3:15 | | | | 43' | | | |
| 3:20 | | | | 40'6" | | | |
| 3:25 | | | | 38'10" | | | |
| 3:30 | | | | 37'6" | | | |
| 3:35 | | | | 36'5" | | | |
| 3:40 | | | | 35'9 1/2" | | | |
| 3:45 | | | | 35'3 1/4" | | | |
| 3:50 | | | | 34'10 3/4" | | | |
| 3:55 | | | | 34'8 1/4" | | | |
| 4:00 | | | | 34'5 1/4" | | | |
| 4:10 | | | | 34'1 1/4" | | | |
| 4:20 | | | | 33'10 3/4" | | | |
| 4:30 | | | | 33'9" | | | |
| | | | | | | | |
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DATE: 11/30/76 DATA BY: E.S. & K.B. DATA SHEET NO. 2

# APPENDIX I

PROJECT NAME: C & R Battery

TDD NO: F3-8503-29

EPA SITE NO.: 4265

REGION: III

# QUALITY ASSURANCE REVIEW OF INORGANIC ANALYTICAL DATA PACKAGE

Case No.: 4265

Contract No.:

Contract Laboratory: Chemtech Consulting Group

Applicable IFB No.:

Reviewer: Steve L. Markham

Review Date:

Applicable Sample No's.:

MCB-311, MCB 242, MCB 244, MCB 245, MCB 226, MCB 227, MCB 229, MCB 230, MCB 246, MCB 243, MCB 249, MCB 231, MCB 232, MCB 233, MCB 234, MCB 235, MCB 236, MCB 237, MCB 238, MCB 239, MCB 240, MCB 241

The inorganic analytical data for this case has been reviewed. The quality assurance evaluation is summarized in the following table:

| Reviewer's Evaluation* | Fraction | | | |
|---|---|---|---|---|
| | TASK I ICP or AA METALS | TASK II FURNACE AA METALS | TASK III COLD VAPOR AA MERCURY | TASK III CYANIDE |
| Acceptable | | | | |
| Acceptable with exception(s) | | | | |
| Questionable | ① | | | |
| Unacceptable | | | | |

* Definitions of the evaluation score categories are listed on next page.

This evaluation was based upon an analysis of the review items indicated below:

- ● DATA COMPLETENESS
- ● BLANK ANALYSIS RESULTS
- ● MATRIX SPIKE RESULTS
- ● DUPLICATE ANALYSIS RESULTS
- ○ STANDARD ADDITIONS RESULTS
- ● QUANTITATIVE CALCULATIONS
- ● INITIAL CALIBRATION VERIFICATION
- ● CONTINUING CALIBRATION VERIFICATION
- ② INTERFERENCE QC RESULTS
- ● DETECTION LIMITS RESULTS
- ● INSTRUMENT SENSITIVITY REPORTS

Data review forms are attached for each of the review items indicated above.

ǂ No errors noted, no form attached.

◒ Spot Check performed.

Comments: ① Blank results

②

# DATA EVALUATION SCORE CATEGORIES

__ACCEPTABLE__: Data is within established control limits, or the data which is outside established control limits does not affect the validity of the analytical results.

__ACCEPTABLE WITH EXCEPTION(S)__: Data is not completely within established control limits. The deficiences are identified and specific data is still valid, given certain qualifications which are listed below.

__QUESTIONABLE__: Data is not within established control limits. The deficiences bring the validity of the entire data set into question. However, the data validity is neither proved nor disproved by the available information.

__UNACCEPTABLE__: Data is not within established control limits. The deficiences imply the results are not meaningful.

| DATA COMPLETENESS | CONC./ MATRIX | L/AQ | L/AQ | L/AQ | L/AQ | L/AQ | L/AQ | L/AQ | L/AQ | L/AQ | L/AQ | L/AQ | L/Sol | L/Sol | L/Sol | L/Sol |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TRAFFIC REPORT # | MCB 311 | MCB 242 | MCB 244 | MCB 245 | MCB 226 | MCB 227 | MCB 229 | MCB 230 | MCB 246 | MCB 248 | MCB 249 | MCB 231 | MCB 232 | MCB 233 | MCB 234 |
| | LAB I.D. # | 478 01 | 478 02 | 478 23 | 478 04 | 478 05 | 478 06 | 478 07 | 478 08 | 478 09 | 478 10 | 478 11 | 478 12 | 478 13 | 478 14 | 478 15 |
| FIELD QC | BLANK | | | | ✓ | | | | ✓ | | | | | | | |
| | DUPLICATE | X✓ | | X✓ | | ✓ | | ✓ | | | | | | | | |
| | SPIKE | | | | | | | | | | | | | | | |
| TASK I: ICAP OR AA: METALS | RAW DATA | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | TAB. RESULTS | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | TAB. D.L.'s | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | QA FORM | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | ICAP INTER. QC | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | INSTR. SENS. | | | | | | | | | | | | | | | |
| TASK II: FURNACE AA: METALS | RAW DATA | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | TAB. RESULTS | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | TAB. D.L.'s | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | QA FORM | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | INSTR. SENS. | | | | | | | | | | | | | | | |
| TASK II: COLD VAPOR AA: MERCURY | RAW DATA | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | TAB. RESULTS | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | TAB. D.L.'s | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | QA FORM | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | INSTR. SENS. | | | | | | | | | | | | | | | |
| TASK III: CYANIDE | RAW DATA | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | TAB. RESULTS | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | TAB. D.L.'s | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | QA FORM. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | INSTR. SENS. | | | | | | | | | | | | | | | |
| OTHER (SPECIFY): | RAW DATA | | | | | | | | | | | | | | | |
| | TAB. RESULTS | | | | | | | | | | | | | | | |
| | TAB. D.L.'s | | | | | | | | | | | | | | | |
| | QA FORM | | | | | | | | | | | | | | | |
| | INSTR. SENS. | | | | | | | | | | | | | | | |
| OTHER (SPECIFY): | RAW DATA | | | | | | | | | | | | | | | |
| | TAB. RUSULTS | | | | | | | | | | | | | | | |
| | TAB. D.L.'s | | | | | | | | | | | | | | | |
| | QA FORM | | | | | | | | | | | | | | | |
| | INSTR. SENS. | | | | | | | | | | | | | | | |

COMMENTS: No spikes or duplicates analyzed for Hg in the water matrix.
No spikes where run for calibration standard, blanks, LCS or spikes for the furnace analysis.

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DATA COMPLETENESS** | | | | | | | | | | | | | | | | |
| | **CONC./ MATRIX** | L/Sol | L/Sol | L/Sol | L/Sol | L/Sol | L/Sol | L/Sol | | | | | | | | |
| | **TRAFFIC REPORT #** | MCB<br>235 | MCB<br>236 | MCB<br>237 | MCB<br>239 | MCB<br>239 | MCB<br>240 | MCB<br>241 | | | | | | | | |
| | **LAB I.D. #** | 478<br>16 | 478<br>17 | 478<br>13 | 478<br>19 | 478<br>20 | 478<br>21 | 478<br>22 | | | | | | | | |
| **FIELD QC** | **BLANK** | | | | | | ✓ | | | | | | | | | |
| | **DUPLICATE** | | | | ✓ | ✓ | | | | | | | | | | |
| | **SPIKE** | | | | | | | | | | | | | | | |
| **TASK I: ICAP OR AA: METALS** | **RAW DATA** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | |
| | **TAB. RESULTS** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | |
| | **TAB. D.L.'s** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | |
| | **QA FORM** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | |
| | **ICAP INTER. QC** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | |
| | **INSTR. SENS.** | | | | | | | | | | | | | | | |
| **TASK II: FURNACE AA: METALS** | **RAW DATA** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | |
| | **TAB. RESULTS** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | |
| | **TAB. D.L.'s** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | |
| | **QA FORM** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | |
| | **INSTR. SENS.** | | | | | | | | | | | | | | | |
| **TASK II: COLD VAPOR AA: MERCURY** | **RAW DATA** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | |
| | **TAB. RESULTS** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | |
| | **TAB. D.L.'s** | | | | | | ✓ | | | | | | | | | |
| | **QA FORM** | | | | | | ✓ | ✓ | | | | | | | | |
| | **INSTR. SENS.** | | | | | | | | | | | | | | | |
| **TASK III: CYANIDE** | **RAW DATA** | | | | | | | | | | | | | | | |
| | **TAB. RESULTS** | | | | | | | | | | | | | | | |
| | **TAB. D.L.'s** | | | | | | | | | | | | | | | |
| | **QA FORM.** | | | | | | | | | | | | | | | |
| | **INSTR. SENS.** | | | | | | | | | | | | | | | |
| **OTHER (SPECIFY):** | **RAW DATA** | | | | | | | | | | | | | | | |
| | **TAB. RESULTS** | | | | | | | | | | | | | | | |
| | **TAB. D.L.'s** | | | | | | | | | | | | | | | |
| | **QA FORM** | | | | | | | | | | | | | | | |
| | **INSTR. SENS.** | | | | | | | | | | | | | | | |
| **OTHER (SPECIFY):** | **RAW DATA** | | | | | | | | | | | | | | | |
| | **TAB. RUSULTS** | | | | | | | | | | | | | | | |
| | **TAB. D.L.'s** | | | | | | | | | | | | | | | |
| | **QA FORM** | | | | | | | | | | | | | | | |
| | **INSTR. SENS.** | | | | | | | | | | | | | | | |

**COMMENTS:**

# BLANK ANALYSIS RESULTS

| TASK | TYPE | CONC | MATRIX | SAMPLE # | SOURCE OF $H_2O$ | CONTAMINANTS (CONCENTRATION / DETECTION LIMI |
|---|---|---|---|---|---|---|
| INOR. I, II, III | FIELD | L | AQ | MCB 230 |  | Al=135 ug/l<br>Ca=732 ug/l<br>Fe=658 ug/l<br>Zn=26 ug/l |
| Inor. I, II | Field | L | AQ | MCB 845 |  | Ca=894 ug/l<br>Fe=105 ug/l<br>Zn=56 ug/l |
| INOR. I, II, III | LAB PREP | L | AQ |  |  | No elements reported by lab |
| Inor. I, II, III | Field | L | sol | MCB 240 |  | Pb=25 mg/Kg<br>Zn=10 mg/Kg |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

LABORATORY REPORTED FIELD BLANK DATA IS COMPARED WITH THE SAMPLE DATA IN A TABULATION FORM WITH SAMPLE ANALYTICAL DATA SUMMARY.

COMMENTS:

(1) RESULT REPORTED BY LABORATORY AND CONFIRMED BY REVIEWER.

(2) RESULT INFERRED FROM RAW DATA

BASED UPON THE ABOVE LISTED CONTAMINANT LEVELS THE FOLLOWING DATA POINTS MAY BE QUESTIONABLE (5X RULE APPLIED):

Al-MCB 311, MCB 344, MCB 246, MCB 248, MCB 249, MCB 223

Fe-MCB 311, MCB 344, MCB 226, MCB 228, MCB 246, MCB 248, MCB 249

Zn-MCB 311, MCB 344, MCB 226, MCB 229, MCB 246, MCB 248, MCB 249, MCB 237

LAB

## Duplicate Analysis Results

The applicable duplicate pairs are:

% solids = 90.9

| sample no. | MCB-311 | MCB-246 | MCB-233 | | | |
|---|---|---|---|---|---|---|
| Field duplicate | | | | | | |
| Lab duplicate | ✓ | ✓ | ✓ | | | |
| sample level | L | L | L | | | |
| sample matrix | AQ | AQ | sol | | | |
| TASK | I, II | III | I, II, III | | | |

The relative percent difference (RPD) for each parameter group was evaluated. The duplicate analysis RPD acceptance criteria should be:

| MATRIX | maximum acceptable<br>Percent Difference |
|---|---|
| AQ | ± 20 % or ± CRDL if conc. < 5 x CRDL |
| SOL | ± ~~40~~ 35 % |

The RPD's exceeding the maximum acceptable percent difference were:

| MATRIX | Compound | Actual RPD | criteria | Sample | Comparison<br>conc. | conc. |
|---|---|---|---|---|---|---|
| AQ | IRON CRDL = 100 | 54 | CRDL → 5 | MCB-311 | 190 | 314 * |
| AQ | ZINC CRDL = 20 | 37 | ±20 → 5 | MCB-311 | 139 | 105 * |
| Sol | Antimony | 176 | ±35 | MCB-233 | 1166 | 73 |
| Sol | Cadmium | 86 | ±CRDL | MCB-233 | 15 | 6 |
| Sol | Lead | 110 | ±35 | MCB-233 | 89130 | [illegible] |
| Sol | Silver | 45 | | MCB-233 | 19 | 12 |
| Sol | ZINC | 67 | | MCB-233 | 212 | 121 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Comments: *contamination

No duplicate analysis of mercury in water matrix

FIELD

## Duplicate Analysis Results

The applicable duplicate pairs are:

| sample no. | MCB 311 | MCB 244 | MCB 226 | MCB 223 | MCB 238 | MCB 239 |
|---|---|---|---|---|---|---|
| Field duplicate | ✓ | | ✓ | | ✓ | ✓ |
| Lab duplicate | | | | | | |
| sample level | L | | L | | L | |
| sample matrix | AQ | | AQ | | SOL | |
| TASK | I, II | | I, II, III | | I, II, III | |

The relative percent difference (RPD) for each parameter group was evaluated. The duplicate analysis RPD acceptance criteria should be:

| MATRIX | maximum acceptable Percent Difference |
|---|---|
| AQ | ± 20% |
| SOL | ± 40% |

The RPD's exceeding the maximum acceptable percent difference were:

| MATRIX | Compound | Actual RPD | Comparison | | |
|---|---|---|---|---|---|
| AQ | Iron | 50 | 314 | 188 | * |
| AQ | Zinc | 44 | 139 | 89 | * |
| AQ | Aluminum | 55 | 823 | 469 | * |
| AQ | Iron | 30% | 2020 | 2743 | * |
| AQ | Lead | 193 | 54 | 326 | [illegible] |
| Sol. | ✓ Antimony | 148 | 52 | 346 | |
| Sol | Arsenic | 170 | 8.4 | 103 | |
| Sol. | Cadmium | 157 | 12 | 99 | |
| Sol | Calcium | 143 | 25218 | [illegible] | |
| Sol | Zinc | 44 | 75 | 118 | |
| | | | | | |
| | | | | | |

Comments: *contamination

# MATRIX SPIKE RECOVERIES

| | | | | | | |
|---|---|---|---|---|---|---|
| Sample No. | mcb-244 | mcb-246 | mcb-238 | mcb-233 | | |
| Field Spike | | | | | | |
| Lab Spike | ✓ | ✓ | ✓ | ✓ | | |
| Matrix | AQ | AQ | Sol | Sol | | |
| Conc. Level | L | L | L | L | | |
| Method Std. | | | | | | |
| TASK | I, II | III | I, II | III | | |

All matrix spike recoveries were within the established control ranges specified in; IFB WA8 -A , Exhibit E, Table 2. ___ Yes [✓ No]

Exception(s):

| Parameter | Accepted Range (%) | Actual % Rec. | Sample Number | Org. Result | Spike Added | Spike Result | Units |
|---|---|---|---|---|---|---|---|
| Sb | 75-125 | 166 | mcb-244 | 50u | 500 | 832 | ug/l |
| As | 75-125 | 65 | mcb-244 | 10u | 20 | 13 | ug/l |
| Co | 75-125 | 70 | mcb-244 | 20u | 500 | 348 | ug/l |
| Fe | 75-125 | 39 | mcb-244 | 188 | 1000 | 574 | ug/l * |
| Pb | 75-125 | 0 | mcb-244 | 23 | 20 | 14 | ug/l |
| Mn | 75-125 | 70 | mcb-244 | 355 | 200 | 496 | ug/l |
| Sn | 75-125 | 0 | mcb-244 | 30u | 200 | 30u | ug/l |
| As | 75-125 | 60 | mcb-238 | 15 | 40 | 39 | ug/l |
| Ba | 75-125 | 135 | mcb-238 | [123] | 2000 | 2824 | ug/l |
| Be | 75-125 | 152 | mcb-238 | 5u | 50 | 76 | ug/l |
| Cd | 75-125 | 172 | mcb-238 | 22 | 50 | 108 | ug/l |
| Cr | 75-125 | 138 | mcb-238 | 26 | 200 | 302 | ug/l |
| Cu | 75-125 | 144 | mcb-238 | 70 | 250 | 430 | ug/l |
| Mn | 75-125 | 121 | mcb-238 | 412 | 500 | 1015 | ug/l |
| Hg | 75-125 | 142 | mcb-238 | 0.78 | 1.0 | 2.2 | ug/l |
| Ni | 75-125 | 136 | mcb-238 | 20u | 500 | 680 | ug/l |
| Se | 75-125 | 60 | mcb-238 | 5u | 10 | 6 | ug/l |

Comments: *contamination

No spike analysis for Hg in water matrix

# MATRIX SPIKE RECOVERIES

| | | | | | | |
|---|---|---|---|---|---|---|
| Sample No. | mcb-244 | mcb-246 | mcb-238 | mcb-233 | | |
| Field Spike | | | | | | |
| Lab Spike | ✓ | ✓ | ✓ | ✓ | | |
| Matrix | AQ | AQ | sol. | sol. | | |
| Conc. Level | L | L | L | L | | |
| Method Std. | | | | | | |
| TASK | I, II | III | I, II | III | | |

All matrix spike recoveries were within the established control ranges specified in;
IFB WA8 -A , Exhibit E, Table 2. ___ Yes [✓ No]

Exception(s):

| Parameter | Accepted Range (%) | Actual % Rec. | Sample Number | Org. Result | Spike Added | Spike Result | Units |
|---|---|---|---|---|---|---|---|
| - Ag | 75-125 | 0 | mcb-238 | 10u | 50 | 10u | ug/l |
| Sn | 75-125 | 326 | mcb-238 | 44 | 200 | 775 | ug/l |
| V | 75-125 | 147 | mcb-239 | 144 | 500 | 237 | ug/l |
| - Zn | 75-125 | 135 | mcb-238 | 134 | 500 | [illegible] | ug/l |

Comments:

## STANDARD ADDITION RESULTS

ocumentation indicates a standard addition correction was performed
all spiked samples for parameters having recoveries outside of
ontrol limits: Yes_____ No_____

or the parameters having poor recoveries in the spiked sample(s),
tandard additions were also performed on all other samples where
following conditions were met:

(1) The sample matrix was similar to the matrix of the sample which was spiked; and

(2) The parameters in question were detected with postive results.

Yes___ No_____ NOT REQUIRED BY CONTRACT

he parameters with poor spike recoveries are listed below, along
h the type of standard addition performed(none, 1, 2, or 3 point).
results for these parameters in other samples which have a similar
atrix are also listed below:

| ample | description of matrix | parameter | recovery | type of std. add. |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | NA | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

mments: ____________________

## Initial Calibration Verification and Continuing Calibration Verification

Documentation indicates calibrations were performed and checked every ten samples: Yes ✓ N

Exceptions: ______________________________

Calibrations and verifications were all within the control limits specified in

______________________: Yes ✓ N

Outliers are listed below:

ORIGINAL
(Red)

| Parameter | Acceptable Range (%) | Calibration Identifier | % of True Value | Comments |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Interference QC Results

Documentation indicates interference QC samples were run before and after every ten samples: Yes___ N

Exceptions: RUN AT START and FINISH OF SHIFT AS REQUIRED BY CONTRACT

Interference QC results were all within the control limits specified in

______________________: EPA CRL III guidelines 85 - 115 % Yes ✓ No_

Exceptions:

| Parameter | Acceptable Range (%) | Calibration Identifier | % of True Value | Comments |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

# QUANTITATIVE CALCULATIONS

CALCULATION ERRORS AND CORRECTED RESULTS ARE LISTED BELOW

ORIGINAL
(Red)

ORIGINAL
(Red)

## Detection Limits Results

Detection limits were reported for all samples analyzed: Yes ✓ No____

Exceptions:____________________

Detection limits were less than or equal to the required detection limits specified in Sow 784. Yes ✓ No____

Exceptions:____________________

## Instrument Sensitivity Reports

Instrument sensitivity reports were documented for all parameters: Yes____ No____

Comments:____________________

**Other Remarks Concerning this Case:**

There are currently no established control ranges for ICP interference check standards. However, although not a contractual requirement, 85% - 115% is used here as a tentative guideline for evaluation. Outliers of this tentative control range, if any, are tabulated on the bottom of the preceeding page.

# APPENDIX J

# Form I

U.S. EPA Contract Laboratory Program
Sample Management Office
P.O. Box 818 - Alexandria, VA 22313
703/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

EPA Sample No.
MCB 226

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

LAB NAME CHEMTECH CONSULTING GROUP

CASE NO. 4265

SOW NO. 784

LAB SAMPLE ID. NO. 62-478-05

QC REPORT NO. 478

### Elements Identified and Measured

Concentration: Low ✓ Medium ______

Matrix: Water ✓ Soil ______ Sludge ______ Other ______

[✓ ug/L] or mg/kg dry weight (Circle One)

| | | | | | |
|---|---|---|---|---|---|
| 1. | Aluminum | 823 PR | 13. | Magnesium | 7949 P. |
| 2. | Antimony | 50 UPR | 14. | Manganese | 517 P.R |
| 3. | Arsenic | 10 DM ~~UP.~~ UFR | 15. | Mercury | 0.2 U |
| 4. | Barium | 50 UP. | 16. | Nickel | 20 UP. |
| 5. | Beryllium | 5 UP. | 17. | Potassium | 5598 P. |
| 6. | Cadmium | 5 UP. | 18. | Selenium | 5 UF. |
| 7. | Calcium | 117500 P. | 19. | Silver | 10 UP. |
| 8. | Chromium | 10 UP. | 20. | Sodium | 20680 P. |
| 9. | Cobalt | 20 UPR | 21. | Thallium | 10 UF. |
| 10. | Copper | 20 UP. | 22. | Tin | 30 UFR |
| 11. | Iron | 2020 P.R * | 23. | Vanadium | 20 UP. |
| 12. | Lead | 326 PR | 24. | Zinc | 119 P. * |
| | Cyanide | 10 U | | Percent Solids (%) | |

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments: ______

Lab Manager ______

## Form I

U.S. EPA Contract Laboratory Program
ample Management Office
.O. Box 818 - Alexandria, VA 22313
703/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

EPA Sample No.
MCB 227

Date 6-5-85

### INORGANIC ANALYSIS DATA SHEET

LAB NAME CHEMTECH CONSULTING GROUP

CASE NO. 4265

SOW NO. 784

QC REPORT NO. 478

LAB SAMPLE ID. NO. G2-478-~~07~~06 DW

**Elements Identified and Measured**

Concentration: Low ✓ Medium ____

Matrix: Water ✓ Soil ____ Sludge ____ Other ____

[✓ ug/L] or mg/kg dry weight (Circle One)

| | | | | | |
|---|---|---|---|---|---|
| 1. | Aluminum | 458500 P.R | 13. | Magnesium | 34600 P. |
| 2. | Antimony | 50 UP.R | 14. | Manganese | 4468 P.R |
| 3. | Arsenic | 80 $^{05}$ P.FR | 15. | Mercury | 0.2U |
| 4. | Barium | 2466 P. | 16. | Nickel | 635 P. |
| 5. | Beryllium | 124 P. | 17. | Potassium | 12926 P. |
| 6. | Cadmium | 90 P. | 18. | Selenium | 5UF. |
| 7. | Calcium | 30870 P. | 19. | Silver | 10 UP. |
| 8. | Chromium | 701 P. | 20. | Sodium | 7785 P. |
| 9. | Cobalt | 135 P.R | 21. | Thallium | 10 UF. |
| 10. | Copper | 571 P. | 22. | Tin | 300 UFER |
| 11. | Iron | 1338000 P.R * | 23. | Vanadium | 1107 P. |
| 12. | Lead | 2157 P.R | 24. | Zinc | 1794 P * |
| | Cyanide | 10 U | | Percent Solids (%) | |

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments: E - FOR Sn DENOTES A MATRIX PROBLEM.

Lab Manager

## Form I

EPA Sample No.
MCB 228

Contract Laboratory Program
anagement Office
x 818 - Alexandria, VA 22313
·2490 FTS: 8-557-2490

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

CASE NO. 4265 ORIGINAL (Red)

E CHEMTECH CONSULTING GROUP

784

QC REPORT NO. 478

IPLE ID. NO. G2-478-07

### Elements Identified and Measured

ntration: Low ✓ Medium ______ Other ______

x: Water ✓ Soil ______ Sludge ______

[✓ ug/L] or mg/kg dry weight (Circle One)

uminum 469 P.R
timony 50 UPR
Arsenic 10 ~~UP.~~ UFR
Barium 50 UP.
Beryllium 5 UP.
Cadmium 5 UP.
Calcium 116400 P.
Chromium 10 UP.
Cobalt 20 UP.R
. Copper 20 UP.
. Iron 2743 PR *
. Lead 5 UFR
anide 10 U

13. Magnesium 7746 P.
14. Manganese 478 P.R
15. Mercury 0.2U
16. Nickel 20 UP.
17. Potassium 5837 P.
18. Selenium 5 UF.
19. Silver 10 UP.
20. Sodium 19860 P.
21. Thallium 10 UF.
22. Tin 30UFR
23. Vanadium 20 UP.
24. Zinc 117 P. *

Percent Solids (%) ______

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments: ______

Lab Manager E Hedrick

## Form I

**EPA Sample No.**
MCB 230

A Contract Laboratory Program
e Management Office
Box 818 - Alexandria, VA 22313
/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

CASE NO. 4265

NAME CHEMTECH CONSULTING GROUP
NO. 784
QC REPORT NO. 478
SAMPLE ID. NO. G2-478-08

### Elements Identified and Measured

ncentration: Low ✓ Medium ____ Other ____
rix: Water ✓ Soil ____ Sludge ____

[✓ ug/L] or mg/kg dry weight (Circle One)

Aluminum [135] P.R
Antimony 50 UPR
Arsenic 10 ~~UP.~~ DT UFR
Barium 50 UP.
b. Beryllium 5 UP.
Cadmium 5 UP.
7. Calcium [732] P.
Chromium 10 UP.
9. Cobalt 20 UP.R
0. Copper 20 UP.
11. Iron 658 PR *
2. Lead 5 UFR
Cyanide 10 U

13. Magnesium [160] P.
14. Manganese 15 UPR
15. Mercury 0.2U
16. Nickel 20 UP.
17. Potassium 1000 UP.
18. Selenium 5 UF.
19. Silver 10 UP.
20. Sodium 1200 UP.
21. Thallium 10 UF.
22. Tin 30 UFR
23. Vanadium 20 UP.
24. Zinc 26 P. *
Percent Solids (%) ____

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

omments: ____

Lab Manager ____

## Form I

U.S. EPA Contract Laboratory Program
Sample Management Office
P.O. Box 818 - Alexandria, VA 22313
703/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

EPA Sample No.
MCB 231

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

LAB NAME CHEMTECH CONSULTING GROUP

CASE NO. 4265

SOW NO. 784

LAB SAMPLE ID. NO. G2-478-12

QC REPORT NO. 478

### Elements Identified and Measured

Concentration: Low ✓ Medium ____

Matrix: Water ____ Soil ✓ Sludge ____ Other ____

ug/L or [✓ mg/kg dry weight] (Circle One)

| | | | | | |
|---|---|---|---|---|---|
| 1. | Aluminum | 20913 P. | 13. | Magnesium | 4737 P. |
| 2. | Antimony | 33 UP. * | 14. | Manganese | 621 P.R |
| 3. | Arsenic | 6.5 UF.R | 15. | Mercury | 0.31 R |
| 4. | Barium | 153 P.R | 16. | Nickel | 32 P.R |
| 5. | Beryllium | 4.0 P.R | 17. | Potassium | [1128] P. |
| 6. | Cadmium | 3.3 PR * | 18. | Selenium | 3.3 UFR |
| 7. | Calcium | [3061] P. | 19. | Silver | 6.5 UPR |
| 8. | Chromium | 33 P.R | 20. | Sodium | 702 UP. |
| 9. | Cobalt | [16] P. | 21. | Thallium | 6.5 UF. |
| 10. | Copper | 13 UP.R | 22. | Tin | 20 UF.R |
| 11. | Iron | 36271 P. | 23. | Vanadium | 59 P.R |
| 12. | Lead | 536 P.* | 24. | Zinc | 98 P.R * |
| | Cyanide | 0.36 | | Percent Solids (%) | 76.7 |

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments: ____

Lab Manager ____

## Form I

ORIGINAL
(Red)

EPA Sample No.
MCB 232

A Contract Laboratory Program
e Management Office
Box 818 - Alexandria, VA 22313
557-2490 FTS: 8-557-2490

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

CASE NO. 4265

NAME CHEMTECH CONSULTING GROUP

NO. 784

QC REPORT NO. 478

SAMPLE ID. NO. G2-478-13

### Elements Identified and Measured

ncentration: Low ✓ Medium ______

rix: Water ______ Soil ✓ Sludge ______ Other ______

ug/L or [✓ mg/kg dry weight] (Circle One)

| | | | | | |
|---|---|---|---|---|---|
| | Aluminum | 13694 P. | 13. | Magnesium | [1562] P |
| | Antimony | 30 UP. * | 14. | Manganese | 37 P.R |
| | Arsenic | 27 FS.R | 15. | Mercury | 0.21 R |
| | Barium | [80] P.R | 16. | Nickel | 12 UPR |
| | Beryllium | 3.0 UP.R | 17. | Potassium | [605] P. |
| | Cadmium | 6.2 P.R * | 18. | Selenium | 3.0 UF.R |
| | Calcium | [264] P. | 19. | Silver | 5.9 UP.R |
| | Chromium | 20 P.R | 20. | Sodium | 713 UP. |
| 9. | Cobalt | 12 UP. | 21. | Thallium | 5.9 UF. |
| 0. | Copper | 12 UP.R | 22. | Tin | [19] F.R |
| 11. | Iron | 10570 P. | 23. | Vanadium | [29] P.R |
| 2. | Lead | 544 P. * | 24. | Zinc | 52 P.R * |
| | Cyanide | 0.30 U | | Percent Solids (%) | 84.2 |

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments: ______

Lab Manager ______

## Form I

**EPA Sample No.** MCB 233

U.S. EPA Contract Laboratory Program
mple Management Office
.O. Box 818 - Alexandria, VA 22313
703/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

Date 6-5-95

## INORGANIC ANALYSIS DATA SHEET

CASE NO. 4265

LAB NAME CHEMTECH CONSULTING GROUP

SOW NO. 784

QC REPORT NO. 478

LAB SAMPLE ID. NO. Gi2-478-14

### Elements Identified and Measured

Concentration: Low / Medium ____

Matrix: Water ____ Soil / Sludge ____ Other ____

ug/L or [✓ mg/kg dry weight] (Circle One)

1. Aluminum 8680 P.
2. Antimony 641 P.*
Arsenic 24 FR
4. Barium [100] P.R
5. Beryllium 2.8 UPR
6. Cadmium 8.5 PR *
7. Calcium 63036 P.
8. Chromium 13 PR
9. Cobalt 11 UP.
10. Copper 74 PR
11. Iron 12107 P.
12. Lead 49026 P.*

Cyanide 0.30

13. Magnesium [1865] P.
14. Manganese 361 PR
15. Mercury 0.68 R
16. Nickel 11 UP.R
17. Potassium 550 UP.
18. Selenium 2.8 UFR
19. Silver 11 P.R
20. Sodium 660 UP.
21. Thallium 5.5 UF.
22. Tin 101 FR
23. Vanadium [25] P.R
24. Zinc 133 P.R *

Percent Solids (%) 40.9

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments:

Lab Manager

## Form I

U.S. EPA Contract Laboratory Program
Sample Management Office
P.O. Box 818 - Alexandria, VA 22313
703/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

EPA Sample No.
MCB 234

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

LAB NAME CHEMTECH CONSULTING GROUP

CASE NO. 4265

SOW NO. 784

QC REPORT NO. 478

LAB SAMPLE ID. NO. G2-478-15

### Elements Identified and Measured

Concentration: Low ✓ Medium ____

Matrix: Water ____ Soil ✓ Sludge ____ Other ____

ug/L or [✓ mg/kg dry weight] (Circle One)

1. Aluminum 8137 P.
2. Antimony 199 P. *
Arsenic 19 FS.R
4. Barium [85] P.R
5. Beryllium 3.1 UP.R
6. Cadmium 60 P.R *
7. Calcium 95922 P.
8. Chromium 8.2 P.R
9. Cobalt 13 UR
10. Copper 91 P.R
11. Iron 10063 P.
12. Lead 38118 P. *
13. Magnesium 1600 P.
14. Manganese 87 P.R
15. Mercury 0.99 R
16. Nickel 31 P.R
17. Potassium [938] P.
18. Selenium 3.1 UFR
19. Silver 6.3 UP.R
20. Sodium [1605] P.
21. Thallium 8.8 FE
22. Tin [23] F.R
23. Vanadium [13] P.R
24. Zinc 73 P.R *

Cyanide ☆

Percent Solids (%) 79.7

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments: E: FOR Tl DENOTES A MATRIX PROBLEM.
☆ - NO VALUE FOR CN⁻ REPORTED DUE TO THE FACT THAT THE SAMPLE WAS TOO VOLATILE TO DISTILL.

Lab Manager

## Form I

U.S. EPA Contract Laboratory Program
ample Management Office
O. Box 818 - Alexandria, VA 22313
703/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

EPA Sample No. MCB 235

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

LAB NAME CHEMTECH CONSULTING GROUP

CASE NO. 4265

SOW NO. 784

QC REPORT NO. 478

LAB SAMPLE ID. NO. 62-478-16

### Elements Identified and Measured

Concentration: Low ✓ Medium ____

Matrix: Water ____ Soil ✓ Sludge ____ Other ____

ug/L or [✓ mg/kg dry weight] (Circle One)

| | | | | | |
|---|---|---|---|---|---|
| 1. | Aluminum | 8506 P. | 13. | Magnesium | [2212] P. |
| 2. | Antimony | 206 P. * | 14. | Manganese | 226 P.R |
| . | Arsenic | 12 FSR | 15. | Mercury | 0.77 R |
| . | Barium | [96] P.R | 16. | Nickel | 12 UP.R |
| 5. | Beryllium | 3.0 UP.R | 17. | Potassium | 610 UP. |
| 6. | Cadmium | 18 P.R * | 18. | Selenium | 3.0 UF.R |
| 7. | Calcium | 222256 P. | 19. | Silver | 11 P.R |
| 8. | Chromium | 10 P.R | 20. | Sodium | 732 P. |
| 9. | Cobalt | 12 UP. | 21. | Thallium | 6.1 UFE |
| 10. | Copper | 59 P.R | 22. | Tin | 183 UF.R |
| 11. | Iron | 9841 P | 23. | Vanadium | [18] P.R |
| 12. | Lead | 40494 P. * | 24. | Zinc | 72 P.R * |
| | Cyanide | 0.76 | | Percent Solids (%) | 82.0 |

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments: 'E': FOR Tl DENOTES A MATRIX PROBLEM.

Lab Manager

## Form I

U.S. EPA Contract Laboratory Program
mple Management Office
O. Box 818 - Alexandria, VA 22313
703/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

EPA Sample No.
MCB 236

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

LAB NAME CHEMTECH CONSULTING GROUP

CASE NO. 4265

SOW NO. 784

LAB SAMPLE ID. NO. G2-478-17

QC REPORT NO. 478

### Elements Identified and Measured

Concentration: Low / Medium ____

Matrix: Water ____ Soil / Sludge ____ Other ____

ug/L or [✓ mg/kg dry weight] (Circle One)

| | | | | | |
|---|---|---|---|---|---|
| 1. | Aluminum | 11375 P. | 13. | Magnesium | [2896] P. |
| 2. | Antimony | 293 P.* | 14. | Manganese | 243 P.R |
| | Arsenic | 29 F.R | 15. | Mercury | 0.65 R |
| 4. | Barium | [103] P.R | 16. | Nickel | 56 P.R |
| 5. | Beryllium | 3.3 UP.R | 17. | Potassium | [768] P. |
| 6. | Cadmium | 96 P.R* | 18. | Selenium | 3.3 UFR |
| 7. | Calcium | 121512 P. | 19. | Silver | 6.5 UP.R |
| 8. | Chromium | 20 P.R | 20. | Sodium | [1346] P. |
| 9. | Cobalt | 13 UP. | 21. | Thallium | 6.5 UF. |
| 10. | Copper | 108 P.R | 22. | Tin | 20 UFR |
| 11. | Iron | 14993 P. | 23. | Vanadium | [25] P.R |
| 12. | Lead | 67731 P.* | 24. | Zinc | 220 P.R* |
| | Cyanide | 0.32 U | | Percent Solids (%) | 76.7 |

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments:

Lab Manager

## Form I

U.S. EPA Contract Laboratory Program
mple Management Office
.O. Box 818 - Alexandria, VA 22313
703/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

EPA Sample No. MCB 237

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

LAB NAME CHEMTECH CONSULTING GROUP

CASE NO. 4265

SOW NO. 784

QC REPORT NO. 478

LAB SAMPLE ID. NO. G2-478-18

### Elements Identified and Measured

Concentration: Low ✓ Medium ______

Matrix: Water ______ Soil ✓ Sludge ______ Other ______

ug/L or [✓ mg/kg dry weight] (Circle One)

| | | | | | |
|---|---|---|---|---|---|
| 1. | Aluminum | 1992 P.R | 13. | Magnesium | [658] P. |
| 2. | Antimony | 2027 P. * | 14. | Manganese | 131 P.R |
| | Arsenic | 62 F.R | 15. | Mercury | 0.6 R |
| 4. | Barium | 499 P.R | 16. | Nickel | [15] P.R |
| 5. | Beryllium | 2.5 UPR | 17. | Potassium | 504 UP. |
| 6. | Cadmium | 21 P.R * | 18. | Selenium | 2.5 UFR |
| 7. | Calcium | 11798 P. | 19. | Silver | 14 P.R |
| 8. | Chromium | 5.2 P.R | 20. | Sodium | 604 UP. |
| 9. | Cobalt | 10 UP.R | 21. | Thallium | 5.0 UF. |
| 10. | Copper | 28 P.R | 22. | Tin | 189 F.R |
| 11. | Iron | 6591 P.R | 23. | Vanadium | 10 UP.R |
| 12. | Lead | 57100 PR * | 24. | Zinc | 30 P.R * |
| | Cyanide | NC | | Percent Solids (%) | 99.3 |

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

100347

Comments: NC - NON-CALCULABLE. CYANIDE VALUE COULD NOT BE DETERMINED BECAUSE SAMPLE WAS CLOUDY.

Lab Manager ______

## Form I

U.S. EPA Contract Laboratory Program
mple Management Office
.O. Box 818 - Alexandria, VA 22313
703/557-2490 FTS: 8-557-2490

EPA Sample No.
MCB 238

ORIGINAL
(Red)

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

LAB NAME CHEMTECH CONSULTING GROUP

CASE NO. 4265

SOW NO. 784

LAB SAMPLE ID. NO. Gi2-478-19

QC REPORT NO. 478

### Elements Identified and Measured

Concentration: Low ✓ Medium ____

Matrix: Water ____ Soil ✓ Sludge ____ Other ____

ug/L or [✓ mg/kg dry weight] (Circle One)

| | | | | | |
|---|---|---|---|---|---|
| 1. | Aluminum | 8464 P. | 13. | Magnesium | [855] P. |
| 2. | Antimony | 52 P.* | 14. | Manganese | 230 P.R |
| 3. | Arsenic | 8.4 FSR | 15. | Mercury | 0.44 R |
| 4. | Barium | [69] P.R | 16. | Nickel | 11 UP.R |
| 5. | Beryllium | 2.8 UP.R | 17. | Potassium | 559 UP. |
| 6. | Cadmium | 12 P.R * | 18. | Selenium | 2.8 UFR |
| 7. | Calcium | 25218. P. | 19. | Silver | 5.6 UP.R |
| 8. | Chromium | 15 P.R | 20. | Sodium | 670 UP. |
| 9. | Cobalt | 11 UP. | 21. | Thallium | 5.6 UF. |
| 10. | Copper | 39 P.R | 22. | Tin | 25 F.R |
| 11. | Iron | 12458 P. | 23. | Vanadium | [25] P.R |
| 12. | Lead | 27659 P.* | 24. | Zinc | 75 P.R * |
| | Cyanide | 0.64 | | Percent Solids (%) | 89.5 |

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments: ____

Lab Manager ____

# Form I

U.S. EPA Contract Laboratory Program
ple Management Office
P.O. Box 818 - Alexandria, VA 22313
703/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

EPA Sample No. MCB 239

Date 6-5-95

## INORGANIC ANALYSIS DATA SHEET

CASE NO. 4265

LAB NAME CHEMTECH CONSULTING GROUP

SOW NO. 784

QC REPORT NO. 478

LAB SAMPLE ID. NO. G2-478-20

### Elements Identified and Measured

Concentration: Low ✓ Medium ______

Matrix: Water ______ Soil ✓ Sludge ______ Other ______

ug/L or [✓ ug/kg dry weight] (Circle One)

| | | | | | |
|---|---|---|---|---|---|
| 1. | Aluminum | 11114 P. | 13. | Magnesium | [2947] P. |
| 2. | Antimony | 346 P.* | 14. | Manganese | 199 P.R |
| | Arsenic | 103 FSR | 15. | Mercury | 0.57 R |
| 4. | Barium | [63] P.R | 16. | Nickel | 61 P.R |
| 5. | Beryllium | 3.5 UPR | 17. | Potassium | [1357] P. |
| 6. | Cadmium | 99 P.R * | 18. | Selenium | 3.5 UF.R |
| 7. | Calcium | 153273 P. | 19. | Silver | 7.0 UPR |
| 8. | Chromium | 19 P.R | 20. | Sodium | [1985] P. |
| 9. | Cobalt | 14 UP. | 21. | Thallium | 7.0 UF. |
| 10. | Copper | 140 P.R | 22. | Tin | 209 UFR |
| 11. | Iron | 15125 P. | 23. | Vanadium | [16] P.R |
| 12. | Lead | 35084 P.* | 24. | Zinc | 118 P.R * |
| | Cyanide | NC | | Percent Solids (%) | 71.8 |

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments: CYANIDE VALUE COULD NOT BE DETERMINED BECAUSE SAMPLE WAS VOLATILE AND ANALYST WAS NOT ABLE TO DISTILL.

Lab Manager

## Form I

U.S. EPA Contract Laboratory Program
Sample Management Office
P.O. Box 818 - Alexandria, VA 22313
703/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

EPA Sample No.
MCB 240

Date 6-5-95

## INORGANIC ANALYSIS DATA SHEET

LAB NAME CHEMTECH CONSULTING GROUP

CASE NO. 4265

SOW NO. 784

LAB SAMPLE ID. NO. G12-478-21

QC REPORT NO. 478

### Elements Identified and Measured

Concentration: Low ✓ Medium ____

Matrix: Water ____ Soil ✓ Sludge ____ Other ____

ug/L or [✓ mg/kg dry weight] (Circle One)

| | | | | | |
|---|---|---|---|---|---|
| 1. | Aluminum | 25 UP. | 13. | Magnesium | 75 UP. |
| 2. | Antimony | 25 UP. * | 14. | Manganese | 7.5 UP.R |
| 3. | Arsenic | 5.0 UF.R | 15. | Mercury | 0.23 R |
| 4. | Barium | 25 UP.R | 16. | Nickel | 10 UP.R |
| 5. | Beryllium | 2.5 UP.R | 17. | Potassium | 500 UP. |
| 6. | Cadmium | 2.5 UPR * | 18. | Selenium | 2.5 UFR |
| 7. | Calcium | 50 UP. | 19. | Silver | 5 UPR |
| 8. | Chromium | 5 UP.R | 20. | Sodium | 600 UP. |
| 9. | Cobalt | 10 UP. | 21. | Thallium | 5.0 UF |
| 10. | Copper | 10 UP.R | 22. | Tin | 15 UFR |
| 11. | Iron | 10 UP. | 23. | Vanadium | 10 UP.R |
| 12. | Lead | 25 F. * | 24. | Zinc | 10 PR * |
| | Cyanide | 0.25 | | Percent Solids (%) | 100.0 |

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments: ____

Lab Manager ____

# Form I

U.S. EPA Contract Laboratory Program
ample Management Office
.O. Box 818 - Alexandria, VA 22313
703/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

EPA Sample No.
MCB 241

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

CASE NO. 4265

LAB NAME CHEMTECH CONSULTING GROUP

SOW NO. 784

QC REPORT NO. 478

LAB SAMPLE ID. NO. G2-478-22

### Elements Identified and Measured

Concentration: Low ✓ Medium ____

Matrix: Water ____ Soil ✓ Sludge ____ Other ____

ug/L or [✓ mg/kg dry weight] (Circle One)

| | | | | | |
|---|---|---|---|---|---|
| 1. | Aluminum | 14995 P. | 13. | Magnesium | [1723] P. |
| 2. | Antimony | 27 UP.* | 14. | Manganese | 395 P.R |
| 3. | Arsenic | 38 F.R | 15. | Mercury | 0.30 R |
| 4. | Barium | [101] P.R | 16. | Nickel | 11 UP.R |
| 5. | Beryllium | 2.7 P.R | 17. | Potassium | [666] P. |
| 6. | Cadmium | 2.7 UP.R* | 18. | Selenium | 2.7 UFR |
| 7. | Calcium | [995] P. | 19. | Silver | 5.6 P.R |
| 8. | Chromium | 15 P.R | 20. | Sodium | 658 UP. |
| 9. | Cobalt | 11 UP. | 21. | Thallium | 5.5 UFE |
| 10. | Copper | 11 UP.R | 22. | Tin | [18] F.R |
| 11. | Iron | 20756 P. | 23. | Vanadium | 38 P.R |
| 12. | Lead | 182 P.* | 24. | Zinc | 59 P.R* |
| | Cyanide | 0.27U | | Percent Solids (%) | 91.2 |

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments: E FOR Tl. DENOTES A MATRIK PROBLEM.

Lab Manager

# Form I

U.S. EPA Contract Laboratory Program
Sample Management Office
P.O. Box 818 - Alexandria, VA 22313
703/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

EPA Sample No. NCB. 242

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

CASE NO. 4265

LAB NAME CHEMTECH CONSULTING GROUP

SOW NO. 784

QC REPORT NO. 478

LAB SAMPLE ID. NO. 62-478-02

### Elements Identified and Measured

Concentration: Low ✓ Medium ____ Other ____

Matrix: Water ✓ Soil ____ Sludge ____

[✓ ug/L] or mg/kg dry weight (Circle One)

| | | | | | |
|---|---|---|---|---|---|
| 1. | Aluminum | 1649 P.R | 13. | Magnesium | 20610 P. |
| 2. | Antimony | 50 UPR | 14. | Manganese | 2063 P.R |
| 3. | Arsenic | 10 ~~UP.~~ UFR | 15. | Mercury | NOT REQUESTED |
| 4. | Barium | 50 UP. | 16. | Nickel | 110 P. |
| 5. | Beryllium | 5.0 P | 17. | Potassium | [1909] P. |
| 6. | Cadmium | 6.6 P. | 18. | Selenium | 5 UF. |
| 7. | Calcium | 33110 P. | 19. | Silver | 10 UP. |
| 8. | Chromium | 10 UP. | 20. | Sodium | 17980 P. |
| 9. | Cobalt | [28] P.R | 21. | Thallium | 10 UF. |
| 10. | Copper | 20 UP. | 22. | Tin | 30 UFR |
| 11. | Iron | 6198 PR * | 23. | Vanadium | 20 UP. |
| 12. | Lead | 16 FSR | 24. | Zinc | 358 P. * |

Cyanide NOT REQUESTED

Percent Solids (%) ____

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments:

Lab Manager

## Form I

EPA Sample No.
NCB. 244

EPA Contract Laboratory Program
mple Management Office
.O. Box 818 - Alexandria, VA 22313
03/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

CASE NO. 4265

AB NAME CHEMTECH CONSULTING GROUP

SOW NO. 784

QC REPORT NO. 478

AB SAMPLE ID. NO. 62-478-03

### Elements Identified and Measured

Concentration: Low ✓ Medium ______ Other ______

atrix: Water ✓ Soil ______ Sludge ______

[✓ ug/L] or mg/kg dry weight (Circle One)

| | | | | | |
|---|---|---|---|---|---|
| 1. | Aluminum | [153] PR | 13. | Magnesium | 8119 P. |
| | Antimony | 50 UP.R | 14. | Manganese | 355 P.R |
| 3. | Arsenic | 10 ~~UP~~ JM. UF R | 15. | Mercury | NOT REQUESTED |
| 4. | Barium | 50 UP. | 16. | Nickel | 20 UP. |
| 5. | Beryllium | 5 UP. | 17. | Potassium | 5373 P. |
| 6. | Cadmium | 5 UP. | 18. | Selenium | 5 UF. |
| 7. | Calcium | 118800 P. | 19. | Silver | 10 UP. |
| 8. | Chromium | 10 UP. | 20. | Sodium | 21200 P. |
| 9. | Cobalt | 20 UP.R | 21. | Thallium | 10 UF. |
| 10. | Copper | 20 UP. | 22. | Tin | 30 UFR |
| 11. | Iron | 188 P.R * | 23. | Vanadium | 20 UP. |
| 12. | Lead | 23 FSR | 24. | Zinc | 89 P. * |
| | | | | Percent Solids (%) | |

Cyanide NOT REQUESTED

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments: ______

Lab Manager ______

# Form I

EPA Sample No.
MCB. 245

Contract Laboratory Program
Management Office
ox 818 - Alexandria, VA 22313
57-2490 FTS: 8-557-2490

ORIGINAL
(Red)

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

CASE NO. 4265

AME CHEMTECH CONSULTING GROUP

NO. 784

QC REPORT NO. 478

AMPLE ID. NO. 62-478-04

## Elements Identified and Measured

centration: Low ✓ Medium ______ Other ______

ix: Water ✓ Soil ______ Sludge ______

[✓ ug/L] or mg/kg dry weight (Circle One)

Aluminum [85] PR
ntimony 50 UPR
Arsenic 10 UP. UFR
Barium 50 UP.
Beryllium 5 UP.
Cadmium 5 UP.
Calcium [894] P
Chromium 10 UP.
). Cobalt 20 UP.R
). Copper 20 UP.
11. Iron 105 P. *
2. Lead 5 UFR

13. Magnesium 150 UP.
14. Manganese 15 UPR
15. Mercury NOT REQUESTED
16. Nickel 20 UP.
17. Potassium 1000 UP.
18. Selenium 5 UF.
19. Silver 10 P.
20. Sodium [1615] P.
21. Thallium 10 UF.
22. Tin 30 UFR
23. Vanadium 20 UP.
24. Zinc 56 P. *

Percent Solids (%) ______

Cyanide NOT REQUESTED

ootnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments: ______

Lab Manager ______

## Form I

U.S. EPA Contract Laboratory Program
Sample Management Office
P.O. Box 818 - Alexandria, VA 22313
703/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

EPA Sample No. MCB 246

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

LAB NAME CHEMTECH CONSULTING GROUP

CASE NO. 4265

SOW NO. 784

LAB SAMPLE ID. NO. 62-478-09

QC REPORT NO. 478

### Elements Identified and Measured

Concentration: Low ✓ Medium ____

Matrix: Water ✓ Soil ____ Sludge ____ Other ____

[✓ ug/L] or mg/kg dry weight (Circle One)

| | | | | | |
|---|---|---|---|---|---|
| 1. | Aluminum | [123] P.R | 13. | Magnesium | 6017 P. |
| 2. | Antimony | 50 UPR | 14. | Manganese | 51 PR |
| 3. | Arsenic | 10 UFR | 15. | Mercury | 0.2U |
| 4. | Barium | 50 UA | 16. | Nickel | 20 UP. |
| 5. | Beryllium | 5 UP. | 17. | Potassium | 8738 P. |
| 6. | Cadmium | 5 UP. | 18. | Selenium | 5 UF. |
| 7. | Calcium | 15840. P. | 19. | Silver | 10 UP. |
| 8. | Chromium | 10 UP. | 20. | Sodium | 211600 P. |
| 9. | Cobalt | 20 UPR | 21. | Thallium | 10 UF. |
| 10. | Copper | 20 UP. | 22. | Tin | 30 UFR |
| 11. | Iron | 654 PR* | 23. | Vanadium | 20 UP. |
| 12. | Lead | 5 UFR | 24. | Zinc | [17] P* |
| | Cyanide | 10 U | | Percent Solids (%) | |

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments: ____

Lab Manager ____

## Form I

U.S. EPA Contract Laboratory Program
Sample Management Office
O. Box 818 - Alexandria, VA 22313
703/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

EPA Sample No.
MCB 248

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

LAB NAME CHEMTECH CONSULTING GROUP

CASE NO. 4265

SOW NO. 784

LAB SAMPLE ID. NO. G2-478-10

QC REPORT NO. 478

### Elements Identified and Measured

Concentration: Low ✓ Medium ______

Matrix: Water ✓ Soil ______ Sludge ______ Other ______

[✓ ug/L] or mg/kg dry weight (Circle One)

| | | | | | |
|---|---|---|---|---|---|
| 1. | Aluminum | [89] P.R | 13. | Magnesium | [882] P. |
| | Antimony | 50 UP.R | 14. | Manganese | 15 UPR |
| 3. | Arsenic | 10 UFR | 15. | Mercury | 0.2U |
| | Barium | 50 UP. | 16. | Nickel | 20 UP. |
| 5. | Beryllium | 5 UP. | 17. | Potassium | [2654] P. |
| | Cadmium | 5 UP | 18. | Selenium | 5UF. |
| 7. | Calcium | 8544. P. | 19. | Silver | 10 P. |
| | Chromium | 10 UP. | 20. | Sodium | 9239 P. |
| 9. | Cobalt | 20 UP.R | 21. | Thallium | 10 UF. |
| 0. | Copper | 28 P. | 22. | Tin | 30 UFR |
| 11. | Iron | 166 P.R * | 23. | Vanadium | 20 UP. |
| 2. | Lead | 5UFR | 24. | Zinc | 50 P. * |

Cyanide 11.0

Percent Solids (%) ______

ootnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

omments: ______

Lab Manager ______

## Form I

U.S. EPA Contract Laboratory Program
Sample Management Office
P.O. Box 818 - Alexandria, VA 22313
703/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

EPA Sample No.
MCB 249

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

CASE NO. 4265

LAB NAME CHEMTECH CONSULTING GROUP

SOW NO. 784

QC REPORT NO. 478

LAB SAMPLE ID. NO. G2-478-11

### Elements Identified and Measured

Concentration: Low ✓ Medium ______

Matrix: Water ✓ Soil ______ Sludge ______ Other ______

[✓ ug/L] or mg/kg dry weight (Circle One)

| | | | | | |
|---|---|---|---|---|---|
| 1. | Aluminum | 245 P.R | 13. | Magnesium | 7179 P. |
| 2. | Antimony | 50 UPR | 14. | Manganese | 161 P.R |
| | Arsenic | 10 UFR | 15. | Mercury | 0.2U |
| 4. | Barium | 50 UP. | 16. | Nickel | 20 UP. |
| 5. | Beryllium | 5 UP. | 17. | Potassium | [3931] P. |
| 6. | Cadmium | 5 UP. | 18. | Selenium | 5UF. |
| 7. | Calcium | 9831 P. | 19. | Silver | 11 P. |
| 8. | Chromium | 12 P. | 20. | Sodium | 12950 P. |
| 9. | Cobalt | 20 UPR | 21. | Thallium | 10 UF. |
| 10. | Copper | 20 UP. | 22. | Tin | 30 UFR |
| 11. | Iron | 3971 P.R * | 23. | Vanadium | 20 UP. |
| 12. | Lead | 5 UFR | 24. | Zinc | 68 P. * |
| | Cyanide | 10 U | | Percent Solids (%) | |

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments: ______

Lab Manager ______

## Form I

**EPA Sample No.**
MCB. 311

U.S. EPA Contract Laboratory Program
Sample Management Office
P.O. Box 818 - Alexandria, VA 22313
703/557-2490 FTS: 8-557-2490

ORIGINAL
(Red)

Date 6-5-85

## INORGANIC ANALYSIS DATA SHEET

LAB NAME CHEMTECH CONSULTING GROUP

CASE NO. 4265

SOW NO. 784

LAB SAMPLE ID. NO. 62-478-01

QC REPORT NO. 478

### Elements Identified and Measured

Concentration: Low ✓ Medium ______

Matrix: Water ✓ Soil ______ Sludge ______ Other ______

[✓ ug/L] or mg/kg dry weight (Circle One)

| | | | | | |
|---|---|---|---|---|---|
| 1. | Aluminum | [159] P.R | 13. | Magnesium | 8340 P. |
| 2. | Antimony | 50 UP.R | 14. | Manganese | 358 P.R |
| 3. | Arsenic | 10 ~~UP~~. UFR | 15. | Mercury | NOT REQUESTED |
| 4. | Barium | 50 UP. | 16. | Nickel | 20 UP. |
| 5. | Beryllium | 5 UP. | 17. | Potassium | 5558 P. |
| 6. | Cadmium | 5 UP. | 18. | Selenium | 5 UF. |
| 7. | Calcium | 122300. P. | 19. | Silver | 10 UP. |
| 8. | Chromium | 10 UP. | 20. | Sodium | 21980 P. |
| 9. | Cobalt | 20 UP.R | 21. | Thallium | 10 UF. |
| 10. | Copper | 20 UP. | 22. | Tin | 30 UFR |
| 11. | Iron | 314 P.R * | 23. | Vanadium | 20 UP. |
| 12. | Lead | 5 UFR | 24. | Zinc | 139 P.* |

Cyanide NOT REQUESTED

Percent Solids (%) ______

**Footnotes:** For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

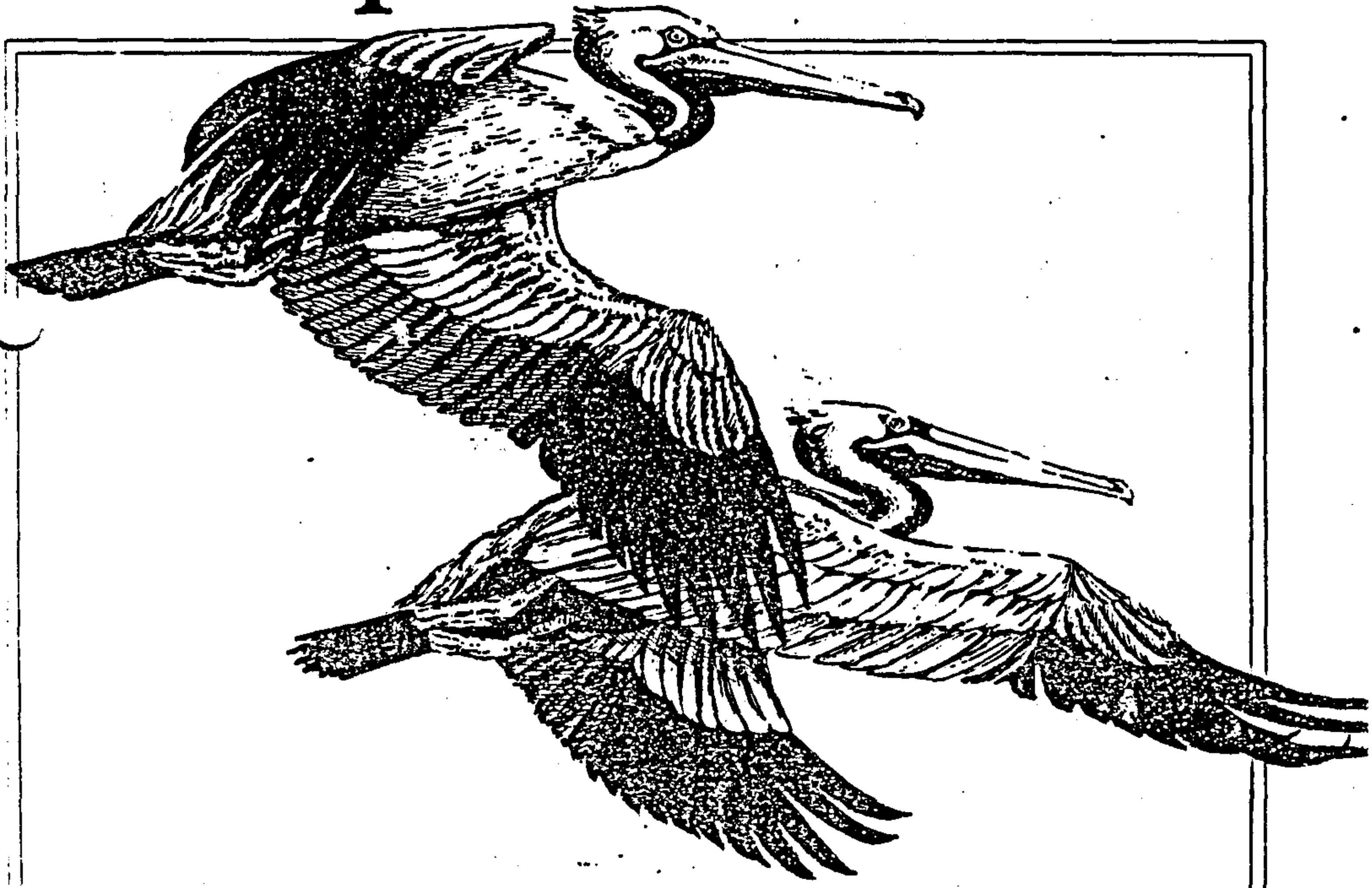
Comments:

Lab Manager

# APPENDIX K

# Virginia's Endangered Species

ORIGINAL
(Red)



Brown pelican, southern bald eagle, peregrine falcon, red-cockaded woodpecker, Bachman's warbler, gray bat, Indiana bat, Delmarva fox squirrel, eastern cougar, Atlantic ridely sea turtle, hawksbill sea turtle, leatherback sea turtle, loggerhead sea turtle, shortnose sturgeon, tan riffle shell mussel, Appalachin monkeyface pearly mussel, birdwing pearly mussel, Cumberland monkeyface pearly mussel, dromedary pearly mussel, fine rayed pigtoe pearly mussel, green blossom pearly mussel, rough pigtoe pearly mussel, and shiny pigtoe pearly mussel.

# OFFICIAL VIRGINIA ENDANGERED LIST
# VETERBRATES AND MOLLUSCS

ORIGINAL (Red)

| Species | Scientific Name | Status |
|---|---|---|
| **Birds:** | | |
| Brown Pelican | *(Pelecanus occidentalis)* | Casual transient |
| Southern bald eagle | *(Haliaeetus leucocephalus)* | Resident, coastal |
| Peregrine falcon | *(Falco peregrinus)* | Migrant transient |
| Red-cockaded woodpecker | *(Dendrocopus borealis)* | Resident-S.E. Virginia |
| Bachman's warbler | *(Vermivora bachmannii)* | Transient-N. Virginia |
| **Mammals:** | | |
| Gray bat | *(Myotis grisescens)* | Western Virginia |
| Indiana bat | *(Myotis sodalis)* | Doubtful, S.W. Virginia |
| Delmarva fox squirrel | *(Sciurus niger cinereus)* | Eastern Shore |
| Eastern cougar | *(Felis concolor cougar)* | Doubtful |
| **Reptiles:** | | |
| Atlantic ridely sea turtle | *(Lepidochelys kempie)* | Atlantic Coast |
| Hawksbill sea turtle | *(Eretmochelys imbricata)* | Atlantic Coast |
| Leatherback sea turtle | *(Dermochelys coriacea)* | Atlantic Coast |
| Loggerhead sea turtle | *(Caretta caretta)* | Atlantic Coast |
| **Fish:** | | |
| Shortnose sturgeon | *(Acipenser brevirostrum)* | Atlantic Coast |
| *Threatened:* | | |
| Yellowfin madtom | *(Noturus flavipinnis)* | S.W. Virginia |
| Spotfin chub | *(Hybopsis monacha)* | S.W. Virginia |
| **Molluscs:** | | |
| Tan riffle shell mussel | *(Epioblasma walkeri)* | Middle Fork, Holston River |
| Appalachian monkeyface pearly mussel | *(Quadrula sparsa)* | S.W. Virginia |
| Birdwing pearly mussel | *(Conradilla caelata)* | S.W. Virginia |
| Cumberland monkeyface pearly mussel | *(Quadrula intermedia)* | S.W. Virginia |
| Dromedary pearly mussel | *(Dromus dromas)* | S.W. Virginia |
| Fine rayed pigtoe pearly mussel | *(Fusconaia cuneolus)* | S.W. Virginia |
| Greenblossom pearly mussel | *(Epioblasma torulosa gubernaculum)* | S.W. Virginia |
| Rough pigtoe pearly mussel | *(Pleurobema plenum)* | S.W. Virginia |
| Shiny pigtoe pearly mussel | *(Fusconaia edgariana)* | S.W. Virginia |

## ENDANGERED SPECIES REFERENCES

Endangered and Threatened Wildlife of the Mid-South—North Carolina Agriculture Extension Service
Endangered Species Symposium—Virginia Polytechnic Institute and State University
Endangered Vertebrates of Virginia—Wayne Russ thesis—VPI&SU
The Red Cockaded Woodpecker—General Report SA-GR7 USDA
At The Crossroads—16 mm film
Endangered Species of the U.S—U.S. Fish and Wildlife Service— 80 slides & script
Endangered Species—How and Why?—U.S. Fish and Wildlife Service—80 slides & script

# Virginia's Endangered Species

Of the world's species known to have become extinct, more than two-thirds have disappeared during the twentieth century alone. Extinction of certain species is inevitable, as the process of natural selection opens up niches for some species while closing up the niches of species unable to compete or adapt; however, this process is usually a slow one and it is clear that more than natural causes are responsible for the rapid rise in extinction rates during this century. Recognizing this trend, and concerned over the threat it poses to the maintenance of natural diversity and a gene pool for future generations, a variety of groups concerned with the environment have promoted such concepts as habitat preservation, wilderness areas and the protection of endangered species. State and federal governments as well as the private sector have responded in a variety of ways. The Endangered Species Act of 1973 provides a program for the protection of species considered to be endangered or threatened with extinction. The act requires the listing of endangered and threatened species according to specified criteria, prohibits [illegible] "taking" of any listed species and encourages the preservation of their habitats.

The terms "endangered" and "threatened" are used rather loosely these days, sometimes for sensationalism and sometimes out of ignorance. A definition of terms is important and a group of experts meeting at Virginia Tech in 1978 agreed upon the following:

*Endangered*

A plant or animal whose prospects for survival are in immediate jeopardy; in danger of extirpation and/or extinction throughout all or a significant portion of its range in Virginia. Also includes those plants and animals on, or being considered for inclusion on, the *U.S. List of Endangered Fauna and Threatened Plant Species of the United States*, as provided under the Endangered Species Act of 1973. (Public Law 93-205).

*Threatened*

A plant or animal which is likely to become *endangered* within the foreseeable future throughout all or a significant portion, but not yet considered *endangered*. Also includes those plants and animals listed under the provisions of Public Law 93-205.

*Special Concern*

A plant or animal which should be continually monitored (a) because it exists in only one or a few small geographic areas and/or is rare (low population density) over a relatively broad range; (b) because its existence may become endangered due to the destruction, drastic modification, or severe curtailment of the habitat; (c) because certain characteristics or requirements make it especially vulnerable to specific pressures; or (d) because of other reasons identifiable by experienced researchers.

*Status Undetermined*

A plant or animal that has been suggested as possibly *threatened* or *endangered* but about which there is not enough data to accurately determine its status.

Recently Extinct or Extirpated

A plant or animal which recently occurred in Virginia, but which no longer exists in the state as determined by historical documents and/or knowledge of experts. ◻

ORIGINAL
(Red)

# The Red-cockaded Woodpecker

The red-cockaded woodpecker was once a common bird in the mature pine forests of the Southeast. It lived from east Texas to Florida and north to Missouri, Kentucky and Maryland. Today, its range and population have been reduced through loss of habitat.

This bird may soon become the victim of its own enigmatic way of life. Over-specialized to the extreme, it nests only in pines infected with a unique fungus disease. This affliction, red heart fungus (*Fomes pini*), decays the heartwood, but does not kill the tree, thus furnishing the woodpecker with ideal nesting sites and a plentiful food supply. Strangely, the bird cannot seem to adapt to other ecological conditions.

In preparing a cavity for nesting, the red-cockaded woodpecker flakes away the bark several feet above and below the cavity entrance. Perhaps the smoother surface makes it harder for snakes to reach the cavity. Scattered about the trunk near the cavity entrance, numerous small holes called resin wells are chipped through the bark. Resin flowing from these holes eventually coats the trunk with pitch. Birds regularly peck at sin wells to stimulate resin flow.

The red-cockaded's ideal tree must have enough heartwood to contain a roosting chamber. A chamber in sapwood would fill with resin. Heartwood is quite hard, but a high percentage of cavities is found in pines infected with a heart rot fungus called red heart. This fungus weakens the heartwood and makes cavity excavation easier. It often the kills the tree, to the dismay of foresters.

Much of the South has been cleared for agriculture or other uses incompatible with the needs of the red-cockaded, and the remaining pine forests are not suitable for it. Each year, more areas become unsuitable. Because of the drastic loss and continued decline of habitat, the bird is considered in danger of extinction.

In 1970, the red-cockaded was declared an endangered species. Mitchell Byrd, of the biology department of the College of William and Mary, has expressed serious concern over the chances for recovery of the red-cockaded woodpecker in Virginia, as habitat analyses reveal that only two to five percent of Virginia counties currently have timber of an age that would support colonies of the bird.

Since it was declared an endangered species, the red-cockaded has the same protection given the better-known bald eagle and whooping crane. But protection alone is not enough. On federal and state lands, forestry practices are giving the bird a better chance for survival by creating a on favorable habitat. Other landowners can take positive steps to their enhance its survival, especially if the red-cockaded already lives on their land. In cooperation with the Union Camp Corporation, a protected research site of about 200 acres has been established in Sussex County for the woodpecker. Dr. Byrd and his colleagues will then have ample time to study the foraging habits, nesting activities, and habitat requirements of the bird.

Among woodpeckers, the red-cockaded has an advanced social system. These birds live in a group called a clan. The clan may have from two to nine birds, but there is never more than one breeding pair. Young birds frequently stay with their parents for several months. The other adults are usually males called helpers.

Extensive surveys in Sussex, Surry, Isle of Wight, King George, Southampton, and Brunswick Counties as well as Virginia Beach and Suffolk Cities were conducted by Dr. Byrd and graduate students to determine the status of the red-cockaded woodpecker (*Picoides borealis*) in these areas. More than 40 sites with one or more cavity trees were located; however, many appeared inactive. Eight of 10 colony areas are active in Sussex County.

The red-cockaded is slightly larger than a bluebird. The back and top of the head are black. Numerous small, white spots arranged in horizontal rows on the back give a ladder-back appearance. The cheek is white. The chest is dull white with small black spots on the side. Males and females look alike, except males have a small red streak above the cheek, visible only with a powerful binocular in bright sunlight. □