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COMMONWEALTH of VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY
TIDEWATER REGIONAL OFFICE
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L. Preston Bryant, Jr.
Secretary of Natural Resources

David K. Paylor
Director

Francis L. Daniel
Regional Director

SOLID WASTE FACILITY PERMIT

PERMIT NUMBER 440

Facility Name: Chesapeake Energy Center

Facility Type: Industrial Landfill **Latitude:** N 36° 45' 48"

Site Location: Chesapeake, Virginia **Longitude:** W 76° 18' 10"

Location Description: The facility is located off Military Highway, along the Southern Branch of the Elizabeth River, Chesapeake, Virginia.

Background: The facility is to serve as an industrial landfill for the disposal of coal ash, in compliance with 9 VAC 20-80-10 et. seq. The rate at which the unit is being filled is 162,500 cubic yards per year. This number is based on a production rate of 800 tons per day (208,000 tons per year), with all units on line and an in-place ash density of 95 pounds per square foot.

Permit Highlights: The permit was amended by a major permit amendment on February 17, 1993, to allow an increase of the final elevation from 51 feet to 89 feet above mean sea level and an additional 222,000 cubic yards of air space. The permit was amended by a major amendment on April 16, 2002, to incorporate groundwater monitoring modules (Modules X and XI) and a groundwater monitoring plan (Permit Attachment X-1). The permit was amended by a minor amendment on August 12, 2002 for the replacement of monitoring well CECW-4. The permit was amended by a minor amendment on July 28, 2009 for the replacement of monitoring well CECW-6. The current amendment is for implementing the Corrective Action Plan and Groundwater Monitoring Plan Permit Module XIV

This permit includes permit modules and associated permit attachments that are, in general, based on information submitted in the permit application. The General Requirements are incorporated in Permit Module I, the Groundwater Corrective Action Plan and associated requirements are incorporated in Permit Module XIV.

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THIS IS TO CERTIFY THAT:

Virginia Electric and Power Company (d.b.a. Dominion Generation)
5000 Dominion Boulevard
Glen Allen, Virginia 23060

is hereby granted a permit to construct, operate, and maintain the facility as described in the attached Permit Modules I, II, X, XI, and XIV and associated permit attachments. These Permit Modules and Permit Attachments are as referenced hereinafter and are incorporated into and become a part of this permit.

The herein described activity is to be established, modified, constructed, installed, operated, used, maintained, and closed in accordance with the terms and conditions of this permit and the plans, specifications, and reports submitted and cited in the permit. The facility shall comply with all regulations of the Virginia Waste Management Board. In accordance with Chapter 14, Section 10.1 - 1408.1(D) of the Code of Virginia, prior to issuing this permit, any comments by the local government and general public have been investigated and evaluated and it has been determined that the proposed facility poses no substantial present or potential danger to human health or the environment. The permit contains such conditions and requirements as are deemed necessary to comply with the requirements of the Virginia Code, the regulations of the Board, and to prevent substantial or present danger to human health or the environment.

Failure to comply with the terms and conditions of this permit shall constitute grounds for the revocation or suspension of this permit and for the initiation of necessary enforcement actions.

The permit is issued in accordance with the provisions of Section 10.1-1408.1.A, Chapter 14, Title 10.1, Code of Virginia (1950) as amended.

Issued: July 27, 1984
Amendment 1: February 17, 1993 (Major)
Amendment 2: April 16, 2002 (Major)
Amendment 3: August 12, 2002 (Minor)
Amendment 4: July 28, 2009 (Minor)

APPROVED:

_____
Regional Director

DATE_____
Amended (Major)

PERMIT MODULES AND PERMIT ATTACHMENTS[1]

REFERENCE LIST

PERMIT MODULE I -- GENERAL PERMIT CONDITIONS

Permit Attachment I-1 - Variance for Omitting Organic Constituents

Permit Attachment I-2 - Variance for Using Alternate Concentration Limits (ACLs)

PERMIT MODULE X –Phase I Monitoring

Permit Attachment X-1 Groundwater Monitoring Plan

PERMIT MODULE XI –Phase II Monitoring

PERMIT MODULE XIV – CORRECTIVE ACTION

Permit Attachment XIV - 1 Corrective Action Plan (Including Surface Water Monitoring)

Permit Attachment XIV- 2 Corrective Action Groundwater Monitoring Plan

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NOTES:

1. Should information contained in an attachment(s) to any permit module, which consists of documents submitted by the permittee, conflict with any requirement or condition set forth by the Department in the permit modules or set forth in 9 VAC 20-80-10 et seq; the regulatory/permit module requirement or condition shall prevail (unless an appropriate variance has been granted).

2. The Department is not responsible for spelling, typographical, or syntax errors in modules based on information submitted by the Permittee.

3. As permit attachments are typically extracted from previously submitted information, they may contain references to calculations and other supporting data which may be omitted from the permit documents. All such information submitted in support of the application may be found in the Department's files.

PERMIT MODULE I
GENERAL PERMIT CONDITIONS

I.A. EFFECT OF PERMIT

The permittee is allowed to dispose of solid waste on-site in accordance with the conditions of this permit. Any disposal of solid waste not authorized by this permit is prohibited. Compliance with the terms of this permit does not constitute a defense to any order issued or any action brought under Sections 10.1-1402(18), 10.1-1402(19), or 10.1-1402(21) of the Virginia Waste Management Act (Chapter 14, Title 10.1-1400 through 1457, Code of Virginia (1950), as amended); or any other law or regulation for protection of public health or the environment. The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstances is held invalid, the application of such provision to other circumstances and the remainder of this permit shall not be affected thereby. For purposes of this permit, terms used herein shall have the same meaning as those in the Virginia Waste Management Act, and pertinent parts of the Virginia Solid Waste Management Regulations (9 VAC 20-80-10 et. seq.), unless this permit specifically provides otherwise; where terms are not defined in the regulations or the permit, the meaning associated with such terms shall be defined by the generally accepted scientific or industrial meaning of the term or a standard dictionary reference. "Director" means the Director of the Department of Environmental Quality, or his designated or authorized representative.

I.B. DUTIES AND REQUIREMENTS

The permittee shall comply with all conditions of this permit and 9 VAC 20-80-10 et. seq. The effect of this permit is detailed in 9 VAC 20-80-550, and it shall be the duty of the permittee to insure the applicable requirements are met. Additionally, the permittee is subject to the recording and reporting requirements detailed in 9 VAC 20-80-570. The facility is subject to a groundwater monitoring program per Permit Module X and XI and to a corrective action plan and monitoring plan per Permit Module XIV. In addition to these requirements, the following additional conditions are invoked per 9 VAC 20-80-490, and shall be complied with:

I.B.1. Noncompliance may be authorized by a schedule of compliance [subdivisions C and G of 9 VAC 20-80-550]. Any other permit noncompliance constitutes a violation of Virginia Waste Management Act and is grounds for enforcement action, or for permit revocation, revocation and re-issuance, or modification [9 VAC 20-80-600 and 9 VAC 20-80-620].

I.B.2. The permittee shall comply with the requirements of this permit. This permit may not act as a shield against compliance with any part of RCRA or any other applicable federal regulation, state regulation or state law.

I.B.3. In an enforcement action, it shall not be a defense for the permittee that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

I.B.4. In the event of noncompliance with this permit, the permittee shall take all reasonable steps to minimize releases of solid wastes or waste constituents to the environment and shall carry out measures to prevent significant adverse impacts on human health or the environment.

I.B.5. The permittee shall at all times properly operate and maintain all units (and related appurtenances) which are installed or used by the permittee to achieve compliance with the operations manual and the conditions of this permit. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing, and training, and adequate laboratory and process controls, including appropriate quality assurance/quality control procedures. This provision requires the operation of back-up or auxiliary equipment only when necessary to achieve compliance with the conditions of this permit.

I.B.6. The permittee shall furnish to the Director, within a reasonable time, any relevant information which the Director may request to determine compliance with the permit, regulations or the Act. The permittee shall also furnish to the Director, upon request, copies of records required to be kept by this permit by the date specified in the request.

I.B.7. The permittee shall allow the Director, or an authorized representative, upon the presentation of appropriate credentials, to:

I.B.7.a. Enter at reasonable times upon the permitted facility where a regulated unit or activity is located or conducted, or where records must be kept under the conditions of this permit;

I.B.7.b. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;

I.B.7.c. Inspect at reasonable times any unit, equipment

(including monitoring and control equipment), practices, or operations regulated or required under this permit; and

I.B.7.d. Sample or monitor, at reasonable times, for the purposes of assuring permit compliance or as otherwise authorized by Virginia Waste Management Act, any substances or parameters at any location within his control.

I.B.8. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity. The method used to obtain a representative sample to be analyzed must be the appropriate method from the latest edition of Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA Publication SW-846, as updated.

I.B.9. This permit is not transferable to any person, unless approved by the Director. The Director may require modification or revocation and re-issuance of the permit pursuant to subdivision F of 9 VAC 20-80-550. Before transferring ownership or operation of the facility during its operational life, the permittee shall notify the new owner or operator in writing of the requirements of 9 VAC 20-80-240 and 9 VAC 20-80-480 of the Virginia Solid Waste Management Regulations, the Financial Assurance Regulations (9 VAC 20-70-10 et. seq.) and this permit.

I.B.10 All facilities must have a Certified Operator as required by the Board of Waste Management Facility Operators-Licensing Regulations, 18 VAC 155-10 et. seq.

I.C. DOCUMENTS TO BE MAINTAINED AT THE FACILITY

The permittee shall maintain the following documents at the facility, or readily accessible to Department representatives, until post-closure is complete and certified by a professional engineer, and shall maintain amendments, revisions, and modification to these documents:

I.C.1. Design Plans.

I.C.2. Operations Manual.

I.C.3. Closure and Post-Closure Plan.

I.C.4. Groundwater Monitoring Plan.

I.C.5. Corrective Action Plan

I.C.6. Corrective Action Monitoring Plan

I.C.7. All other documents/records required and applicable from the following:

I.C.7.a. Monitoring records for leachate, gas, and groundwater.

I.C.7.b. Inspection records as required from construction / installation, operational, closure, post-closure inspection requirements.

I.C.7.c. Personnel training records.

I.C.7.d. Daily operational records (i.e., solid waste received and processed, fill area records, records of special wastes accepted, a logbook which is a daily narrative account of the activities at the landfill).

I.D. DOCUMENT SUBMITTALS

In addition to the documents/records/reports to be submitted per the requirements of 9 VAC 20-80-10 et. seq., and § 10.1-1410.2.B of the Code of Virginia, and those further described in this Permit, the permittee shall also submit to the Director, within the timeframes listed below the following regarding post-closure monitoring:

I.D.1 Not less than 180 days prior to the completion of the post-closure monitoring and maintenance period as prescribed by the Board's regulations or by the Director, the owner or operator shall submit to the Director a certificate, signed by a professional engineer licensed in the Commonwealth, that post-closure monitoring and maintenance have been completed in accordance with the facility's post-closure plan.

I.D.2 The certificate submitted under I.D.1, shall be accompanied by an evaluation, prepared by a professional engineer licensed in the Commonwealth, and signed by the owner or operator, which assesses and evaluates the landfill's potential for harm to human health and the environment in the event that post-closure monitoring and maintenance are discontinued.

I.D.3 If the Director determines that continued post-closure monitoring or maintenance is necessary to prevent harm to human health or the environment, he shall extend the post-closure period for such additional time as the Director deems necessary to protect human health and the environment and shall direct the owner or operator to submit a revised post-closure plan and to continue post-closure monitoring and maintenance in accordance therewith. Requirements for financial

assurance shall apply throughout such extended post-closure period.

I.E. REPORTS, NOTIFICATIONS, AND SUBMISSIONS TO THE DIRECTOR

All reports, notifications, or other submissions which are required by this permit to be sent or given to the Director should be sent by certified mail to:

Director
Virginia Department of Environmental Quality
Office of Solid Waste – 5th Floor
P.O. Box 1105
Richmond, VA 23218

Director
Tidewater Regional Office
Virginia Department of Environmental Quality
5636 Southern Blvd.
Virginia Beach, VA 23462

I.F. SITE SPECIFIC CONDITIONS

The provisions of this section are in addition to the permit conditions and regulatory requirements and are specifically developed for this facility. The permittee shall comply with all conditions of this section, as follows:

I.F.1. Activities authorized by this permit must comply with all requirements of 33 U.S.C. ' 1344 and regulations promulgated thereunder, as regards the filling of wetlands.

I.F.2. Prior to any new construction, the Erosion and Sediment Control Plan shall be approved by the local or state authority. This plan shall be implemented and maintained in accordance with the local and/or state regulations.

I.F.3. The permittee shall submit all necessary information required by the Virginia Department of Historic Resources for preview under Section 106 of the National Historic Preservation Act of 1966, as amended from time to time, so that potentially affected historic properties can be considered as the project is developed.

I.F.4. The landfill operators must be certified in accordance with the Board of Waste Management Facility Operators Rules and Regulations, Title 54.1, Chapter 22.1, latest publication.

I.G. MAJOR PERMIT AMENDMENTS

A major permit amendment was issued on February 17, 1993 for vertical expansion of the landfill.

A major permit amendment was issued on April 16, 2002 to establish groundwater protection standards and to incorporate a groundwater monitoring plan.

I.H. MINOR PERMIT AMENDMENTS

A minor permit amendment was approved on August 12, 2002 to replace monitoring well CECW-4.

A minor permit amendment was approved on July 28, 2009 to replace monitoring well CECW-6 and update the groundwater monitoring plan.

PERMIT ATTACHMENT I-1

Variance for Omitting Organic Constituents

Variance to the Virginia Solid Waste Management Regulations
Elimination of Organic Constituents from Semi-Annual Sampling

Virginia Power and Electric Company
Chesapeake Energy Center Industrial Landfill, Permit No. 440

In response to a Petition for Variance, submitted by Virginia Power and Electric Company (VEPCO), the Department hereby approves a variance from the Virginia Solid Waste Management Regulations (VSWMR), 9 VAC 20-80, Appendix 5.6 for the VEPCO Chesapeake Energy Center Industrial Landfill, Permit No. 440. The variance is for the elimination of organic Appendix 5.5 constituents from the semi-annual sampling program. The variance specifies the following requirements, as long as the facility is in Phase II monitoring:

- The facility shall sample semi-annually for Appendix 5.5 inorganic constituents, as well as any additionally detected Appendix 5.1 inorganic constituents.
- The facility shall sample for the entire list of Appendix 5.1 constituents (organic and inorganic) every two years. Any additional Appendix 5.1 constituents (organic and inorganic) detected (not quantified) shall be added to the semi-annual monitoring list.

If any of the conditions outlined above are violated in any form or manner, the variance will be withdrawn.

APPROVED: Leslie A Romanchik for Director DATE: 1/31/02

PERMIT ATTACHMENT I-2

Variance for Using Alternate Concentration Limits (ACLs)

Variance to the Virginia Solid Waste Management Regulations
Use of Alternate Concentration Limits as Groundwater Protection Standards

In response to a Petition for Variance, submitted by Dominion Generation for the Chesapeake Energy Center Industrial landfill, Permit 440, as allowed under 9 VAC 20-80-760.A, the Department hereby grants approval to a Variance from Virginia Solid Waste Management Regulations [9 VAC 20-80-300.C.4] limited to the conditions outlined below:

1] The Variance approval is for the use of Alternate Concentration Limits (ACLs) as groundwater protection standards for the 160 constituents listed below which lack background data, or a USEPA Maximum Concentration Level (MCL):

1) Acenaphthene, 2) Acenaphthylene, 3) Acetone, 4) Acetonitrile / Methyl cyanide, 5) Acetophenone, 6) 2-Acetylaminofluorene / 2-AAF, 7) Acrolein, 8) Acrylonitrile, 9) Aldrin, 10) Allyl chloride 11) 4-Aminobiphenyl, 12) Anthracene, 13) Benzo[a]anthracene, 14) Benzo[b]fluoranthene 15) Benzo[k]flouranthene, 16) Benzo[ghi]perylene, 17) Benzyl alcohol, 18) BHC-alpha 19) BHC-beta, 20) BHC-delta, 21) Bis(2-chlorethoxy)methane, 22) Bis(2-chloroethyl)ether / Dichloroethyl ether, 23) Bis(2-chloro-1-methylethyl)ether / 2,2-Dichlorodiisopropyl ether, 24) Bis(2-ethylhexyl)phthalate, 25) Bromochloromethane / Chlorobromomethane, 26) 4-Bromophenyl phenyl ether 27) Butyl benzl phthalate / Benzyl butyl phthalate, 28) Carbon disulfide, 29) p-Chloroaniline / 4-Chloroaniline, 30) Chlorobenzilate, 31) p-Chloro-m-cresol / 4-Chloro-3-methylphenol, 32) Chloroethane / Ethyl chloride, 33) 2-Chloronaphthalene, 34) 2-Chlorophenol, 35) 4-Chlorophenyl phenyl ether, 36) Chloroprene, 37) Chrysene, 38) Cobalt, 39) Copper, 40) m-Cresol / 3-Methylphenol, 41) o-Cresol / 2-Methylphenol, 42) p-Cresol / 4-Methylphenol, 43) 4, 4-DDD, 44) 4,4-DDE, 45) 4,4-DDT, 46) Diallate, 47) Dibenz[a,h]anthracene, 48) Dibenzofuran, 49) Di-n-butyl phthalate, 50) m-Dichlorobenzene / 1,3-Dichlorobenzene, 51) 3,3-Dichlorobenzidine, 52) Trans-1,4-Dichloro-2-butene, 53) Dichlorodifluoromethane / CFC-12, 54) 1,1-Dichloroethane / Ethylidene chloride, 55) 2,4-Dichlorophenol, 56) 2,6-Dichlorophenol, 57) 1,3-Dichloropropane / Trimethylene dichloride, 58) 2,2-Dichloropropane / Isopropylidene chloride 59) 1,1-Dichloropropene, 60) Cis-1,3-Dichloropropene, 61) Trans-1,3-Dichloropropene, 62) Dieldrin, 63) Diethyl phthalate, 64) 0,0-Diethyl 0-2-pyrazinyl phosphorothioate / Thionazin, 65) Dimethoate, 66) p-(Dimethylamino)azobenzene / Azobenzene, 67) 7,12-Dimethylbenzidine[a]anthracene, 68) 3,3-Dimethylbenzidine, 69) 2,4-Dimethylphenol / m-Xyenol, 70) Dimethyl phthalate, 71) m-Dinitrobenzene, 72) 4,6-Dinitro-o-cresol / 4,6-Dinitro-2-methylphenol, 73) 2,4-Dinitrophenol, 74) 2,4-Dinitrotoluene, 75) 2,6-Dinitrotoluene, 76) Di-n-octyl phthalate, 77) Diphenylamine, 78) Disulfoton, 79) Endosulfan I, 80) Endosulfan II, 81) Endosulfan sulfate, 82) Endrin aldehyde, 83) Ethyl methacrylate, 84) Ethyl methanesulfonate, 85) Famphur, 86) Flouranthene, 87) Fluorene, 88) Hexachlorobutadiene, 89) Hexachloroethane, 90) Hexachloropropene, 91) 2-Hexanone / Methyl butyl ketone, 92) Isobutyl alcohol / Isobutanol, 93) Isodrin, 94) Isophrone, 95) Isosafrole, 96) Kepone, 97) Lead, 98) Methacrylonitrile, 99) Methapyrilene, 100) Methyl bromide / Bromomethane, 101) Methyl Chloride / Chloromethane, 102) 3-Methylcholanthrene, 103) Methyl Ethyl Ketone / MEK / 2-Butanone, 104) Methyl iodide / Iodomethane, 105) Methyl methacrylate, 106) Methyl methanesulfonate, 107) 2 Methylnaphthalene, 108) Methyl parathion / Parathion methyl, 109) 4-Methyl-2-pentanone / Methyl isobutyl ketone, 110) Methylene bromide, 111) Naphthalene 112) 1,4-Naphthoquinone, 113) 1-Naphthylamine, 114) 2-Naphthylamine, 115) Nickel 116) o-Nitroaniline / 2-Nitroaniline, 117) m-Nitroaniline / 3-Nitroaniline, 118) p-Nitroaniline / 4-Nitroaniline, 119) Nitrobenzene, 120) o-Nitrophenol / 2-Nitrophenol, 121) p-Nitrophenol / 4-Nitrophenol, 122) N-Nitrosodi-n-butylamine, 123) N-Nitrosodiethylamine, 124) N-Nitrosodimethylamine, 125) N-Nitrosodiphenylamine, 126) N-Nitrosodipropylamine / Di-n-propylnitrosamine, 127) N-Nitrosomethylethylamine, 128) N-Nitrosopiperidine, 129) N-Nitrosopyrrolidine, 130) 5-Nitro-o-toludidine, 131) Parathion, 132) Pentachlorobenzene, 133) Pentachloronitobenzene, 134) Phenacetin, 135) Phenanthrene, 136) Phenol, 137) p-Phenylenediamine, 138) Phorate, 139) Pronamide, 140) Propionitrile / Ethyl cyanide, 141) Pyrene, 142) Safrole, 143) Silver, 144) Sulfide, 145) 1,2,4,5-Tetrachlorobenzene, 146) 1,1,1,2-Tetrachloroethane, 147) 1,1,2,2-Tetrachloroethane, 148) 2,3,4,6-Tetrachlorophenol, 149) Tin, 150) o-Toluidine / 2-Methylaniline, 151) Trichlorofluoromethane / CFC-11, 152) 2,4,5-Trichlorophenol, 153) 2,4,6-Trichlorophenol, 154) 2,4,5-Trichloro-phenoxyacetic acid, 155) 1,2,3-Trichloropropane, 156) O,O,O-Triethyl phosphorothioate, 157) (syn) 1,3,5-Trinitrobenzene, 158) Vanadium, 159) Vinyl acetate, 160) Zinc

2] Establishment of an ACL for use as groundwater protection standards for any constituent not listed above will require the submittal and review of a separate Variance Petition.

3] If a Maximum Contaminant Level (MCL) is promulgated under Section 1412 of the Safe Drinking Water Act (Part 141, Title 40, Code of Federal Regulations) for any of the constituents listed above, the newly promulgated MCL will supercede the ACL as the groundwater protection standard, and Variance approval for the use of the ACL shall be withdrawn.

4] For those constituents listed above, when REAMS-based ACL concentration values change as a result of modifications to the toxicity or health risk data used by USEPA, the revised ACL concentration value shall immediately replace the outdated concentration value and the Permittee will not be required to go through the Variance process before implementing the revised value. However, nothing within this Variance shall restrict the Permittee from filing a Variance for use of revised ACL concentration values if he/she so chooses.

5] Updated REAMS-based ACL values will be released twice a year by the Department on June 30th and December 30th of each calendar year and it will be the responsibility of the facility to check for the most recent updates and incorporate any revised ACL values when performing comparisons against GPS.

6] For those constituents listed above that have an ACL concentration value of zero, or have an ACL concentration value which is lower than the laboratory's Limit of Quantitation (LOQ), the LOQ shall act as the groundwater protection standard (GPS) for the purposes of performing statistical comparisons, only.

APPROVAL

- The Director hereby grants authorization to the Petitioner to use the above-listed ACL's as groundwater protection standards (GPS) at the Chesapeake Energy Center Industrial Landfill.
- If any of the conditions outlined above are violated in any form or manner, the Director's approval of this Variance shall be immediately withdrawn.

APPROVED: Debra A. Miller

Debra A. Miller, Director
Office of Solid Waste

DATE: 5/10/2007

Table XI - 1
Groundwater Protection Standards with ACL's
Facility Name: Chesapeake Energy Center Industrial Landfill

Constituent (CAS RN)		Concentration		Source
Acenaphthene	83-32-9	134	µg/l	ACL
Acenaphthylene	208-96-8	(0)*	µg/l	ACL
Acetone	67-64-1	2012	µg/l	ACL
Acetonitrile	75-05-8	38	µg/l	ACL
Acetophenone	98-86-2	224	µg/l	ACL
2-Acetylaminofluorene / 2-AAF	53-96-3	(0)*	µg/l	ACL
Acrolein	107-02-8	0.015	µg/l	ACL
Acrylonitrile	107-13-1	0.037	µg/l	ACL
Aldrin	309-00-2	0.004	µg/l	ACL
Allyl chloride	107-05-1	4.54	µg/l	ACL
4-Aminobiphenyl	92-67-1	(0)*	µg/l	ACL
Anthracene	120-12-7	671	µg/l	ACL
Antimony	[illegible]	[illegible]	µg/l	MCL
Arsenic	[illegible]	[illegible]	µg/l	MCL
Barium	[illegible]	[illegible]	µg/l	MCL
Benzene	[illegible]	[illegible]	µg/l	MCL
Benzo[a]anthracene	56-55-3	0.092	µg/l	ACL
Benzo[b]fluoranthene	205-99-2	0.092	µg/l	ACL
Benzo[k]fluoranthene	207-08-9	0.917	µg/l	ACL
Benzo[ghi]perylene	191-24-2	(0)*	µg/l	ACL
Benzo[a]pyrene	50-32-8	[illegible]	µg/l	MCL
Benzyl alcohol	100-51-6	4,695	µg/l	ACL
Beryllium	[illegible]	[illegible]	µg/l	MCL
BHC-alpha	319-84-6	0.011	µg/l	ACL
BHC-beta	319-85-7	0.037	µg/l	ACL
BHC-delta	319-86-8	(0)*	µg/l	ACL
BHC-gamma (Lindane)	58-89-9	[illegible]	µg/l	MCL
Bis(2-chloroethoxy)methane	111-91-1	47	µg/l	ACL
Bis(2-chloroethyl)ether / Dichloroethyl ether	111-44-4	0.009	µg/l	ACL
Bis(2-chloro-1-methylethyl)ether / 2,2-Dichlorodiisopropyl ether	108-60-1	0.26	µg/l	ACL
Bis(2-ethylhexyl)phthalate	[illegible]	[illegible]	µg/l	MCL
Bromochloromethane / Chlorobromomethane	74-97-5	(0)*	µg/l	ACL
Bromodichloromethane	75-27-4	[illegible]	µg/l	MCL
Bromoform	75-25-2			
Chloroform	67-66-3			
Dibromochloromethane	124-48-1			
Trihalomethane group	[illegible]			
Bromoform / Tribromomethane				
4-Bromophenyl phenyl ether	101-55-3	(0)*	µg/l	ACL
Butyl benzyl phthalate / Benzyl butyl phthalate	85-68-7	3130	µg/l	ACL
Cadmium	[illegible]	[illegible]	µg/l	MCL
Carbon disulfide	75-15-0	391	µg/l	ACL
Carbon tetrachloride	56-23-5	[illegible]	µg/l	MCL
Chlordane	[illegible]	[illegible]	µg/l	MCL
p-Chloroaniline / 4-Chloroaniline	106-47-8	62.6	µg/l	ACL
Chlorobenzene	108-90-7	100	µg/l	MCL
Chlorobenzilate	510-15-6	0.248	µg/l	ACL
p-Chloro-m-cresol / 4-Chloro-3-methylphenol	59-50-7	10,955	µg/l	ACL
Chloroethane / Ethyl chloride	75-00-3	3.638	µg/l	ACL
Chloroform / Trichloromethane				
2-Chloronaphthalene	91-58-7	179	µg/l	ACL
2-Chlorophenol	95-57-8	11.2	µg/l	ACL
4-Chlorophenyl phenyl ether	7005-72-3	(0)*	µg/l	ACL

Chloroprene	126-99-8	5.13	µg/l	ACL
Chromium	[illegible]	100	µg/l	MCL
Chrysene	218-01-9	9.17	µg/l	ACL
Cobalt	---	156.5	µg/l	ACL
Copper	---	626	µg/l	ACL
m-Cresol / 3-Methylphenol	108-39-4	783	µg/l	ACL
o-Cresol / 2-Methylphenol	95-48-7	783	µg/l	ACL
p-Cresol / 4-Methylphenol	106-44-5	78.3	µg/l	ACL
Cyanide	57-12-5	200	µg/l	MCL
2,4-D / 2,4-Dichlorophenoxyacetic acid	94-75-7	70	µg/l	MCL
4, 4-DDD	72-54-8	0.279	µg/l	ACL
4,4-DDE	72-55-9	0.197	µg/l	ACL
4,4-DDT	50-29-3	0.197	µg/l	ACL
Diallate	2303-16-4	0.173	µg/l	ACL
Dibenz[a,h]anthracene	53-70-3	0.009	µg/l	ACL
Dibenzofuran	132-64-9	(0)*	µg/l	ACL
Dibromochloromethane / Chlorodibromomethane		[illegible]	[illegible]	[illegible]
1,2-Dibromo-3-chloropropane / DBCP	96-12-8	0.2	µg/l	MCL
1,2-Dibromoethane / Ethylene dibromide	106-93-4	0.05	µg/l	MCL
Di-n-butyl phthalate	84-74-2	1,565	µg/l	ACL
Di-n-octyl phthalate	117-84-0	313	µg/l	ACL
o-Dichlorobenzene / 1,2-Dichlorobenzene	95-50-1	600	µg/l	MCL
m-Dichlorobenzene / 1,3-Dichlorobenzene	541-73-1	6.71	µg/l	ACL
p-Dichlorobenzene / 1,4-Dichlorobenzene	106-46-7	75	µg/l	MCL
3,3-Dichlorobenzidine	91-94-1	0.149	µg/l	ACL
Trans-1,4-Dichloro-2-butene	110-57-6	(0)*	µg/l	ACL
Dichlorodifluoromethane / CFC-12	75-71-8	125.2	µg/l	ACL
1,1-Dichloroethane / Ethylidene chloride	75-34-3	327	µg/l	ACL
1,2-Dichloroethane / Ethylene dichloride	107-06-2	5	µg/l	MCL
1,1-Dichloroethylene / 1,1-Dichloroethene	75-35-4	7	µg/l	MCL
Cis-1,2-Dichloroethylene / Cis-1,2-Dichloroethene	156-59-2	70	µg/l	MCL
Trans-1,2-Dichloroethylene / Trans-1,2-Dichloroethene	156-60-5	100	µg/l	MCL
2,4-Dichlorophenol	120-83-2	47	µg/l	ACL
2,6-Dichlorophenol	87-65-0	(0)*	µg/l	ACL
1,2-Dichloropropane / Propylene dichloride	78-87-5	5	µg/l	MCL
1,3-Dichloropropane / Trimethylene dichloride	142-28-9	44.7	µg/l	ACL
2,2-Dichloropropane / Isopropylidene chloride	594-20-7	(0)*	µg/l	ACL
1,1-Dichloropropene	563-58-6	(0)*	µg/l	ACL
Cis-1,3-Dichloropropene	10061-01-5	(0)*	µg/l	ACL
Trans-1,3-Dichloropropene	10061-02-6	(0)*	µg/l	ACL
Dieldrin	60-57-1	0.004	µg/l	ACL
Diethyl phthalate	84-66-2	12,520	µg/l	ACL
0,0-Diethyl 0-2-pyrazinyl phosphorothioate / Thionazin	297-97-2	(0)*	µg/l	ACL
Dimethoate	60-51-5	3.13	µg/l	ACL
p-(Dimethylamino)azobenzene / Azobenzene	60-11-7	(0)*	µg/l	ACL
7,12-Dimethylbenz [a] anthracene	57-97-6	0.0003	µg/l	ACL
3,3-Dimethylbenzidine	119-93-7	(0)*	µg/l	ACL
2,4-Dimethylphenol / m-Xyenol	105-67-9	313	µg/l	ACL
Dimethyl phthalate	131-11-3	(0)*	µg/l	ACL
m-Dinitrobenzene	99-65-0	1.565	µg/l	ACL

4,6-Dinitro-o-cresol / 4,6-Dinitro-2-methylphenol	534-52-1	1.565	µg/l	ACL
2,4-Dinitrophenol	51-28-5	31.3	µg/l	ACL
2,4-Dinitrotoluene	121-14-2	31.3	µg/l	ACL
2,6-Dinitrotoluene	606-20-2	15.65	µg/l	ACL
2-sec-Butyl-4,6-dinitrophenol / Dinoseb	88-85-7	[illegible]	µg/l	MCL
Diphenylamine	122-39-4	391	µg/l	ACL
Disulfoton	298-04-4	0.63	µg/l	ACL
Endosulfan I	959-96-8	93.9	µg/l	ACL
Endosulfan II	33213-65-9	(0)*	µg/l	ACL
Endosulfan sulfate	1031-07-8	(0)*	µg/l	ACL
Endrin	72-20-8	[illegible]	µg/l	MCL
Endrin aldehyde	7421-93-4	(0)*	µg/l	ACL
Ethylbenzene	100-41-4	3,700	µg/l	MCL
Ethyl methacrylate	97-63-2	201	µg/l	ACL
Ethyl methanesulfonate	62-50-0	(0)*	µg/l	ACL
Famphur	52-85-7	(0)*	µg/l	ACL
Fluoranthene	206-44-0	626	µg/l	ACL
Fluorene	86-73-7	89.4	µg/l	ACL
Heptachlor	76-44-8	[illegible]	µg/l	MCL
Heptachlor epoxide	1024-57-3	[illegible]	µg/l	MCL
Hexachlorobenzene	118-74-1	[illegible]	µg/l	MCL
Hexachlorobutadiene	87-68-3	0.86	µg/l	ACL
Hexachlorocyclopentadiene	77-47-4	50	µg/l	MCL
Hexachloroethane	67-72-1	4.784	µg/l	ACL
Hexachloropropene	1888-71-7	(0)*	µg/l	ACL
2-Hexanone / Methyl butyl ketone	591-78-6	1120	µg/l	ACL
Indeno [1,2,3-cd] pyrene	193-39-5	0.092	µg/l	ACL
Isobutyl alcohol / Isobutanol	78-83-1	671	µg/l	ACL
Isodrin	465-73-6	(0)*	µg/l	ACL
Isophorone	78-59-1	70.5	µg/l	ACL
Isosafrole	120-58-1	(0)*	µg/l	ACL
Kepone	143-50-0	7.83	µg/l	ACL
[illegible]	[illegible]	[illegible]	[illegible]	MCL
Mercury (inorganic)	[illegible]	[illegible]	µg/l	MCL
Methacrylonitrile	126-98-7	0.39	µg/l	ACL
Methapyrilene	91-80-5	(0)*	µg/l	ACL
Methoxychlor	72-43-5	[illegible]	µg/l	MCL
Methyl Bromide / Bromomethane	74-83-9	3.13	µg/l	ACL
Methyl Chloride / Chloromethane	74-87-3	58.1	µg/l	ACL
3-Methylcholanthrene	56-49-5	0.003	µg/l	ACL
Methylene bromide	74-95-3	22.36	µg/l	ACL
Methylene chloride	**75-09-2**	**5**	**µg/l**	**MCL**
Methyl Ethyl Ketone / MEK / 2-Butanone	78-93-3	2,630	µg/l	ACL
Methyl iodide / Iodomethane	74-88-4	(0)*	µg/l	ACL
Methyl methacrylate	80-62-6	510	µg/l	ACL
Methyl methanesulfonate	66-27-3	(0)*	µg/l	ACL
2 Methylnaphthalene	91-57-6	8.94	µg/l	ACL
Methyl parathion / Parathion methyl	298-00-0	3.91	µg/l	ACL
4-Methyl-2-pentanone / Methyl isobutyl ketone	108-10-1	1,923	µg/l	ACL
Naphthalene	91-20-3	2.33	µg/l	ACL
1,4-Naphthoquinone	130-15-4	(0)*	µg/l	ACL
1-Naphthylamine	134-32-7	(0)*	µg/l	ACL
2-Naphthylamine	91-59-8	0.037	µg/l	ACL
Nickel	---	313	µg/l	ACL
o-Nitroaniline / 2-Nitroaniline	88-74-4	(0)*	µg/l	ACL
m-Nitroaniline / 3-Nitroaniline	99-09-2	3.35	µg/l	ACL
p-Nitroaniline / 4-Nitroaniline	100-01-6	3.35	µg/l	ACL
Nitrobenzene	98-95-3	1.30	µg/l	ACL
o-Nitrophenol / 2-Nitrophenol	88-75-5	(0)*	µg/l	ACL

p-Nitrophenol / 4-Nitrophenol	100-02-7	(0)*	µg/l	ACL
N-Nitrosodi-n-butylamine	924-16-3	0.002	µg/l	ACL
N-Nitrosodiethylamine	55-18-5	0.0004	µg/l	ACL
N-Nitrosodimethylamine	62-75-9	0.0013	µg/l	ACL
N-Nitrosodiphenylamine	86-30-6	13.7	µg/l	ACL
N-Nitrosodipropylamine / Di-n-propylnitrosamine	621-64-7	0.01	µg/l	ACL
N-Nitrosomethylethylamine	10595-95-6	0.003	µg/l	ACL
N-Nitrosopiperidine	100-75-4	0.01	µg/l	ACL
N-Nitrosopyrrolidine	930-55-2	0.03	µg/l	ACL
5-Nitro-o-toluidine	99-55-8	2.03	µg/l	ACL
Parathion	56-38-2	93.9	µg/l	ACL
Polychlorinated biphenyls (PCBs)	[illegible]	0.5	µg/l	MCL
Pentachlorobenzene	608-93-5	12.5	µg/l	ACL
Pentachloronitrobenzene	82-68-8	0.26	µg/l	ACL
Pentachlorophenol	87-86-5	[illegible]	µg/l	MCL
Phenacetin	62-44-2	30.4	µg/l	ACL
Phenanthrene	85-01-8	(0)*	µg/l	ACL
Phenol	108-95-2	4,695	µg/l	ACL
p-Phenylenediamine	106-50-3	2,973	µg/l	ACL
Phorate	298-02-2	(0)*	µg/l	ACL
Pronamide	23950-58-5	1,173	µg/l	ACL
Propionitrile / Ethyl cyanide	107-12-0	(0)*	µg/l	ACL
Pyrene	129-00-0	67.1	µg/l	ACL
Safrole	94-59-7	0.304	µg/l	ACL
Selenium	[illegible]	50	µg/l	MCL
Silver	---	78.3	µg/l	ACL
Silvex (2,4,5-TP)	93-72-1	50	µg/l	MCL
Styrene	100-42-5	100	µg/l	MCL
Sulfide	18496-25-8	(0)*	µg/l	ACL
1,2,4,5-Tetrachlorobenzene	95-94-3	4.69	µg/l	ACL
1,1,1,2-Tetrachloroethane	630-20-6	0.406	µg/l	ACL
1,1,2,2-Tetrachloroethane	79-34-5	0.053	µg/l	ACL
Tetrachloroethylene / PCE	127-18-4	[illegible]	µg/l	MCL
2,3,4,6-Tetrachlorophenol	58-90-2	470	µg/l	ACL
Thallium	[illegible]	[illegible]	µg/l	MCL
Tin	---	9,390	µg/l	ACL
Toluene	108-88-3	1,000	µg/l	MCL
o-Toluidine / 2-Methylaniline	95-53-4	0.28	µg/l	ACL
Toxaphene	N/E	[illegible]	µg/l	MCL
1,2,4-Trichlorobenzene	120-82-1	70	µg/l	MCL
1,1,1-Trichloroethane / Methylchloroform	71-55-6	200	µg/l	MCL
1,1,2-Trichloroethane	79-00-5	5	µg/l	MCL
Trichloroethylene / Trichloroethene	79-01-6	5	µg/l	MCL
Trichlorofluoromethane / CFC-11	75-69-4	470	µg/l	ACL
2,4,5-Trichlorophenol	95-95-4	1,565	µg/l	ACL
2,4,6-Trichlorophenol	88-06-2	6.09	µg/l	ACL
2,4,5-Trichloro-phenoxyacetic acid	93-76-5	157	µg/l	ACL
1,2,3-Trichloropropane	96-18-4	0.005	µg/l	ACL
O,O,O-Triethyl phosphorothioate	126-68-1	(0)*	µg/l	ACL
1,3,5-Trinitrobenzene	99-35-4	470	µg/l	ACL
Vanadium	---	1137	µg/l	BKG
Vinyl acetate	108-05-4	148	µg/l	ACL
Vinyl chloride / Chloroethene	75-01-4	2	µg/l	MCL
Xylene (total)	N/E	10,000	µg/l	MCL
Zinc	---	4,695	µg/l	ACL

End Notes
MCL >USEPA Maximum Contaminant Level, represents Federal standards set for drinking water under the Safe Drinking Water Act.
MCL[a] > USEPA MCL "action level" (non-risk based), used as ACL for Lead.
If a revised MCL is promulgated by EPA for any constituent on this listing, the new MCL shall immediately be adopted as the groundwater protection standard.
ACL > Alternate Concentration Limits (risk-based). In those cases where the ACL value listed in this table is found to be less than the laboratory Limit of Quantitation (LOQ) for the constituent, the LOQ shall serve as the "ACL" for statistical comparison purposes.
For facilities which obtained an approved state-wide ACL variance in 2007, or an initial Variance in 2007; when REAMS-based ACL's are revised in the future based on new EPA toxicity and/or health risk criteria, those ACL's shall immediately be adopted for use as the groundwater protection standard (GPS). The facility shall check for ACL updates at least twice a year on June 30th and December 31st of each calendar year.
For facilities which desire to use non REAMS-based ACL values, the use of those ACL's as GPS must be approved via the Variance procedure outlined in the VSWMR.
BKG > Site specific background concentration data, as approved by DEQ.
µg/l > micrograms per liter (parts per billion).
(0)* > Indicates those constituents which have no established ACL. In cases such as these, the laboratory Limit of Quantitation (LOQ) for the constituent shall serve as the "ACL" for statistical comparison purposes.
CAS RN > Chemical Abstracts Service Registry Number.
Shaded Rows (if any) denote those groundwater constituents for which Groundwater Protection Standards are set as MCL's.
The MCL for the Trihalomethane group is a cumulative number of 80 ppb, for one, two, or all of the constituents.

A GPS exceedance is triggered for a sampling event when there is a statistical exceedance of:	1) an MCL	2) an ACL	3) site specific background	4) the lab LOQ, when MCL, BKG, or ACL is unavailable

PERMIT MODULE X

PHASE I MONITORING

PERMIT MODULE – X

PHASE 1 MONITORING
9 VAC 20-80-300.A and C.3

Phase 1 monitoring is designed to ensure the earliest possible recognition of a leachate release from a regulated solid waste management unit (SWMU).

X.A. GROUNDWATER COMPLIANCE POINT

X.A.1 Uppermost Aquifer

The compliance point for groundwater monitoring is the uppermost aquifer on site [9 VAC 20-80-300.A.2.a]. The uppermost aquifer encompasses the entire thickness between the first encounter with groundwater (not to include any perched water) and the first encounter with a confining unit forming the lower boundary of the uppermost aquifer [9 VAC 20-80-300.A.3.f.(1).(b)].

X.A.2 Monitoring Well Locations

All wells in the monitoring network shall be installed within the permitted facility boundary [9 VAC 20-80-770.A], screened within the uppermost aquifer, and located at, or as close as practical to, the SWMU boundary [9 VAC 20-80-300.A.3.a] unless a variance meeting the requirements of 9 VAC 20-80-770.B has been granted. No monitoring well serving the function defined under 9 VAC 20-80-300.A.3.a can be located more than 500 feet away from the SWMU boundary [9 VAC 20-80-770.A].

X.B. MONITORING NETWORK REQUIREMENTS

X.B.1 Performance Standards

X.B.1.a The Permittee shall install a groundwater monitoring network that meets the requirements of 9 VAC 20-80-300.A.2 and A.3.

X.B.1.b All wells utilized in the monitoring network shall at a minimum meet the requirements of 9 VAC 20-80-300.A.3.c and f.(1).

X.B.1.c Any wells that require abandonment shall be sealed and abandoned in accordance with existing EPA Resource Conservation and Recovery Act guidance as well as any applicable state or local requirements.

X.B.1.d If any wells require replacement due to non-performance, the Permittee shall:

X.B.1.e.(1) Within 30 days of recognizing the non-performance, notify the Department of the need to replace the non-performing well. Within that notification, provide for Department review [9 VAC 20-80-570.C.1], the proposed location for the new well shown on a site plan.

X.B.1.e.(2) Install the replacement well, prior to the next regularly scheduled groundwater sampling event unless the Director has granted an extension to meeting the monitoring system compliance requirements under 9 VAC 20-80-300.A.3.a.

X.B.2 Operations and Maintenance

The Permittee shall operate and maintain all wells in the monitoring network in a manner meeting the requirements of 9 VAC 20-80-300.A.3.e.

X.B.3 Well Designations

At a minimum, the monitoring network installed shall meet the requirements of 9 VAC 20-80-300.A.3.f.(2). The following wells are included in the monitoring network:

Upgradient Well(s)	Downgradient Wells		Piezometers
MW-4R	PO-8	CECW-2	N/A
MW-5	PO-9	CECW-3	
	PO-10	CECW-4	
	PO-11	CECW-5	
	CECW-1	CECW-6I	

X.C AQUIFER INFORMATION

X.C.1 Aquifer Data Acquisition - Requirements and Response

X.C.1.a Static groundwater elevations shall be:

X.C.1.a.(1) measured in all monitoring wells in a manner that meets the requirements of 9 VAC 20-80-300.A.4.c.

X.C.1.a.(2) measured to an accuracy of 0.01 foot.

X.C.1.a.(3) obtained from all wells in the network within a

single 24 hour period to avoid temporal variations/fluctuations in the groundwater table.

X.C.1.b Each time groundwater is sampled on site, the Permittee shall determine the groundwater flow rate and direction [9 VAC 20-80-300.A.4.c] in the uppermost aquifer using methods accepted for use in EPA RCRA programs.

X.C.1.c The Permittee shall evaluate the function of each of the wells included in the monitoring network using the static groundwater elevation data obtained each time groundwater is sampled. If the evaluation shows that one or more of the monitoring well(s) no longer functions in a manner that meets the requirements of 9 VAC 20-80-300.A.3.e, the Permittee shall:

X.C.1.c.(1) Within 30 days of recognizing the non-performance, notify the Department of the need to modify the number, location, or depth of the monitoring wells, and provide for Department review, proposed locations for new (replacement) monitoring wells keyed to a site plan.

X.C.1.c.(2) Complete additions or modifications to the network, prior to the next regularly scheduled groundwater sampling event, unless an extension has been granted by the Director for meeting the monitoring system compliance requirements under 9 VAC 20-80-300.A.3.a.

X.D. SAMPLING REQUIREMENTS

The Permittee shall meet the following:

X.D.1 Field sampling and laboratory procedures shall at a minimum meet the requirements of 9 VAC 20-80-300.A.4.a.

X.D.2 Sampling and analytical methods shall at a minimum meet those set forth in EPA SW-846 as amended [9 VAC 20-80-300.A.4.b].

X.D.3 Samples shall not be filtered prior to analysis.

X.D.4 The Permittee shall sample the groundwater for the Phase 1 parameters referenced under 9 VAC 20-80-300.C.3.a.

X.E SAMPLING FREQUENCY

X.E.1 Unless otherwise required when sampling to determine background for the Phase 1 [9 VAC 20-80-300.C.3.b] program, the Permittee shall, during the active life and post-closure care periods, sample and analyze all monitoring wells on at least a semi-annual basis [9 VAC 20-80-300.C.3.c].

X.E.2 The length of the semi-annual sampling period shall meet the requirements of 9 VAC 20-80-10.

X.F DETERMINATION OF BACKGROUND

X.F.1 The Permittee shall establish site background values for all Phase 1 parameters in a manner consistent with the requirements of 9 VAC 20-80-300.A.4.d through f and timeframes of 9 VAC 20-80-300.C.3.b.

X.G. STATISTICAL PROCEDURES

When evaluating the groundwater sampling event results, the Permittee shall:

X.G.1 use a statistical test meeting the requirements of 9 VAC 20-80-300.D.

X.G.2 within 30 days of completion of the laboratory analysis for each sampling event [9 VAC 20-80-300.A.4.h.(2)], determine whether or not there is a statistically significant increase (SSI) over site background for each monitoring constituent using a method meeting the requirements of 9 VAC 20-80-300.A.4.h.(1) and 300.A.4.g.

X.G.3 For the purpose of this Permit, laboratory analysis is considered complete upon issuance of the analytical report under laboratory signature.

X.G.4 Statistical comparisons are not required during the first year of Phase 1 monitoring [9 VAC 20-80-300.C.3.d.(1)].

X.G.5 Statistical comparisons during the Phase 1 monitoring program shall consist of both interwell and intrawell analysis [9 VAC 20-80-300.C.3.d.(1)].

X.H ADDRESSING BACKGROUND EXCEEDANCES

If the statistical comparisons required under the monitoring program show no exceedances, the Permittee shall continue monitoring groundwater within the current

program [9 VAC 20-80-300.C.3.d.(1).(b)].

When a Permittee has determined there has been an exceedance over Phase 1 site background for one or more of the monitoring parameters, the Permittee shall:

X.H.1 upon the end of the 30-day SSI determination period allowed by 9 VAC 20-80-300.A.4.h.(2), notify the Director within the timeframes of 9 VAC 20-80-300.C.3.d.(1).(a) concerning upgradient wells and 9 VAC 20-80-300.C.3.d.(1).(c) concerning downgradient wells. The notification shall indicate which groundwater monitoring parameters have shown statistically significant increases over background and describe whether the Permittee shall:

X.H.1.a initiate Phase 2 monitoring described under 9 VAC 20-80-300.C.4 within the timeframes of 9 VAC 20-80-300.C.3.d.(4), unless allowed to enter the Modified sampling program under 9 VAC 20-80-300.C.4.b.(4)

X.H.1.b submit an Alternate Source Demonstration [9 VAC 20-80-300.C.3.c.(2)] meeting the content requirements and timeframe of 9 VAC 20-80-300.A.5. Unless Director approval of the demonstration is obtained, the Permittee shall follow the requirements and timeframes of 9 VAC 20-80-300.C.3.c.(3) and d.(4).

X.I. RECORD-KEEPING REQUIREMENTS

The Permittee shall retain all records identified under 9 VAC 20-80-300.E.1 as well as 9 VAC 20-80-570.B.1 and B.2 throughout the active life (including closure) and post-closure care period.

The records shall be retained at the facility or another location approved by the Director.

X.J REPORTING REQUIREMENTS

X.J.1 *Annual groundwater reports* containing at a minimum the content described under 9 VAC 20-80-300.E.2.b, shall be submitted to the Director no later than March 1st of each calendar year.

X.J.2 *Semi-annual groundwater evaluations* containing at a minimum, the groundwater flow rate and direction determinations required under 9 VAC 20-80-300.A.4.c and the results of the statistical comparisons required under 9 VAC 20-80-300.C.3.d.(1) shall be submitted to the Department within 180 days of each semi-annual (or quarterly) sampling event.

X.J.3 While background is being established, the Permittee shall report to the

Director, within 15 days of receipt of the data from the laboratory, the *laboratory analytical results* [9 VAC 20-80-300.E.2.a] for each background sampling event.

X.J.4. The Permittee shall report to the Department established background for the Phase 1 and Phase 2 programs, shall report re-established background due to the installation of new monitoring wells, and shall report re-established background due to a change in sampling technique in accordance with 9 VAC 20-80-300.E.2.a.

X.J.5 Within 44 days of well completion, the Permittee shall supply the Director a *Well Installation Report* containing the well number, surveyed elevation, boring log, casing length, total depth, and a completion diagram for each monitoring well, along with a certification from a qualified groundwater scientist that the monitoring wells have been installed in accordance with the submitted plans [9 VAC 20-80-300.A.3.d; 300.A.3.f.(3), and 300.E.1.c].

X.J.6 Within 44 days of well abandonment, the Permittee shall supply the Director a *Well Abandonment Report* containing information including field methods utilized, and a certification from a qualified groundwater scientist verifying the well abandonment activities met all applicable requirements [9 VAC 20-80-300.E.1.c].

X.K NOTIFICATION REQUIREMENTS

X.K.1 *Background SSI Notifications* shall be submitted to the Director within the timeframes noted under 9 VAC 20-80-300.A.4.h.(2) and C.3.d.(1).(c).

X.K.2 *Well Non-Performance Notifications* shall be submitted to the Director within 30 days of recognizing the non-performance of one or more wells in order to meet 9 VAC 20-80-570.C.1 through 3.

X.L. MISCELLANEOUS ALLOWANCES

X.L.1 Alternate Site Background. The Permittee may request the Director allow site background to be developed using wells that are not hydrologically upgradient of the SWMU as long as the request addresses the technical criteria contained under 9 VAC 20-80-300.A.4.e, and is certified by a qualified groundwater scientist. Until such time as Director approval is obtained, background shall be determined by sampling wells which are upgradient of the SWMU and meet the requirements of 9 VAC 20-80-300.A.3.f.(2).

X.L.2 Alternate Statistical Method. The Permittee may request the Director allow the use of an Alternate Statistical Method as long as the Permittee can demonstrate

the alternate method can meet the technical criteria defined under 9 VAC 20-80-300.D.2. Until such time as Director approval is obtained, the statistical test(s) applied to site groundwater data shall be one from 9 VAC 20-80-300.D.1.a through d. Whichever method is approved for use at the site, the method shall be listed in the facility *Groundwater Monitoring Plan* as required under 9 VAC 20-80-300.A.4.g.

X.L.3 Verification Sampling. The Permittee, at any time within the 30 day statistical determination period defined under 9 VAC 20-80-300.A.4.h.(2), may obtain verification samples if the initial review of analytical data suggests results which might not be an accurate reflection of groundwater quality. Undertaking verification sampling is a voluntary action and shall not alter the timeframes associated with determining or reporting a statistically significant increase as otherwise defined under 9 VAC 20-80-300.A.4.h.(2).

X.L.4 Data Validation. The owner or operator may at any time within the 30 day statistical determination period defined under 9 VAC 20-80-300.A.4.h.(2), undertake third-party data validation of the analytical data received from the laboratory. Undertaking such validation effort is a voluntary action and shall not alter the timeframes associated with determining or reporting a SSI as otherwise defined under 9 VAC 20-80-300.A.4.h.(2).

X.M. MISCELLANEOUS DEMONSTRATIONS

X.M.1 To address an exceedance which is the result of something other than a release of solid waste constituents from the SWMU, the Permittee may submit a report entitled *Alternate Source Demonstration*, certified by a qualified groundwater scientist, for review by the Director within 90 days of providing the SSI notification unless the submission and approval timeframe has been extended by the Director for good cause [9 VAC 20-80-300.A.5].

X.M.1.a If a successful demonstration of an alternate source for the noted increase is made by the Permittee and approved by the Director within the 90 day timeframe, the Permittee may continue in the Detection monitoring program as defined in this Permit Module.

X.M.1.b If a successful demonstration of an alternate source for the noted increase is not made by the Permittee within the 90 day timeframe, the Permittee shall take actions required under 9 VAC 20-80-300.C.3.d.(4) under the Regulatory timeframes unless an extension has been granted by the Director.

X.M.2 The Permittee may submit to the Director, a *Multi-unit Groundwater Monitoring System Demonstration* containing the content defined under 9

VAC 20-80-300.A.3.b and certified by a qualified groundwater scientist, to demonstrate that the implementation of such a monitoring system is equally or more protective of human health and the environment as an individual system.

X.M.2.a If a successful demonstration is made and approved by the Director, the Permittee may discontinue use of individual monitoring systems and institute the monitoring of a multi-unit system.

X.M.2.b If a successful demonstration is not made, the Permittee shall initiate (or continue) to monitor individual networks under Detection monitoring.

X.M.3 The Permittee may request the Director suspend groundwater monitoring requirements by submitting a *No-Potential-Migration Demonstration,* certified by a qualified groundwater scientist, meeting the technical requirements of 9 VAC 20-80-300.A.1.c. Groundwater monitoring activities shall continue pursuant to this Module while the request is evaluated by the Director.

X.M.3.a If a successful demonstration is made and approved by the Director, the Permittee may suspend groundwater monitoring actions.

X.M.3.b If a successful demonstration is not made, the Permittee shall continue monitoring as required under 9 VAC 20-80-300.C.3.

X.N MODULE ATTACHMENTS

As required under 9 VAC 20-80-520.C, the Permittee shall have an Operations Plan that includes detailed instructions concerning groundwater monitoring [9 VAC 20-80-520.C.2.a]. These detailed groundwater monitoring instructions shall at a minimum cover the items listed under 9 VAC 20-80-300.A.4.a. The document containing these instructions, called the *Groundwater Monitoring Plan*, shall be attached as Attachment X-1 to this Module.

It shall be the responsibility of the Permittee to update this Plan as needed, which may include a Permit amendment action as defined under 9 VAC 20-80-620.A through F, if changes to the monitoring program have taken place since original Plan development.

X.O LIMITATIONS

Solid waste shall not be deposited in or permitted to enter any surface waters or groundwater [9 VAC 20-80-250.C.10].

The groundwater monitoring and reporting requirements set forth here are minimum requirements. The Director may require, by amending the Permit, any owner or operator to install, operate, and maintain a groundwater monitoring system and program that contains requirements more stringent than those of the Virginia Solid Waste Management Regulations whenever it is determined that such requirements are necessary to prevent significant adverse effects on public health or the environment [9 VAC 20-80-300.A.2.c].

Should information contained in any Permittee authored attachment to this Module conflict with any requirement or condition contained herein, or language found within 9 VAC 20-80-10 et seq., as amended; the Module condition and/or Regulatory requirement shall prevail over the language in the Permittee supplied attachment [see 9 VAC 20-80-60.D and 550.E] unless it can be demonstrated that a Variance from that regulatory requirement has been granted by the Director under 9 VAC 20-80-730 et seq.

When the Permittee recognizes a failure to submit any relevant facts or has submitted incorrect information in any groundwater monitoring report to the Director, he shall, within 7-days, promptly submitted such omitted facts or the correct information with a full explanation [9 VAC 20-80-570.E].

PERMIT ATTACHMENT X – 1

GROUNDWATER MONITORING PLAN

RECEIVED – DEQ
AUG 12 2009
Tidewater Regional Office

GROUNDWATER MONITORING PLAN (GMP)

For the

CHESAPEAKE ENERGY CENTER

(Module X of Solid Waste Permit 440)

2701 Vepco Street
Chesapeake, Virginia 23323

Prepared by:

Dominion Electric Environmental Services

June 2009

41807

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1.0 TRANSMITTAL LETTER

This Groundwater Monitoring Plan was developed and reviewed by a Professional Groundwater Scientist and will be managed to comply with current VA Solid Waste Regulations 9VAC 20-80-300.

CERTIFICATION STATEMENT

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signature:	
Printed Name:	Donald Hintz
Title:	Environmental Geologist

2.0 GROUNDWATER MONITORING PROGRAM

2.1 Site Location Information

The CEC Industrial Landfill is located at 2701 Vepco Street, in Chesapeake, Virginia, approximately eight miles west of Virginia Beach and seven miles south of the City of Norfolk. The facility is located on an inverted L-shaped peninsula measuring approximately 6,000 feet (ft) from north to south and 1,200 to 4,000 ft from west to east (Figure 1a). The Facility is located north of and inside the Interstate 64/664 beltway, which encircles/connects Chesapeake, Norfolk, Portsmouth, and Hampton, Virginia. The Facility is bounded to the north by the Norfolk and Western rail line and Military Highway (Route 13/460), to the east by the Southern Branch of the Elizabeth River (SBER), and to the west by a non-contact cooling water discharge channel. The peninsula, on which the facility is situated, is surrounded by the SBER, Deep Creek, and a cooling water discharge canal on its eastern, southern, and western flanks, respectively. The CEC Power Station general layout is presented as Figure 1b to illustrate the relationship of the landfill to the power station.

The landfill encompasses approximately 22.25 acres. The ground surface is relatively flat and ranges from approximately elevation 5 to 12 ft mean sea level (msl) (with the exception of the landfill).

2.2 Description of the Uppermost Aquifer

CEC is located within the Atlantic Coastal Plain physiographic province, approximately 75 miles east of the Fall Line, which separates the Coastal Plain from the Piedmont physiographic province. Altitudes in the vicinity of the Facility range from 0 to 25 ft above msl. Extensive drilling has been conducted on site for purposes of geotechnical study and monitoring well installation. A geotechnical study was undertaken by Dominion Generation in 1999 for purposes of evaluating the suitability of the site for vertical expansion. The study employed test borings and laboratory analysis to characterize site geology. Applicable sections of the geotechnical study report dated October 28, 1999, are included in Appendix A.

Locally, based on published geologic literature and boring logs, the geologic stratigraphy from the ground surface down consists of existing fill, recent alluvial deposits, the Norfolk Formation, and the Yorktown Formation. The clayey sands of fill were used to construct the inner and outer perimeter dikes surrounding the former ash pond/landfill. Alluvial deposits consist of Holocene alluvium, sand, and marsh sediment representing an estuarine-beach, tidal marsh depositional environment and are described as fluvial silt, sand, and clay with organic material (peat). The Pliocene Norfolk Formation represents a fluvial estuarine and brackish marine depositional environment and is described as silty sand. The Pliocene Yorktown Formation is a bluish-gray, greenish- and dark greenish-gray, very fine to coarse sand, in part glauconitic and phosphoric, commonly very shelly and interbedded with sandy and silty clay (Powars, 2000).

The hydrogeologic framework of the shallow aquifer system in the vicinity of the Facility is composed of the Columbia Aquifer, the Yorktown Confining Unit, and the Yorktown-Eastover Aquifer. The Columbia Group water table aquifer is the uppermost aquifer present beneath the landfill. The Columbia Group Aquifer is unconfined; however, clayey fine sand, silt, clay, and peat deposits within the aquifer cause local confined to semi-confined conditions in some areas (Smith and Harlow, 2001). The depth to groundwater in wells surrounding the landfill typically varies between 4 and 13 feet, depending on well location. Under the site, the thickness of the Columbia Group aquifer intercepted by the monitoring wells ranges between approximately 20 and 35 feet (note: the monitoring wells used in the program do not extend to the base of the Columbia Group aquifer).

The Yorktown Confining Unit is defined as a series of coalescing clay layers at or near the top of the Yorktown Formation. The principal water-bearing zones within the Yorktown Formation occur within 50 to 100 feet of its surface. The Yorktown-Eastover Aquifer is defined as the predominantly sandy deposits of the Yorktown Formation and the upper part of the Eastover Formation above the confining clays of the St. Mary's Formation (Meng and Harsh, 1988).

The landfill is constructed on a peninsula and groundwater flow tends to be radial from the landfill to the west, south, and east. To the north, the groundwater gradient appears relatively flat. Accordingly the wells used as "upgradient" wells are located several hundred feet to the northwest of the landfill and do not relate to the groundwater gradient at the facility. Although groundwater movement through the unconfined and confined aquifers is generally lateral with discharge into surrounding water bodies including the SBER and Deep Creek, some groundwater movement also occurs vertically from confining units into deeper confined aquifers.

Hydraulic conductivity values of the uppermost aquifer have been determined using slug tests to be 6.48 x 10^{-4} ft/min. The hydraulic gradient in the vicinity of well PO-10 has been measured at approximately 0.02 ft/ft. The calculated groundwater flow rate under the landfill is typically around 29 ft/yr.

Figure 2 provides an interpreted Groundwater Contour Map. The USDA Soil Survey classifies the soils in the immediate vicinity of the Chesapeake Energy Center Landfill as primarily Udorthents-Urban land complex surrounded by small areas of Muden fine sandy loam, Tomotley-Nimmo complex, and dragson fine sandy loam. A copy of the USDA Natural Resource Soil Survey Map is provided as Figure 3.

2.3 Groundwater Monitoring Plan Sheet

Figure 2 displays the relationship of the landfill's topography, well locations, and the groundwater topography. The table below provides the surveyed elevations.

WELLS	MW-4R	MW-5	CECW-1	CECW-2	CECW-3	CECW-4	CECW-5	CECW-6I	PO-8	PO-9	PO-10	PO-11
Top of Casing (TOC) Elevation (msl)	14.12	14.43	22.94	23.35	28.75	23.40	21.87	22.12	14.68	9.99	7.49	24.42
Depth of Borehole – (in feet)	14.5	14.5	27.4	25	24	21.5	26	34	16	10	10	21
Length of Screened Interval (in feet)	10	10	10	15	14	10	20	5	5	5	5	10

2.4 Design of the Groundwater Monitoring System

General:
The following well network exists at the facility and has been deemed by DEQ as acceptable. There are a sufficient number of background and downgradient wells that are screened at appropriate depths to account for spatial variability in the aquifer. The downgradient wells are spaced appropriately for intersection of lateral/horizontal groundwater flow. Each well is inspected every sampling for damages or unusual conditions and noted on the Monitoring Well Field sheet.

Upgradient (Background) Wells	MW-4R, MW-5
Downgradient Wells	CECW-1, CECW-2, CECW-3, CECW-4, CECW-5, CECW-6I, PO-8, PO-9, PO-10, PO-11

Horizontal Placement:
The downgradient wells are placed as close to the proposed landfill as is practical and, based on the groundwater contours, at a point where a release would be detected. The background wells are placed several hundred feet to the northwest of the landfill and do not relate to the groundwater gradient at the facility. This is necessary because there is no location truly upgradient of the landfill.

Vertical
All monitoring wells have been drilled and completed to monitor the surficial or water table (Columbia Group) aquifer.

Screen Interval Placement:
Monitoring well screens are typically either five or ten feet in length, and placed to intercept the top of the Columbia Group aquifer. The rationale for this screen placement is to intercept, with minimal dilution, contaminants which may be entering groundwater from the facility. Also, at least five feet of screen is considered necessary to minimize velocities through the screen.

Special Conditions:
The following special conditions apply to this facility:

a) The waste disposal site is located above the former ash sluice facility for the power station. This is a significant factor with respect to the groundwater monitoring program, because the materials placed inside the landfill are similar in characteristics to materials on which the landfill has been constructed. Accordingly, potential contaminants identified in groundwater wells may have a source other than the landfill.

b) The waste disposal site is located on a geographic peninsula with no true upgradient conditions. For this reason, background wells MW-4 and MW-5 are located in the same aquifer, but do not relate to the groundwater gradient of the landfill. The use of off-site wells for the identification of background water quality is an adequate approach under these conditions.

c) The waste disposal site is located in an area whereby nearby surface water can influence groundwater levels (i.e., tidal fluctuations in the Southern Branch of the Elizabeth River are likely to influence groundwater fluctuations). This is a factor with respect to the groundwater monitoring program because potential contaminants identified in groundwater wells may have a source other than the landfill.

Non-Upgradient Background Wells:
The waste disposal site is located on a geographic peninsula with no true upgradient conditions. For this reason, background wells MW-4 and MW-5 are located in the same aquifer, but do not relate to the groundwater gradient of the landfill. The use of off-site wells for the identification of background water quality is an adequate approach under these conditions.

Monitoring Well Replacement:
Any monitoring well which fails to perform as designed shall be replaced prior to the next regularly scheduled groundwater sampling event.

In February of 2000 monitoring well CECW-5 was replaced after being reported dry during several semi annual sampling events. Monitoring well CECW-4 was abandoned and replaced in June of 2002 as the result of significant damage. In 2006, monitoring well MW-4 was damaged and was subsequently replaced with MW-4R in September of that year. Finally, monitoring well CECW-6 was reported dry for four consecutive semi annual sampling events and was abandoned in April of 2008. At that time, well CECW6-I was approved by the DEQ as an appropriate substitute for the abandoned CECW-6.

2.5 Geotechnical Investigation Techniques

Drilling Methods:
Monitoring well MW-5 was installed in December of 1982. Monitoring wells PO-8, PO-9, and PO-10 were installed in December of 1983. Wells CECW-1, CECW-2, and CECW-3 were installed in August of 1998. Replacement wells CECW-5 and CECW6-I were installed in February and May of 2000 respectively. Finally, replacement monitoring well MW-4R was installed in December of 2006.

All monitoring wells were drilled using hollow stem auger equipment drilling a 6½ inch diameter bore hole. It is anticipated that future wells will also be constructed using hollow stem augur equipment. For details of the boring logs, please refer to Appendix B.

Equipment Decontamination

a) Heavy Equipment

Drilling equipment, including auger flights, drill rod, water swivels, casing materials, wrenches, drill rigs, and other heavy equipment is to be cleaned prior to drilling at each location by use of steam cleaning apparatus. In the event that tar or other material is so persistent that steam cleaning is ineffective, then sand blasting or kerosene will be used to remove the material and steam cleaning will follow. Decontamination fluids, soils, and materials shall be collected and disposed of in accordance with applicable regulations.

b) Sampling Equipment

Sampling equipment (split spoons, shelby tubes etc.) used to collect soil samples during drilling shall be decontaminated between each sample as follows:

1. Scrub sampling device with a nonphosphate low sudsing detergent (e.g.,Liquinox).
2. Rinse thoroughly with tap water
3. Rinse a minimum of three times with distilled water
4. Air dry
5. Dispose of decontamination fluids in accordance with applicable regulations.

2.6 Monitoring Well Construction

Construction Materials (Existing and Future Wells)

a) Well Casing & Screens

The wells are constructed of PVC. Given the nature of the waste, no organic compounds are expected that would be incompatible with PVC. These materials are normally used in this type of construction and no degradation due to intense well development is expected. It is understood that any non-functioning well will be replaced and/or abandoned.

b) Well Filter Pack and Sealant

The filters are of a clean washed sand of size compatible with the 0.01 slots in the PVC screen. This will provide for even distribution of flow across the screen. It is not anticipated that the inert sand would be affected by any leachate constituent. The filter pack shall fill the annular space to a minimum of two feet above the top of the well screen. A bentonite sealant at least two feet in thickness shall be placed above the filter pack prior to the placement of grout in the remaining annular space. Pre-slotted screens shall be used and the screen and casing sections

are to be flush threaded. Surface completion shall include locking metal riser cover set in formed concrete pad.

c) Well Intake Design:

Placement size and type of screen for each well are identified in the individual boring logs (Appendix B). The well screens extend at least 5 feet into the saturated zone to allow for samples to be taken over a wide band of groundwater and to minimize velocities through the screen.

The introduction of formational material into the sample area is minimized due to the filtering action of the sand pack.

Surveying:
Wells, including potential future wells, are to be surveyed by a licensed or otherwise certified land surveyor to within ± 0.5 feet on the horizontal plane and ± 0.01 feet vertically.

The permittee shall install and maintain a groundwater monitoring system as specified below:

- The permittee shall maintain groundwater monitoring wells at the locations depicted on Figure 1b.
- The downgradient monitoring system has been installed at the waste management unit boundary, or as close as practical, to ensure detection of groundwater contamination in the uppermost aquifer.
- The background monitoring system has been installed in order to provide representative samples of background water in the uppermost aquifer near the facility but not affected by the facility. The landfill is constructed on a peninsula and groundwater flow tends to be radial from the landfill to the west, south, and east. To the north, the groundwater gradient appears relatively flat. Because of this, there is no location which can be considered "upgradient" of the landfill. Accordingly, the wells used as "upgradient" wells are located several hundred feet to the northwest of the landfill and do not relate to the groundwater gradient at the facility.
- As necessary, the permittee shall construct additional wells and maintain all the monitoring wells in accordance with the methods outlined below.

2.7 Well Development

The process of drilling disturbs the subsurface materials through which the well bores are advanced, which can result in the clogging of the screens from suspended materials dislodged during drilling. To counter such drilling effects and allow for the subsequent collection of representative groundwater samples, wells are developed in order to flush drilling residues

from the well bore. The goals of development are to (i) remove fines from the filter pack and natural formation in the vicinity of the well screen; and (ii) to enhance the settlement and stabilization of filter pack material adjacent to the well screen.

The well development process is comprised of (i) the application of sufficient energy in a monitoring well to create groundwater flow reversals (surging) in and out of the well and filter pack to release and draw fines into the well; and (ii) removing these materials from the well.

Following installation, each well is developed until pH and conductivity stabilize within approximately 10% over the last two measurements in the well bore. Development may be accomplished by use of a valved and air-vented surge block accompanied by pumping or bailing.

It may become necessary to redevelop a well if suspended material in the well builds up to the point that it interferes with the collection of a representative groundwater sample. In the event that redevelopment becomes necessary, the well may not be sampled for a period of at least 48 hours following well development.

2.8 Well Abandonment

All wells deleted from the monitoring program shall be plugged and abandoned.

Wells drilled but not required for groundwater monitoring shall be sealed (abandoned) in accordance with procedures outlined in the National Well Association's 1991 publication "Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells". Well (or boring) abandonment will include pulling or removing the existing casing while grout is placed simultaneously in the borehole via a tremie pipe. The grout (or seal) will consist of a cement/bentonite mixture. If the casing cannot be pulled from the borehole, overdrilling will be used to remove the casing. If the well is out of an active disposal area, a concrete cap will be placed on top of the grout plug. The objectives of the abandonment procedures are to: 1) eliminate physical hazards, 2) prevent groundwater contamination, 3) conserve aquifer yield and hydrostatic head, and 4) prevent intermixing of subsurface water (EPA, 1975).

Well abandonment data will be on file at the facility and will include:

- Surveyed well location
- Type and purpose of well Abandonment
- Well abandonment method
- Well ID
- Copy of the well installation boring log
- Replacement Materials Used (quantities and placement methods)
- Name and address of firm performing abandonment

The permittee will obtain VDEQ approval prior to the removal of any well(s) from the active monitoring program and will submit documentation to VDEQ following well abandonment.

2.9 Documentation

Boring Logs and well construction diagrams are included in Appendix B.

Within 30 days of installation, monitoring wells will be certified by a qualified groundwater professional. This certification along with boring and construction logs for newly installed permitted wells shall be submitted to VDEQ within 14 days of certification. The submission should include the following information:

a) Date/time of construction;

b) Drilling method and drilling fluid used;

c) Borehole diameter and well casing diameter;

d) Casing materials;

e) Screen size/length;

f) Filter pack material, size, and grain analysis;

k) Filter pack volume calculations;

l) Filter pack placement method;

m) Sealant materials (% bentonite);

n) Sealant volume (pounds per gallon of cement);

o) Sealant placement method;

p) Surface seal design and construction;

q) Well development procedure;

r) Type of protective well cap;

s) "As built" well diagram including dimensions

t) Well location, specified to within 0.5 foot in horizontal plane;

u) Well depth, specified to within 0.01 foot;

v) Ground surface elevation to within ± 0.01 foot;

w) Surveyor's pin elevation on concrete pad, specified to within ± 0.01 foot;

x) Top of monitoring well casing, specified to within ± 0.01 foot;

y) Top of protective steel casing elevation, specified to within ± 0.001 foot

z) Drilling and lithologic logs.

3.0 GROUNDWATER SAMPLING AND ANALYSIS PLAN

3.1 Sample Collection

Procedures for collecting the samples shall be in accordance with EPA methods described in SW-846 (most recent version) and are as follows:

Sampling personnel shall check in with the Site Operator.

Static Water Level Elevations
The depth to water in each well shall be gauged from a designated mark at the top of the well casing using a water level indicator and shall be measured to an accuracy of 0.01 foot. The water level indicator shall be decontaminated using a non-phosphate detergent and triple rinsed with deionized water prior to each gauging event.

Well Evacuation
Wells have been outfitted with dedicated pumps for Low Flow sampling. Turn on pump to begin evacuating standing water from the well, careful not to exceed 0.1m/0.33ft/4in. of drawdown as hydrologic conditions permit. The water level indicator meter will be used to monitor drawdown during pumping operations.

Number of Samples
For every groundwater sampling event, measurements will be conducted at 5 minute intervals, collect and record the following parameters data: Time, Temperature, pH, Conductivity, Turbidity. The sampling frequency is currently semi-annual but is subject to change in accordance with the VSWMR and/or DEQ.

The flowing information outlines the key events of Phase I and Phase II groundwater monitoring regulation in 9VAC20-80-300 and the parameters/frequency that are sampled.

1. Phase I Monitoring

In the event that the facility is able to return to Phase I monitoring, the following procedures will be followed.

Phase I background data have been accumulated for the facility, and Phase I monitoring shall be conducted semi-annually. During each monitoring event, the permittee shall determine the concentration or value in groundwater samples of:

Specific Conductance
pH
TOC
TOX

The permittee shall perform a statistical evaluation of the analytical results comparing each well to its own background and to the upgradient wells. If the comparisons for the upgradient

wells show a statistically significant increase (or pH decrease), the permittee shall submit the information to the VDEQ in the Ground Water Annual Report. If the comparisons for downgradient wells show a statistically significant increase (or pH decrease), the permittee may obtain within 30 days additional groundwater samples from those wells, split the samples in two, and obtain analyses of all additional samples to determine whether the significant difference is confirmed (verification sampling). If a statistically significant increase (or pH decrease) is not confirmed, the permittee shall submit the information to the VDEQ in its annual report. If a statistically significant increase (or pH decrease) is confirmed:

- the permittee shall within 14 days notify the VDEQ of the determination and that Phase II monitoring will be implemented
- within 90 days the permittee shall either demonstrate that a source other than the unit caused the contamination or establish Phase II monitoring

2. Phase II Monitoring

a) Phase II Monitoring Parameters

A Phase II monitoring program shall include the monitoring parameters identified in Table 5.5 of the VSWMR. The facility has been granted a variance which allows it to omit VSWMR Table 5.5 volatile organic compounds from semi-annual Phase II monitoring. In addition, the variance also specifies sampling semi-annually for detected Table 5.1 inorganic parameters and every two years for the entire Table 5.1 list.

b) First Determination

The purpose of Phase II monitoring is to allow for the performance of a first determination. The first determination should be completed as soon as technically feasible, but no later than 21 months after determining a statistically significant increase (or pH decrease) under the Phase I Monitoring Program.

The number and frequency of sampling events shall be determined in accordance with the requirements of the statistical method by which the first determination will be made. During the first determination period of the Phase II monitoring program, the permittee shall submit the groundwater analytical results from each background event with in 15 days of receipt from the laboratory. The results of the first determination, including an assesment of groundwater quality, shall be submitted to the VDEQ within 21 months of determining a statistically significant increase under the Phase I monitoring Program.

c) Actions Following First Determination

1. If the permittee finds that no Table 5.5 constituents (as modified by variance) from the facility have entered groundwater, the permittee may then reinstate the Phase I monitoring program. The permittee shall notify the VDEQ of the

reinstatement of the Phase I monitoring program in the First Determination Report. The following requirements pertain to a reinstated Phase I program:

a. If the permittee reenters the Phase I monitoring program and continues to observe statistically significant increases (SSIs) for Phase I parameters, the facility will reenter the modified sampling program (as outlined in 9VAC-80-300.C.5), and will sample for 5.1 constituents within 90 days.

b. If no Table 5.1 constituents are detected in groundwater, the permittee shall continue the Phase I monitoring program, and continue to sample and analyze groundwater for Table 5.1 constituents every 2 years.

c. If Table 5.1 constituents are detected and confirmed in groundwater during any Table 5.1 event, the permittee shall establish a background value for each detected 5.1 constituent within a period not to exceed 18 months.

2. If the first determination identifies a statistically significant increase in any Table 5.5 constituent (as modified by variance), the permittee shall

a. Continue to make the required determinations on an (at least) semi-annual basis until Corrective Action Program is implemented. The permittee may request that VDEQ approve an appropriate set of monitoring wells applicable to this phase of monitoring.

b. Within 90 days, sample the groundwater in all monitoring wells and analyze the samples for the constituents of Table 5.1 of the VSWMR.

c. No later than 18 months after the statistically significant increase for Table 5.1 constituents, establish a background value for each Table 5.1 constituent that has been found at the waste management unit boundary.

d) Proposal of Groundwater Protection Standards.

Within 60 days of the establishment of Table 5.1 background, the permittee shall propose a groundwater protection standard (GPS) for each Table 5.1 constituent detected in groundwater. The GPS shall be:

1. For constituents for which a maximum contaminant level (MCL) has been promulgated under Section 1412 of the Safe Drinking Water Act (Part 141, Title 40, Code of Federal Regulations), the MCL for that constituent will be used.

2. For constituents for which MCLs have not been promulgated, the background concentration, as approved by the VDEQ for the constituent established from wells, or

3. For constituents for which the background level is higher than the MCL or health based levels, the background concentration, as approved by the VDEQ.

e) Evaluation of Table 5.1 Constituents

After each subsequent monitoring event following establishment of ground water protection standards the permittee shall submit to VDEQ an evaluation of the concentration of any Table 5.1 constituents found in the groundwater in each monitoring well at the waste management unit boundary. If the concentration of:

1. All Table 5.1 constituents are shown to be at or below background values using the statistical procedures described in this Plan for two consecutive sampling events, the permittee shall notify VDEQ and may reinstate Phase I monitoring.

2. Any Table 5.1 constituents are shown to be above background values but below the applicable GPS, the permittee shall continue Phase II monitoring.

3. Any Table 5.1 constituents indicate exceedance above the established GPS in any specified monitoring well at the waste unit boundary, the permittee may demonstrate that a source other than the landfill (Alternate Source Demonstration (ASD)) caused the increase or an error in sampling, analysis, or evaluation was committed. In making such a demonstration, the permittee shall:

   a. Notify the VDEQ in writing within 14 days of the permittee's intention to make the demonstration.

   b. Within 90 days, submit the ASD that proves a source other than the landfill unit caused the increase, or that the increase resulted from error in sampling, analysis, or evaluation.

   c. Continue Phase II monitoring on semi-annual basis.

f) Actions in the Event of Statistical Exceedance of GPS. If the above alternate source demonstration (ASD) is not made or is inapplicable, the permittee shall:

1. Collect and submit all data necessary to justify any variance sought for GPS, or

2. Characterize the nature and extent of the release and notify all property owners of the land that overlies the plume of contamination, and

3. Initiate within 90 days the Corrective Action Program 9VAC20-80-310.

Sampling Equipment
All wells have been outfitted with dedicated pumps. Turn on pump to begin evacuating standing water from the well, careful not to exceed 0.1m/0.33ft/4in. of drawdown as hydrologic conditions permit. The water level indicator meter will be used to monitor drawdown during pumping operations.

Sampling Order
The wells shall be sampled in the same order for each sampling event. The sampling order shall be as follows:

MW-4R, MW-5, PO-8, CECW-5, CECW-6I, PO-9, CECW-4, CECW-3, PO-10, CECW-2, CECW-1, PO-11

Sampling Measurements
A field technician shall record and maintain with Log Book; date, time arriving & leaving site, and weather condition. In addition, at each well the following information is to be recorded:

Confirm water quality meters (Temperature, pH, conductivity, turbidity) are operational and calibrated.

All wells have been outfitted with dedicated bladder pumps, turn on pump to begin evacuating standing water from the well, careful not to exceed 0.1m/0.33ft/4in. of drawdown as hydrologic conditions permit. The water level indicator meter will be used to monitor drawdown during pumping operations. Evacuated water will be discharged to the ground at the well site.

At 5 minute intervals, collect and record the following parameters data: Time, Temperature, pH, Conductivity, Turbidity.

Field parameters must have stabilized within the following units over at least three consecutive measurements prior to sampling, unless the well's recharge capability is limited.

- pH $\pm$ 0.2 pH units
- Conductivity $\pm$ 3% of reading
- Turbidity $\pm$ 10% of prior reading or the readings be less than 10ntu.

Remove by low flow pumping a volume sufficient to analyze for the applicable parameters and divide into proportions with proper preservative. The sample collection order shall be:

- Volatile Organics
- EDB/DBCP
- Semi-Volatile Organics, Organochlorine Pesticides and PCBs, Chlorinated Herbicides
- Cyanide, Sulfide, Metals

Decontamination & Calibration Procedures
Rinse water level meter and flush water quality meter's flow-through cells prior to each sampling event. The sampling equipment will be calibrated per manufacture recommendations (Appendix F). The water level and water quality meters will be calibrated prior to every sampling event and after every 5 samples. The records of calibration will be maintained in the Biology Environmental Lab's file. (The field calibrations will be recorded on every 5th sampling well field sheet.)

3.2 Sample Preservation and Handling

Sample analytical requests are conducted by phone, written paper request form, and electronic means. The field technicians will check the Chain of Custody upon sample bottle pick-up to ensure the appropriate number and type of containers are provided for the sampling event.

Sample Containers
The appropriate parameter specific sample bottle type (approved plastic or glass) and quantity shall be pre-preserved using the preservatives outlined in Appendix G, Tables 1A through 1H. In order to ensure that sample containers are free of contaminants, clean sample containers will be obtained directly from the laboratory for all wells, field blank, trip blank, and field duplicate. The required sample quantity per analytical method is provided in Appendix G.

Sample Preservation
The appropriate sample containers will be placed on ice and transported to the laboratory in sealed coolers and/or crates by the technicians in a manner which prevents breakage or cross-contamination.

3.3 Chain of Custody

Technicians shall complete a Chain-of-Custody form, provided to the laboratory, for each set of samples. An example Chain-of-Custody form is included in Appendix C. The order of sampling, chain-of-custody, sample preservation, and decontamination procedures remain consistent during each monitoring event conducted at the site.

Sample Labels
Sample labels affixed to the samples shall contain at least the following information:

- Sample Identification Number(s)
- Name of Collector; - Date, time, and place of collection;
- Parameters to be analyzed for (if space permits);

Sample Seal
When samples remain in Dominion's custody, ensure the bottles are appropriately sealed and the Chain of Custody is transferred to the lab.

When samples leave the operator and/or technicians immediate control, such as shipment to a

laboratory by a common carrier, the operator/technician shall require the shipping container and/or individual bottles be sealed.

Chain – of – Custody Record
Technicians taking samples and delivering to the lab for subsequent analysis shall keep a chain of custody record containing the following information:

- Place of collection
- Sample Identification Numbers (s)
- Name of Collector
- Parameters to be analyzed for (as designated by LIMS project code)
- Date(s) and Time(s) of Sample Collection
- Signature of Collector
- Signature of Recipient
- Temperature of Samples upon arrival at the laboratory

3.4 Field Log Book

Blank copies of example field sheets are provided in Appendix D.

3.5 Laboratory Analytical Procedures

Data from each well will be reported to the Site Operator upon completion of the analysis.

Field and laboratory quality control procedures shall be employed at all stages. The guidelines contained in Test Methods/Evaluation Solid Waste, Physical/Chemical Methods (SW-846) by the EPA

Equipment used shall be calibrated routinely as recommended by the manufacturer.

Records of all analysis as well as copies of log book field data and chain-of-custody records shall be retained throughout the life of the facility and post-closure period and shall be available upon request.

3.6 Quality Assurance and Quality Control

Any commercial laboratories hired must exercise a QA/QC program that meets or exceeds that noted in the most current version of *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods, SW-846 – USEPA.*

Field QA/QC Program
A trip blank, field blank, and duplicate will be included during every sampling event. Please reference Section 3.1 for detailed field equipment QA/QC procedures and documentation.

Laboratory QA/QC Program
The lab will use a method blank on at least 5% of the samples, prior to analysis. Analysis of prepared standards of known concentration shall be used to confirm the validity of the analysis.

3.7 Establishing Background Data

Background groundwater quality will be established at the Facility using current and historical groundwater monitoring data collected from background wells MW-4R and MW-5 for each constituent on the monitoring list.

3.8 Techniques for the Evaluation of Groundwater Quality Data

Statistical Tests
The following summarizes the methodology used for statistical analyses:

- Historical concentrations for background wells (inter-well) are compiled and screened for outliers using methods by Dixon (1953) for data sets less than 25 and for data sets larger than 25, Rosner's Outlier Test (which follows the procedure described by Gilbert (1987)) is used. If statistical outliers are detected, they are removed from the baseline dataset prior to statistical analysis.

  - Please note, analytical concentration between the limit of detection (LOD) and the LOQ are noted in reports by "J" flagging. The result is therefore and estimated value without the required level of accuracy or precision to be considered quantifiable.

- Determination of the appropriate method for upper prediction limit (UPL) analyses is determined based on the percent non-detects (%ND) for the data set and its distribution:

  - Datasets with 25% or less NDs – NDs of a data set are replaced with one-half the LOD or LOQ and the data set is tested for normality or lognormality. The parametric UPL approach is used for normal or lognormal data sets. A non-parametric approach is used for non-normal or non-lognormal data sets.

  - Datasets with % ND between 25% and 50% - the mean standard deviation of a data set is adjusted using Aitchison's or Cohen's adjustments, and then the data set is analyzed for normality or lognormality. The parametric UPL approach is used for adjusted normal or lognormal data sets. A non-parametric UPL approach is used for non-normal or non-lognormal data sets.

  - Data sets with %ND greater than 50% - these data sets are considered non parametric and therefore the non-parametric UPL approach is used.

  - 95% Prediction Interval Analysis is preformed.

- GPS were initially implemented at the Facility on May 23, 2001. On March 18, 2002, the VDEQ approved a final variance for establishing alternate concentration limits (ACLs) as GPS. Because the Facility is currently sampling on a semi-annual frequency, the statistical method of GPS analysis is a point comparison method. The point comparison method consists of a direct comparison of the semi-annual compliance data for a given constituent and well to the GPS. With this method, a statistically significant increase (SSI) above the GPS is indicated by at least one of the two samples having a concentration above the GPS.

- In the event that the facility is able to return to Phase I monitoring, statistical evaluation of the data would include intra-well analysis in addition to the inter-well analysis described above. As above, 95% prediction interval analyses would be used to evaluate significance. However, this analysis would compare individual well data to its own historical concentrations rather than the historical concentrations for the background wells.

Verification Sampling
In the event that statistical analysis of the test data identifies potential statistically significant increases in one or more parameters, the well or wells of concern will be resampled within 30 days of the completion of statistical analysis. Verification sampling must be performed within the same compliance period as the event being verified. Verification sampling shall be performed in accordance with the DEQ technical paper titled "Data Analysis for Solid Waste Facilities". Verification samples will be analyzed for the parameter or parameters of concern. If the verification sample remains statistically significant, then statistical significance will be considered verified and must be reported to the VDEQ within 14 days. If the verification sample is not statistically significant, then no statistical significance will be recorded for the monitoring event.

Records and Reports
The field equipment calibration records and field sampling sheets will be maintained in Dominion Environmental Biology Lab's files. The chain of custody will be maintained in the analyzing Lab's files. The analytical data will be stored in Dominion's Laboratory Information System (LIMS) database. A copy of the reports and correspondences will be sent to the facility and maintained in Dominion Electric Environmental Services' (EES) corporate files.

3.9 Statistical Analysis of Subsequent Well Data

The statistical tests used to evaluate the comparisons, including treatment of outliers, missing data, data below detection limits or quatification limits, and treatment of non-normally distributed data, shall be performed in accordance with the version of the DEQ technical paper "Data Analysis for Solid Waste Facilities" in effect at the time of statistical analysis of the data. A copy of the current Guidance (March 2008) is included in Appendix E.

At least annually, the permittee shall evaluate the data on static groundwater surface elevations to determine whether the requirements for locating the monitoring wells continue to be satisfied. If the evaluation shows that the requirements of the groundwater monitoring system are no longer satisfied, the permittee shall notify VDEQ for approval to immediately modify

the number, location, or depth of the monitoring wells to bring the groundwater monitoring system into compliance with that requirement.

Comparison with Subsequent Well Data

See section 3.8

Required Response Actions

In accordance with 9VAC20-80-300.C.4(e), the following actions are required for evaluating groundwater on a semi-annual basis:

- If background statistical analysis indicates no SSIs and all constituents are shown to be at or below background values for two consecutive sampling events, the Facility may petition to reinstate Phase I monitoring;
- If Phase II constituents are found to be above background values, but below GPS, the concentrations will be reported in the facility's semi-annual and annual report submission and the facility will remain in Phase II monitoring;
- If statistical analysis reveals the concentration of any Phase II constituent is above GPS, the Facility will notify the Department within 14 days of noting the exceedance. The notification will include a statement that within 90 days the Facility will:
    - Further characterize the nature and extent of a release by installing additional monitoring wells as necessary;
    - Install at least one additional groundwater monitoring well at the Facility boundary in the direction of contaminant migration;
    - Notify property owners of lands above which contaminant migration has occurred;
    - Initiate a corrective action program; or
    - Submit an alternate source determination

3.10 Groundwater Evaluation Data Interpretation

The permittee shall determine the elevation of the groundwater surface at each well each time groundwater is sampled to the nearest 0.01 foot. Groundwater level measurements are to be made within a 24 hour period. Because the aquifer may be tidally influenced, the facility shall endeavor to make all groundwater elevation measurements within a four hour window. A potentiometric map based on one of these monitoring events shall be submitted to the VDEQ each year. The rate and direction of groundwater flow shall be determined at and submitted with the Annual Groundwater Report. Additional potentiometric maps may need to be

submitted in some cases, i.e., if seasonal or other variations in the groundwater surface are encountered.

3.11 Record Keeping and Reporting

The permittee shall retain all monitoring, testing, and analytical data obtained throughout the active life of the facility and the post-closure care period.

The permittee shall report to the Director on an annual basis no later than March 1 following each calendar year:

- The concentrations or values of the parameters for each monitoring well along with appropriate evaluations as required.
- The results of the evaluation of groundwater surface elevations as required and a description of the response to these evaluations, where applicable.
- The results of the evaluation of the groundwater quality assessment program, to include, but not necessarily be limited to, the calculated or measured rate of migration of solid waste constituents in groundwater during the reporting period.

4.0 REFERENCES

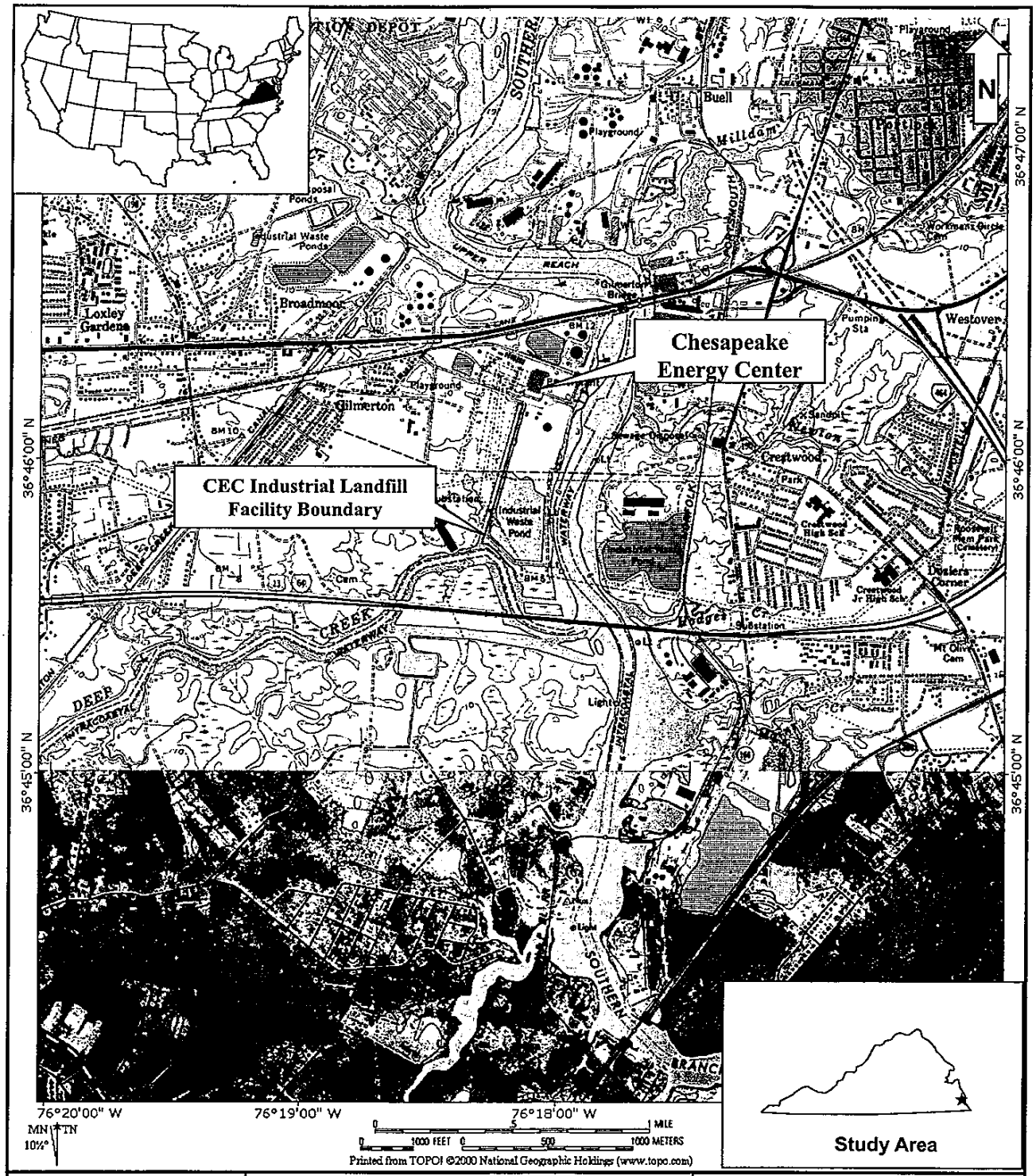
Dominion Electric Environmental Services, 2006. *Groundwater Monitoring Plan for Chesapeake Energy Center Permit No. 440 Landfill.*

Submission Instructions No. 11: Groundwater Monitoring and Sampling & Analysis Plans for Existing Regulated CDD & Industrial Landfills, VDEQ May 2003.

Virginia Solid Waste Management Regulations (VSWMR), 9VAC20-80-270.D & 9VAC20-80-300

United States Environmental Protection Agency (USEPA) protocol described in *RCRA Groundwater Monitoring Technical Enforcement Guidance Document.*

Virginia Department of Environmental Quality (VDEQ). Technical Paper: Data Analysis for Solid Waste Facilities. March 2008.



Source: USGS Quads, Norfolk South, Virginia 1986 and Deep Creek, Virginia, 1986 TOPO! ©2000 National Geographic Holdings WWW.TOPO.COM	Topographic Quadrangle Map			Figure 1a
	Date: December 2007		URS Project No.: 11656611	Chesapeake Energy Center Groundwater Monitoring Plan
	Drawn by: KAH	Checked by: KAH	Reviewed by: KAH / Approved by: JOS	URS CORPORATION 5540 FALMOUTH ST., SUITE 201 RICHMOND, VA 23230
	Scale: *As Shown*		File name: Fig 1 Topo Map	

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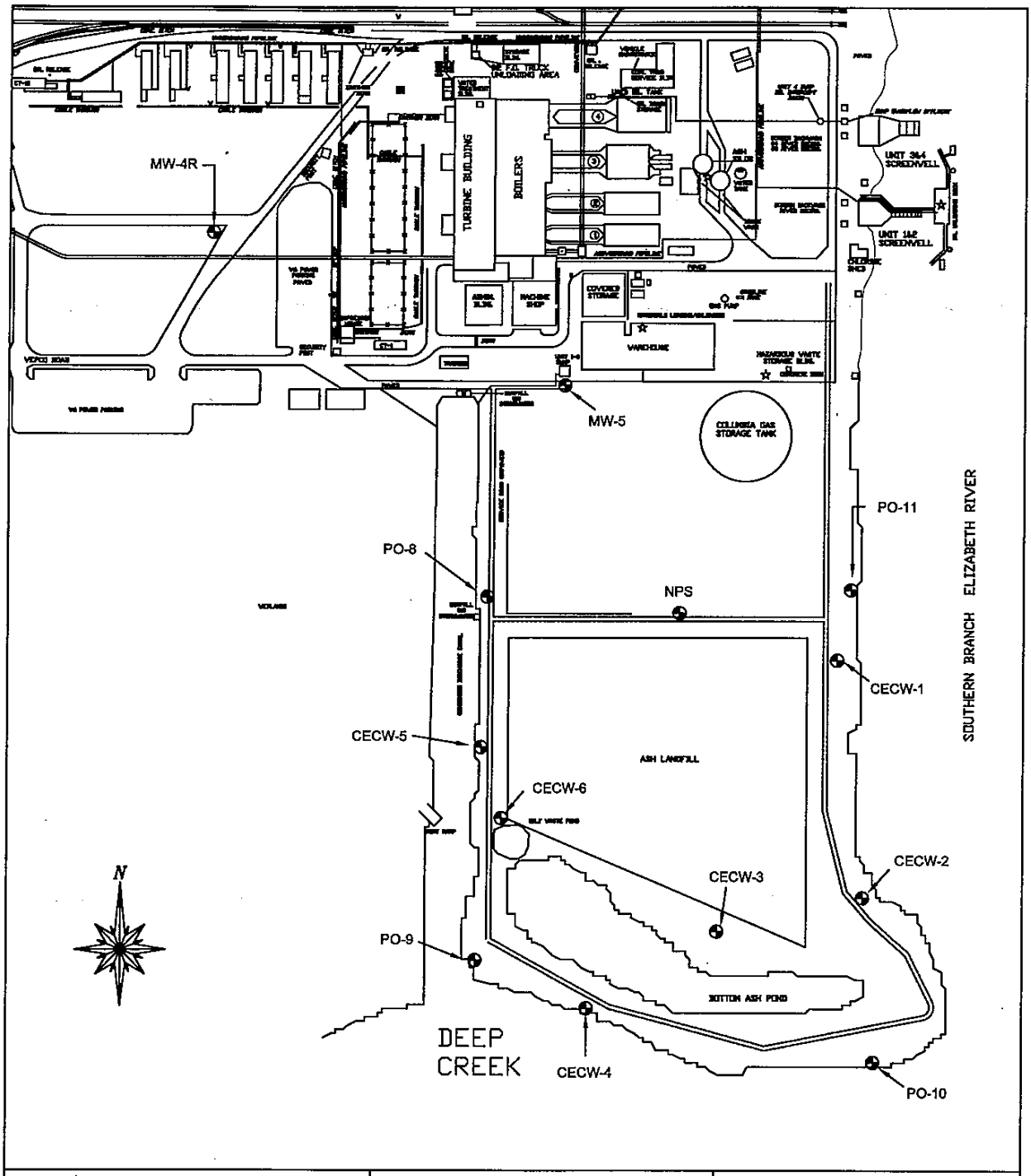


Legend

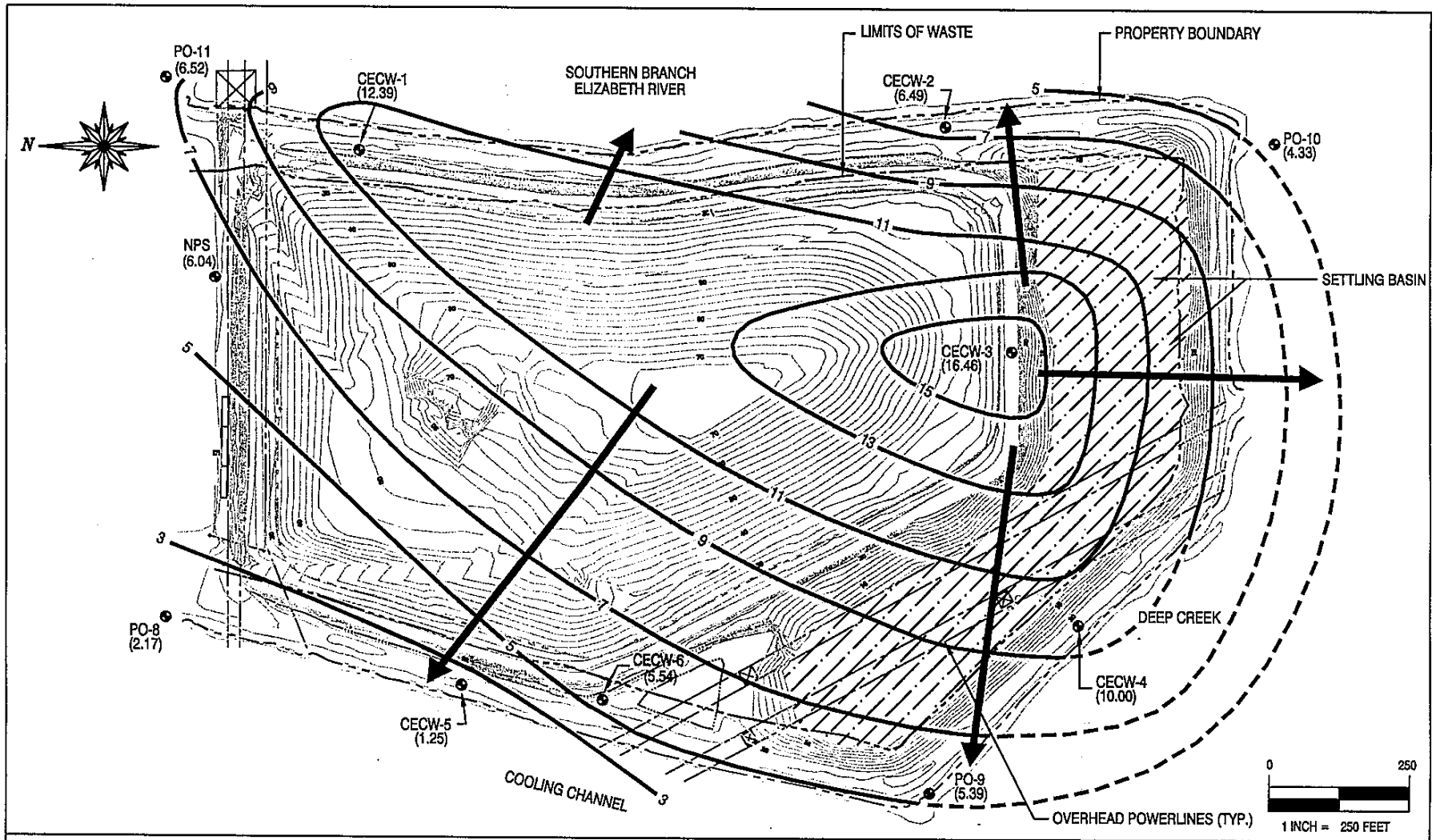
Approximate Monitoring Well Location

FIGURE 1b
Site Map with Well Locations

Date: January 2008	URS Project #: 11656611
Drawn By: DBC	Approved By: KAH
Scale: 1" = ~350'	File Name: Fig.1b SiteMap

Dominion Generation
CEC Landfill
City of Chesapeake, VA

URS Corporation
5540 Falmouth Street
Suite 201
Richmond, Virginia 23230



Legend

- Monitoring Well
- (2.17) September 2007 Groundwater Elevation (Feet MSL)
- Potentiometric Contour
- Inferred Potentiometric Contour
- —50— Topographic Contours (Feet MSL)
- Groundwater Flow Direction
- Property Boundary
- Overhead Powerlines
- Limits of Waste
- Settling Basin

FIGURE 2
2007 Potentiometric Surface Map

DATE: January 2008	DRAWN/REVIEWED BY: DBC/KAH
SCALE: 1"=250'	FILE NAME: 11656611

Dominion Generation
CEC Landfill
City of Chesapeake, VA

URS
URS CORPORATION
5540 FALMOUTH ST.,
SUITE 201
RICHMOND, VA 23230

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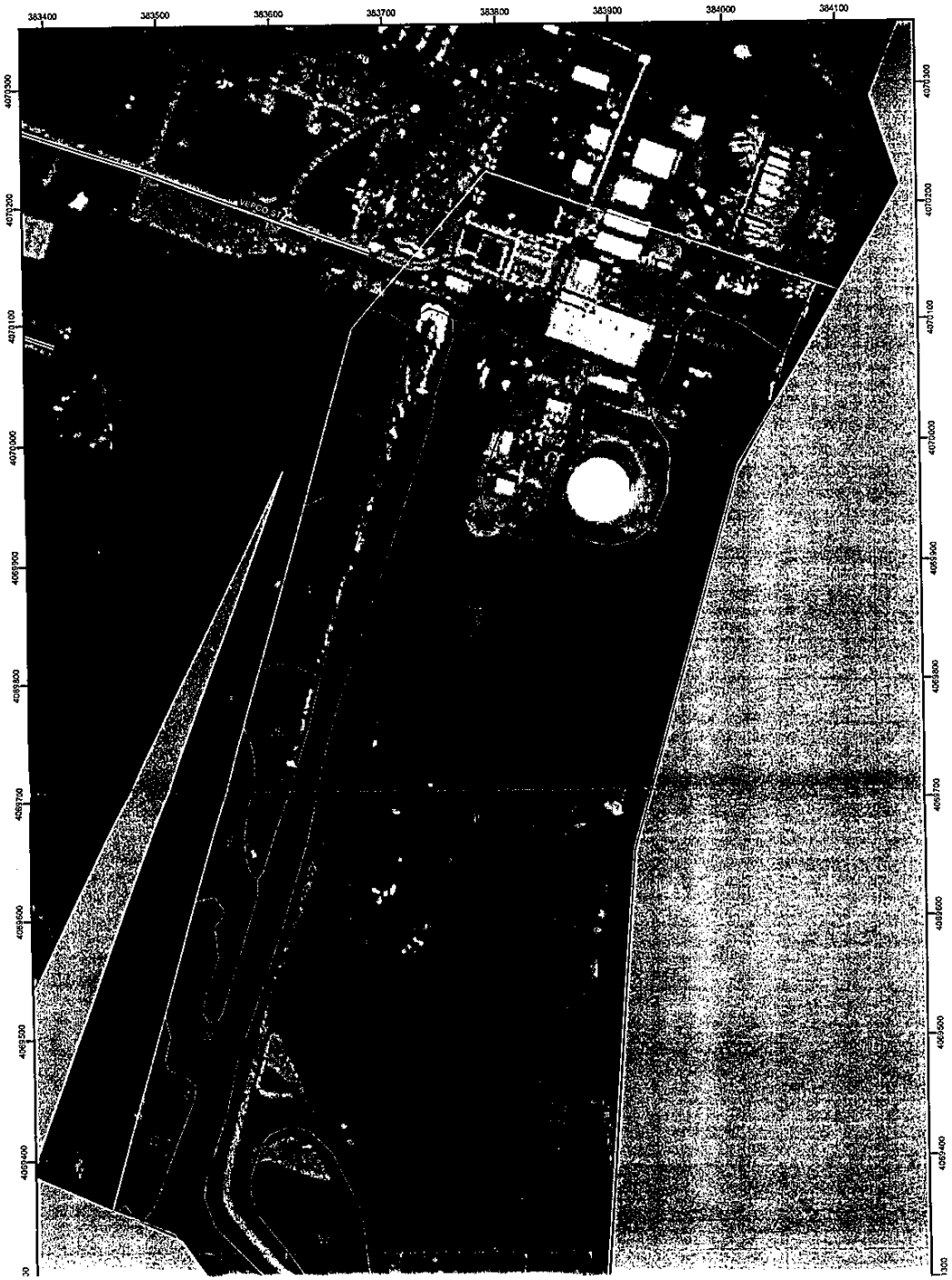
Figure 3. Soil Ma, .esapeake City, Virginia
(Chesapeake Energy Center Landfill)



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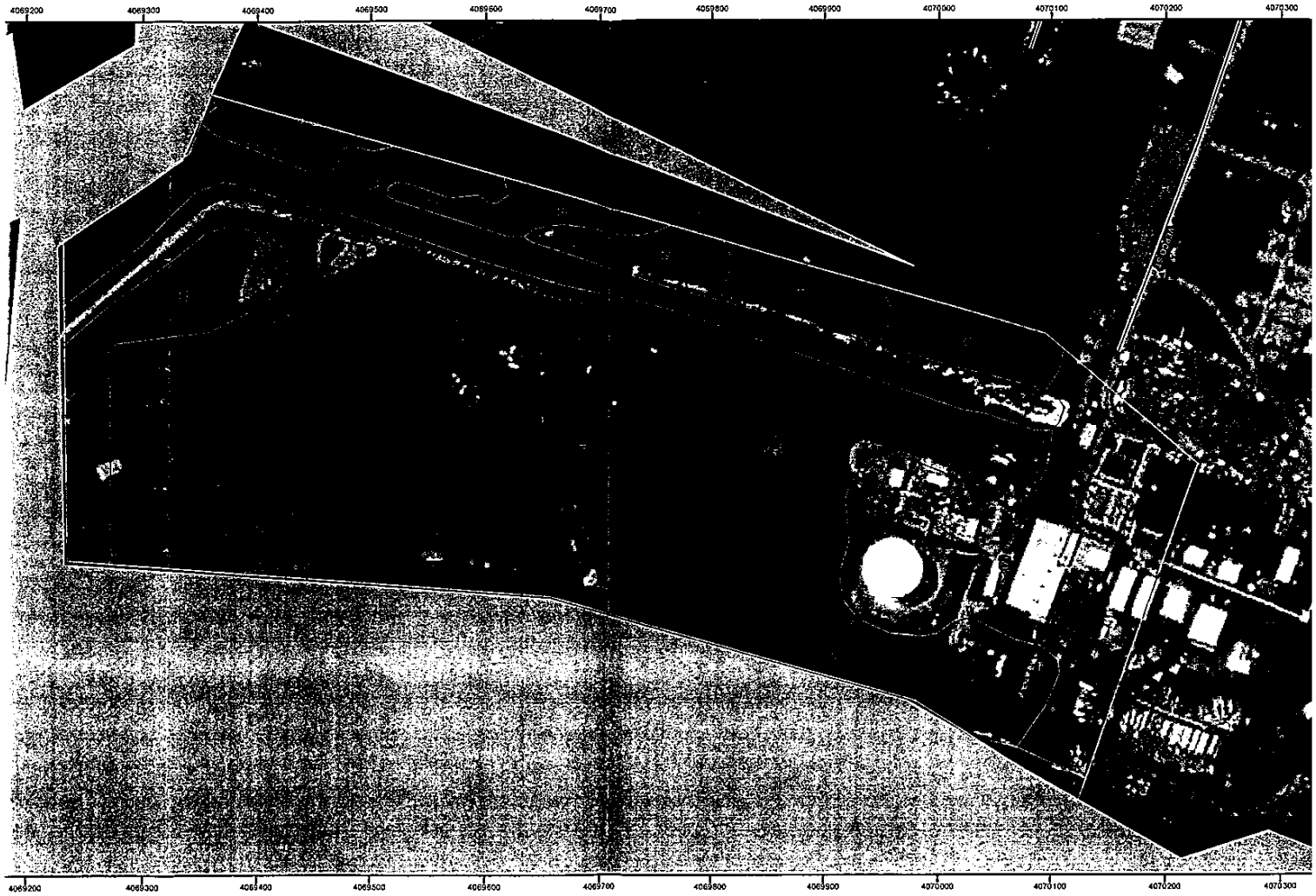
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MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features

- Gully
- Short Steep Slope
- Other

Political Features

Municipalities

- Cities
- Urban Areas

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails

Roads

- Interstate Highways
- US Routes
- State Highways
- Local Roads
- Other Roads

MAP INFORMATION

Original soil survey map sheets were prepared at publication scale. Viewing scale and printing scale, however, may vary from the original. Please rely on the bar scale on each map sheet for proper map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 18N

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Chesapeake City, Virginia
Survey Area Data: Version 8, Dec 20, 2007

Date(s) aerial images were photographed: 3/22/1994

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Chesapeake City, Virginia (VA550)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
19	Dragston fine sandy loam, 0 to 2 percent slopes	1.6	1.7%
25	Munden fine sandy loam, 0 to 2 percent slopes	1.8	1.9%
33	Pocaty mucky peat, 0 to 1 percent slope, very frequently flooded	2.1	2.2%
45	Tomotley-Nimmo complex, 0 to 1 percent slopes	2.0	2.1%
49	Udorthents-Urban land complex, 0 to 45 percent slopes	58.3	61.5%
50	Urban land, 0 to 5 percent slopes	14.7	15.5%
W	Water	14.3	15.1%
Totals for Area of Interest (AOI)		94.7	100.0%

Appendix A

Excerpts from 1999 Geotechnical Evaluation Report

Geotechnical Engineering Study
Ash Fill Expansion
Chesapeake Energy Center
2701 Vepco Street
Chesapeake, Virginia

Project 993318

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Geotechnical Engineering Study
Ash Fill Expansion
Chesapeake Energy Center
Chesapeake, Virginia

Project 993318

October 28, 1999

Prepared for:

Fossil and Hydro Technical Services
Innsbrook Technical Center
5000 Dominion Boulevard
Glen Allen, Virginia 23060

Prepared by:

Schnabel Engineering Associates, Inc.
One West Cary Street
Richmond, Virginia 23220

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EXECUTIVE SUMMARY

An existing ash fill is located in the southern part of Virginia Power's Chesapeake Energy Center facility in Chesapeake, Virginia. This ash fill area covers the original ash disposal pond where ash was sluiced from the power plant for disposal. The pond was converted to a dry ash fill and a geosynthetic liner was installed inside the new dike and on the dike slopes. The dry ash fill was initially permitted by the DEQ for 6H:1V ash slopes and a top grade at El 51. In 1991 a top grade of about El 89 with the same slopes was permitted. Virginia Power wants to steepen the fill slopes to raise the height of the fill above its current permitted height.

The geologic stratigraphy from the ground surface down, typically consists of Existing Fill, Recent Alluvial Deposits, the Norfolk Formation, and the Yorktown Formation. The existing fill soils were placed to construct the berms and roads surrounding the ash pond, and also consist of the ash fill already placed at the facility.

Laboratory tests were performed on selected soil samples and direct shear interface testing was performed on selected materials proposed for the cap systems. Based on boring data, laboratory test results, and our previous experience, we selected design parameters for use in our analyses.

Our geotechnical engineering analyses indicate that the proposed landfill design with 3H:1V final slopes and 2 ft high berms is suitable for the proposed maximum height of the landfill to El 160. Our stability analyses indicate adequate factors of safety. Our settlement calculations do not indicate settlement-induced stresses that will jeopardize the integrity of the existing liner or proposed cap system. Our engineering evaluations considered foundation settlements and calculated strain on the existing liner, static slope stability and seismic (pseudo-static) slope stability.

Please read the report in its entirety to obtain our detailed recommendations.

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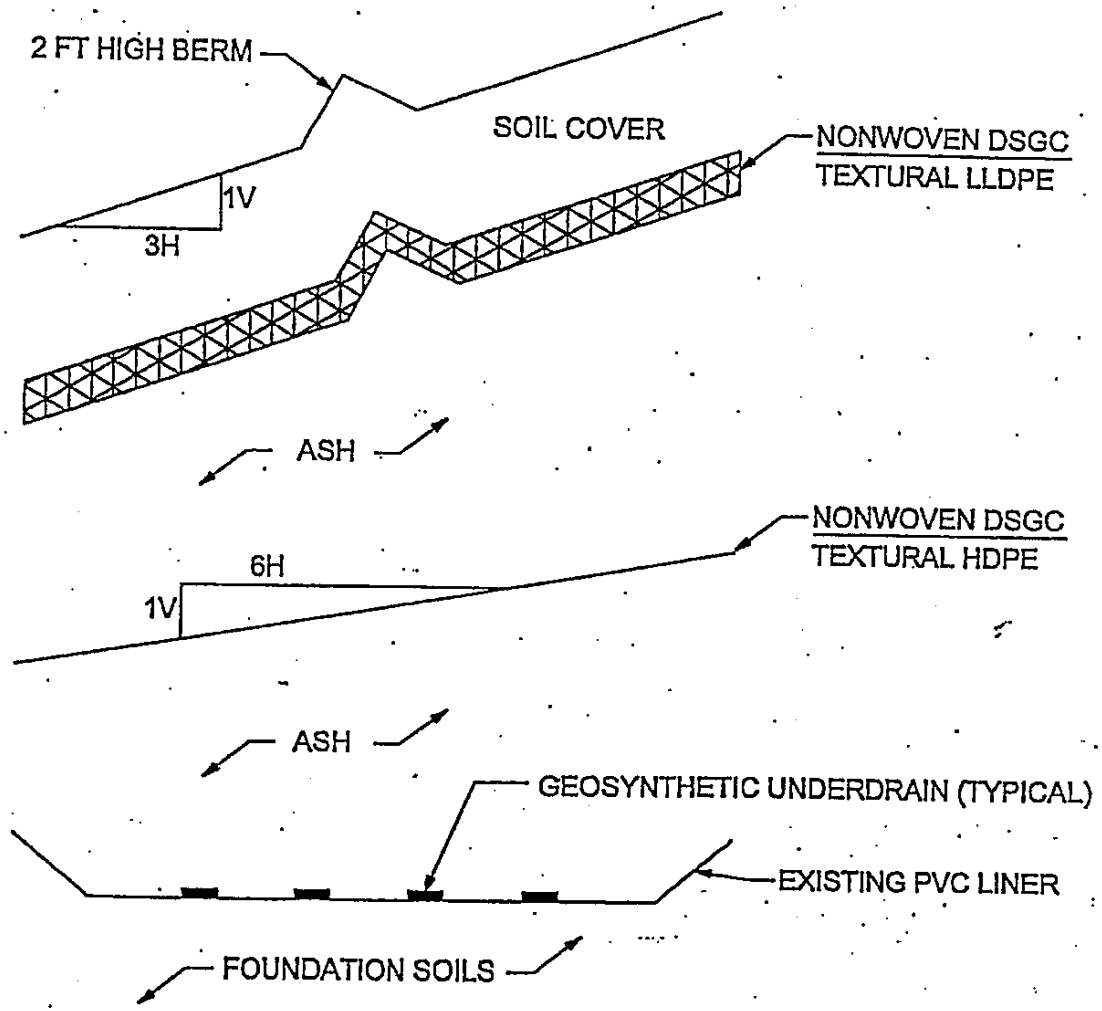
Appendix A: Subsurface Exploration Data
Appendix B: Soil Laboratory Test Results
Appendix C: Engineering Calculations

FIGURE 1

ASH FILL EXPANSION
CHESAPEAKE ENERGY CENTER
CHESAPEAKE, VIRGINIA

LANDFILL TYPICAL SECTION

NOT TO SCALE



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2 DATA COLLECTION AND ANALYSIS

2.1 Geology

The geologic stratigraphy from the ground surface down, typically consists of Existing Fill, Recent Alluvial Deposits, the Norfolk Formation, and the Yorktown Formation. These existing fill soils were placed to construct the berms and roads surrounding the ash pond, and also consist of the ash fill already placed at the facility.

The existing fill soils are underlain by Recent Alluvial deposits of the Elizabeth River and Pleistocene age deposits of the Norfolk Formation. These deposits typically consist of soft clays and loose sands. The clay soils are generally highly compressible.

The Norfolk Formation is underlain by the late Miocene to early Pliocene age Yorktown Formation. The Yorktown Formation is moderately preconsolidated and exhibits high strength.

2.2 Data Collection Techniques

Fishburne Drilling of Chesapeake, Virginia drilled sixteen test borings at this site under our observation. In addition to these borings we drilled eight borings in 1980. Specific observations, remarks, and logs for the borings, classification criteria and sampling protocols are included in Appendix A. Approximate test boring locations are shown in Figure A1 in Appendix A. Soil samples will be retained up to 45 days beyond the issuance of this report, unless other disposition is requested.

Our geotechnical laboratory conducted tests on selected samples obtained in the test borings. This testing aided in the classification of soils encountered in the subsurface exploration and provided data for use in the development of foundation and earthwork recommendations. The natural moisture content values of selected soil samples are

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Consulting Geotechnical Engineers

IDENTIFICATION OF SOILS

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I. DEFINITION OF SOIL GROUP NAMES (ASTM D-2487-83)

			SYMBOL	GROUP NAME
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels – More than 50% of coarse fraction retained on No. 4 sieve Coarse, ¾" to 3" Fine, No. 4 to ¾"	Clean Gravels Less than 5% fines	GW	Well graded gravel
			GP	Poorly graded gravel
		Gravels with fines More than 12% fines	GM	Silty gravel
			GC	Clayey gravel
	Sands – 50% or more of coarse Fraction passes No. 4 sieve Coarse, No. 40 to No. 4 Medium, No. 40 to No. 10 Fine, No. 200 to No. 40	Clean Sands Less than 5% fines	SW	Well-graded sand
			SP	Poorly graded sand
		Sands with fines More than 12% fines	SM	Silty sand
			SC	Clayey sand
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays – Liquid Limit less than 50 Low to medium plasticity	Inorganic	CL	Lean clay
			ML	Silt
		Organic	OL	Organic clay
				Organic silt
	Silts and Clays – Liquid Limit 50 or more Medium to high plasticity	Inorganic	CH	Fat clay
			MH	Elastic silt
		Organic	OH	Organic clay
				Organic silt
Highly Organic Soils	Primarily organic matter, dark in color and organic odor		PT	Peat

II. DEFINITION OF MINOR SOIL COMPONENT PROPORTIONS

Adjective Form			Examples
	Gravelly Sandy	30% or more coarse grained	Gravelly lean clay
"With"	With gravel With sand	15% or more coarse grained	Fat clay with gravel
	With silt With clay	5% to 12% fine grained	Poorly graded sand with silt
"Trace"	Trace gravel Trace sand	1% to 15% coarse grained	Silty sand, trace gravel
	Trace clay Trace silt	1% to 5% fine grained	Poorly graded sand, trace clay

III. GLOSSARY OF MISCELLANEOUS TERMS

SYMBOLS ..... Unified Soil Classification Symbols are shown above as group symbols. Dual symbols are used for borderline classifications.

BOULDERS & COBBLES..... Boulders are considered rounded pieces of rock larger than 12 inches, while cobbles range from 3 to 12 inch size.

DISINTEGRATED ROCK..... Residual rock materials with a standard penetration resistance (SPT) between 60 blows per foot and refusal. Refusal is defined as a SPT of 100 blows for 2" or less penetration.

ROCK FRAGMENTS ..... Angular pieces of rock, distinguished from transported gravel, which have separated from original vein c strata and are present in a soil matrix.

QUARTZ ..... A hard silica mineral often found in residual soils.

IRONITE ..... Iron oxide deposited within a soil layer forming cemented deposits.

CEMENTED SAND..... Usually localized rock-like deposits within a soil stratum composed of sand grains cemented by calcium

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GENERAL NOTES FOR SUBSURFACE EXPLORATION LOGS

1. Numbers in sampling data column next to Standard Penetration Test (SPT) symbols indicate blows required to drive a 2 inch O.D., 1-3/8 inch I.D. sampling spoon 6 inches using a 140 pound hammer falling 30 inches. The Standard Penetration Test (SPT) N value is the number of blows required to drive the sampler 12 inches, after a 6 inch seating interval. The Standard Penetration Test is performed in accordance with ASTM-1586.

2. Visual classification of soil is in accordance with terminology set forth in "Identification of Soil." The ASTM D-2487 group symbols (e.g. CL) shown in the classification column are based on visual observations.

3. Estimated ground water levels indicated by ▽; these levels are only estimates from available data and may vary with precipitation, porosity of the soil, site topography, etc.

4. Refusal at the surface of rock, boulder, or obstruction is defined as an SPT resistance of 100 blows for 2 inches or less of penetration.

5. The logs and related information depict subsurface conditions only at the specific locations and at the particular time when drilled or excavated. Soil conditions at other locations may differ from conditions occurring at these locations. Also, the passage of time may result in a change in the subsurface soil and ground water conditions at the test boring, test pit and/or hand auger locations.

6. The stratification lines represent the approximate boundary between soil and rock types as obtained from the subsurface exploration. Some variation may also be expected vertically between samples taken. The soil profile, water level observations and penetration resistances presented on these logs have been made with reasonable care and accuracy and must be considered only an approximate representation of subsurface conditions to be encountered at the particular location.

7. Key to symbols and abbreviations:

▮	5+10+15	Standard Penetration Test
▮	3T 24/18	2" or 3" Undisturbed Tube Sample Length Pushed/Recovery (in inches)
		Rock Core Sample Core Diamater Size/Recovery %/RQD%
w		Water Content
Do		Ditto
WOW		Water Observation Well

Stratum A1 (DIKE FILL): This stratum consists of soft to stiff consistency sandy lean clay FILL and sandy fat clay FILL. This soil stratum is observed in Borings B-1 through B-3, B-5 and B-6. The fill soils encountered in this stratum contain organic matter and trace gravel. Stratum A1 was encountered below Stratum A2 and A3 to depths of about 2 to 12 ft.

Stratum A2 (DIKE FILL): This stratum consists of very loose to compact density silty sand FILL, clayey sand FILL and poorly graded sand FILL. The fill soils encountered in this stratum contain organic matter, crushed stone and shell fragments. Stratum A2 was encountered from the ground surface to about 20 ft below and interbedded with Stratum A1 and A3.

Stratum A3 (ASH FILL): This stratum consists of very loose to firm density FLY ASH FILL, classifying generally as silty sand with some layers classifying as clayey sand, poorly graded sand, and very soft to very stiff consistency sandy silt. The fill soils of this stratum contain shell fragments and trace gravel. Stratum A3 was encountered from the ground surface to depths of about 30 ft below and interbedded with Stratum A1 and A2.

Two consolidation tests were performed on samples representing Stratum A3. Test results indicate this material is preconsolidated to about 2 to 4 tsf, or about 1-2 tsf above the existing overburden pressure. Compression and Recompression ratios of 0.055 to 0.061 and 0.004 to 0.006 were also obtained from this test.

We performed a series of consolidated-undrained triaxial shear tests on samples representing Stratum A3. These tests indicated total and effective angles of internal friction of 23 and 33 degrees, respectively. These tests also indicated total and effective cohesion values of about 1,000 psf and 0 psf, respectively.

Stratum B1 (RECENT ALLUVIUM): This stratum consists of very soft to stiff consistency LEAN CLAY (CL) AND FAT CLAY (CH) soils. The soils of this stratum contain trace amounts of organic matter. Stratum B1 can be found below Strata A1, A2

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SUBSURFACE EXPLORATION PROCEDURES

Test Boring Procedures

The borings were advanced using mud rotary drilling methods. At the designated depth drillers performed the Standard Penetration Test, as defined below.

Standard Penetration Test Results

The numbers in the Sampling Data column of the boring logs represent Standard Penetration Test (SPT) results. Each number represents the blows needed to drive a 2-inch O.D., 1-3/8 inch I.D. split-spoon sampler 6 inches, using a 140-pound hammer falling 30 inches. The sampler is typically driven a total of 18 inches. The first 6 inches are considered a seating interval. The total of the number of blows for the second and third 6-inch intervals is the SPT "N value". The Standard Penetration Test is conducted according to ASTM D-1586.

Soil Classification Criteria

The group symbols on the boring logs represent the Unified Soil Classification System Group Symbols (ASTM D-2487) based on visual observation and limited laboratory testing of the samples. Criteria for visual identification of soil samples are included in this appendix. Some variation may be expected between samples visually classified and samples classified in the laboratory.

Pocket Penetrometer Results

The values following "PP=" in the sampling data column of the logs represent pocket penetrometer readings. Pocket penetrometer readings provide an estimate of the unconfined compressive strength of fine-grained soils.

The ground water levels on the logs show our estimate of the hydrostatic water table at the time the borings were drilled. Fluctuations in the hydrostatic water table should be anticipated depending on variations in precipitation, surface runoff, pumping, tidal action, evaporation, leaking utilities, stream levels and similar factors.

2.5 Design Parameters

2.5.1 Soil Properties

Based on boring data, laboratory test results, and our previous experience, we selected design parameters for use in our analyses as shown in Table 1. These properties were used in our engineering analyses which are included in Appendix C.

The properties we selected, where correlations were used, are considered conservative. For example, the consolidated undrained triaxial strength test results indicated an undrained cohesion for the fine-grained Norfolk Formation of 1150 psf. In our analyses, we used an undrained cohesion of 250 psf since the clay is soft (N values 2 to 5) with pocket penetrometer readings less than or equal to 0.5 tsf. Another example to illustrate conservative values are indicated by the internal angle of friction values we used for the coarse-grained alluvium. Again, as these soils are loose (N values 1 to 2) and given that it is impractical to obtain an undisturbed sample of this material, we used a value of 27 degrees for the internal angle of friction which correlates with the low N values for the very loose sands in this stratum.

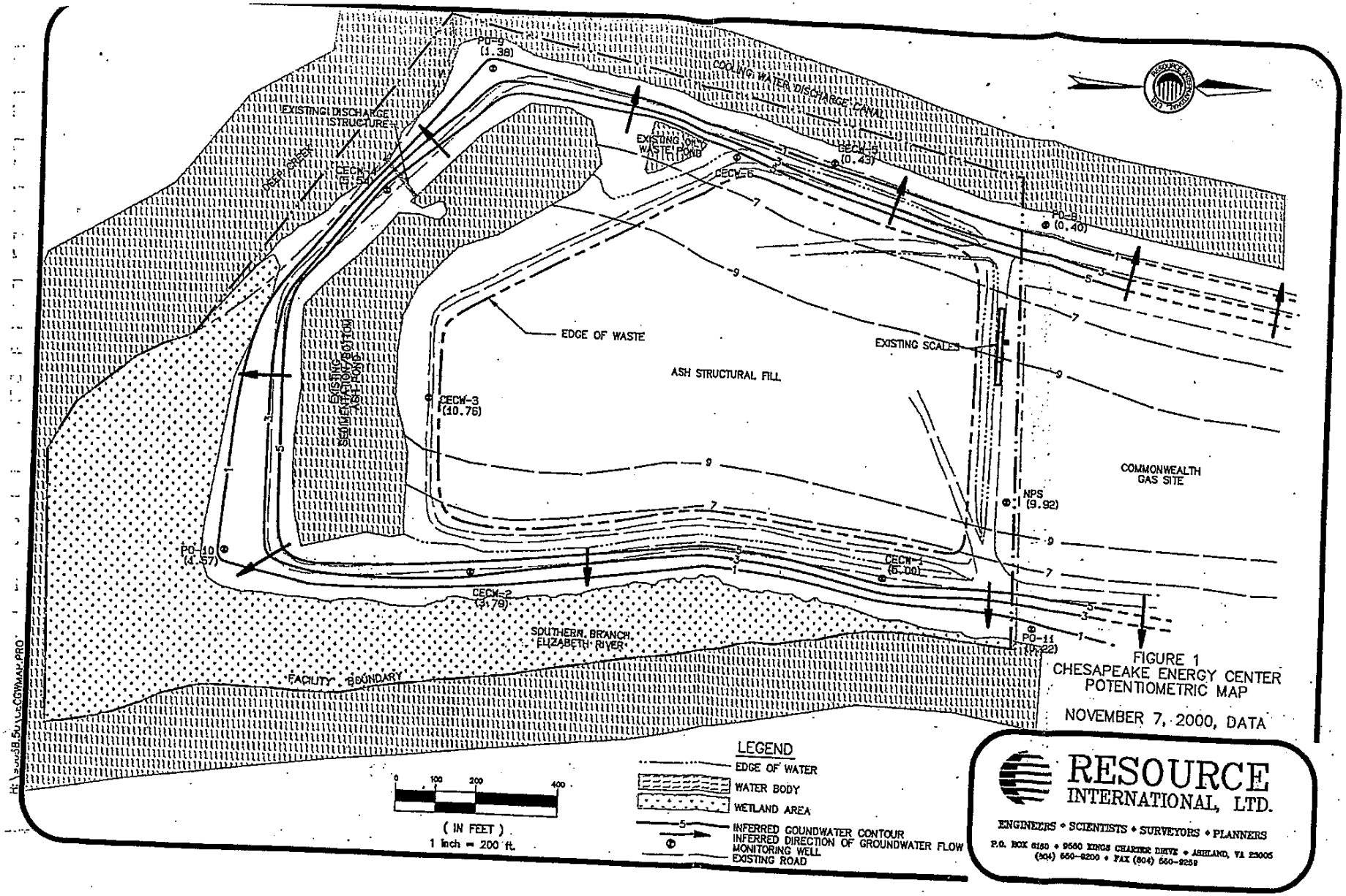
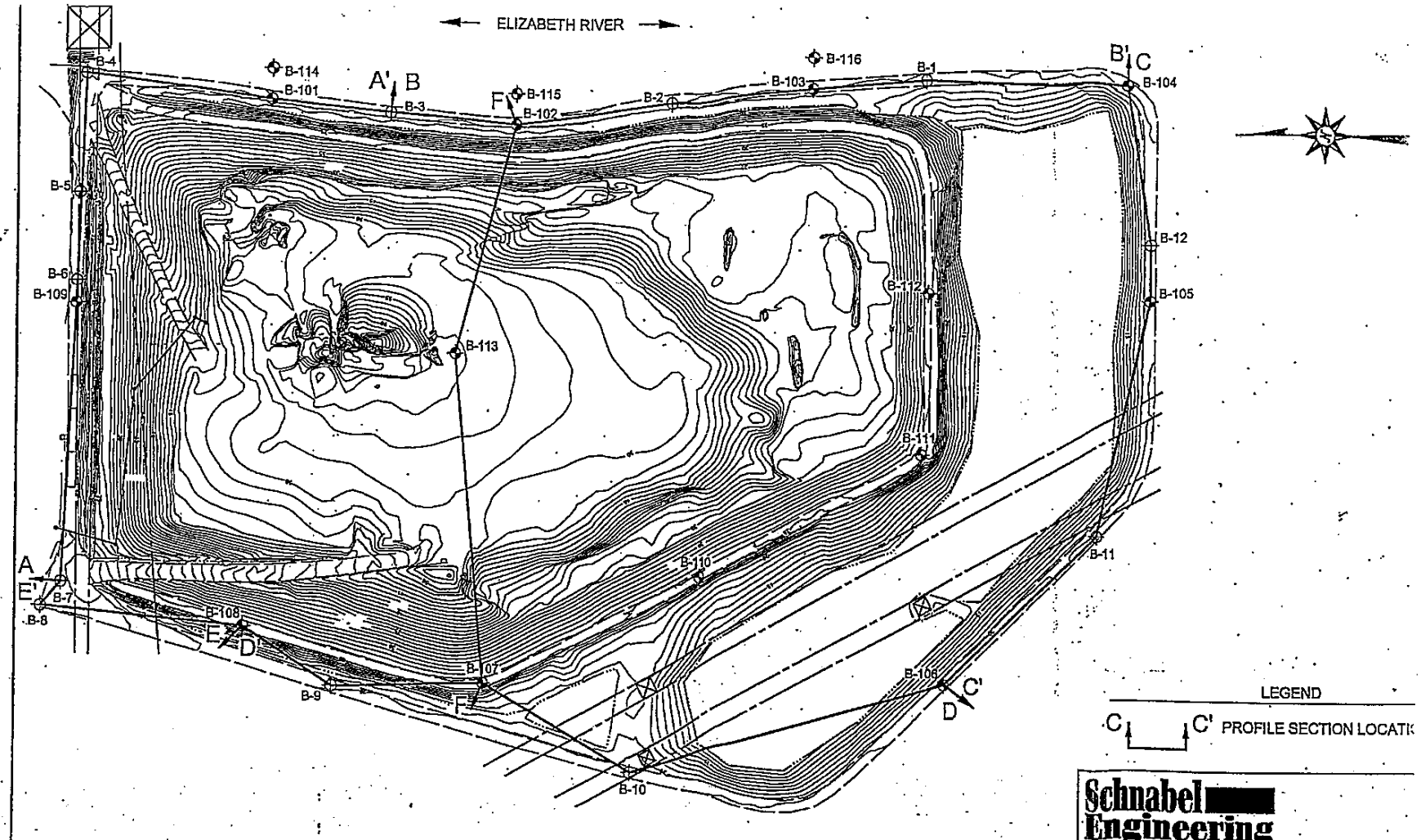


FIGURE 1
CHESAPEAKE ENERGY CENTER
POTENTIOMETRIC MAP

NOVEMBER 7, 2000, DATA

41850

41851



NOTE: BASE PLAN TAKEN AFTER PHASE I GRADING PLAN
BY RESOURCE INTERNATIONAL, 8-2-99.

LEGEND

C C' PROFILE SECTION LOCATI

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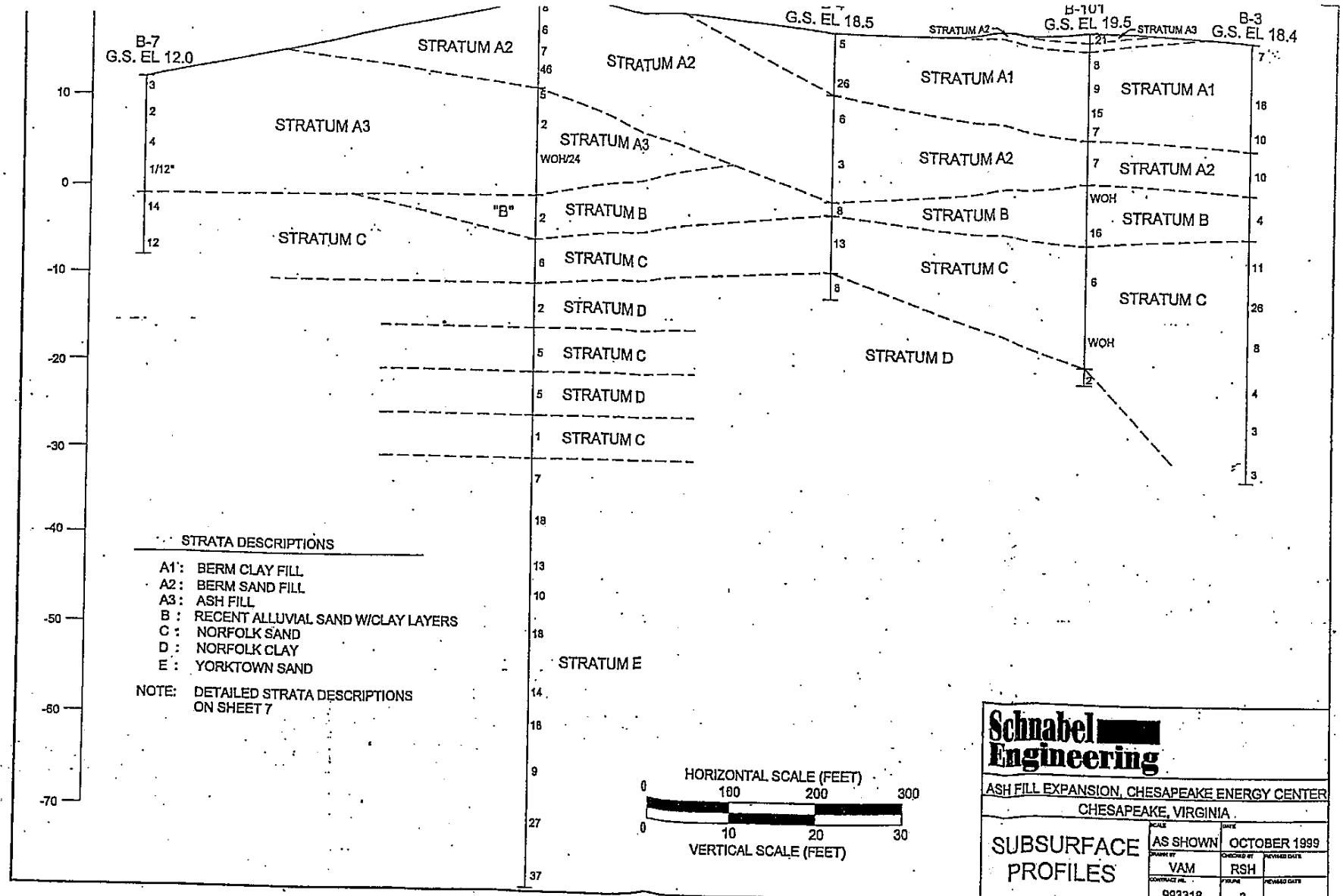
ASH FILL EXPANSION, CHESAPEAKE ENERGY CE
CHESAPEAKE, VIRGINIA

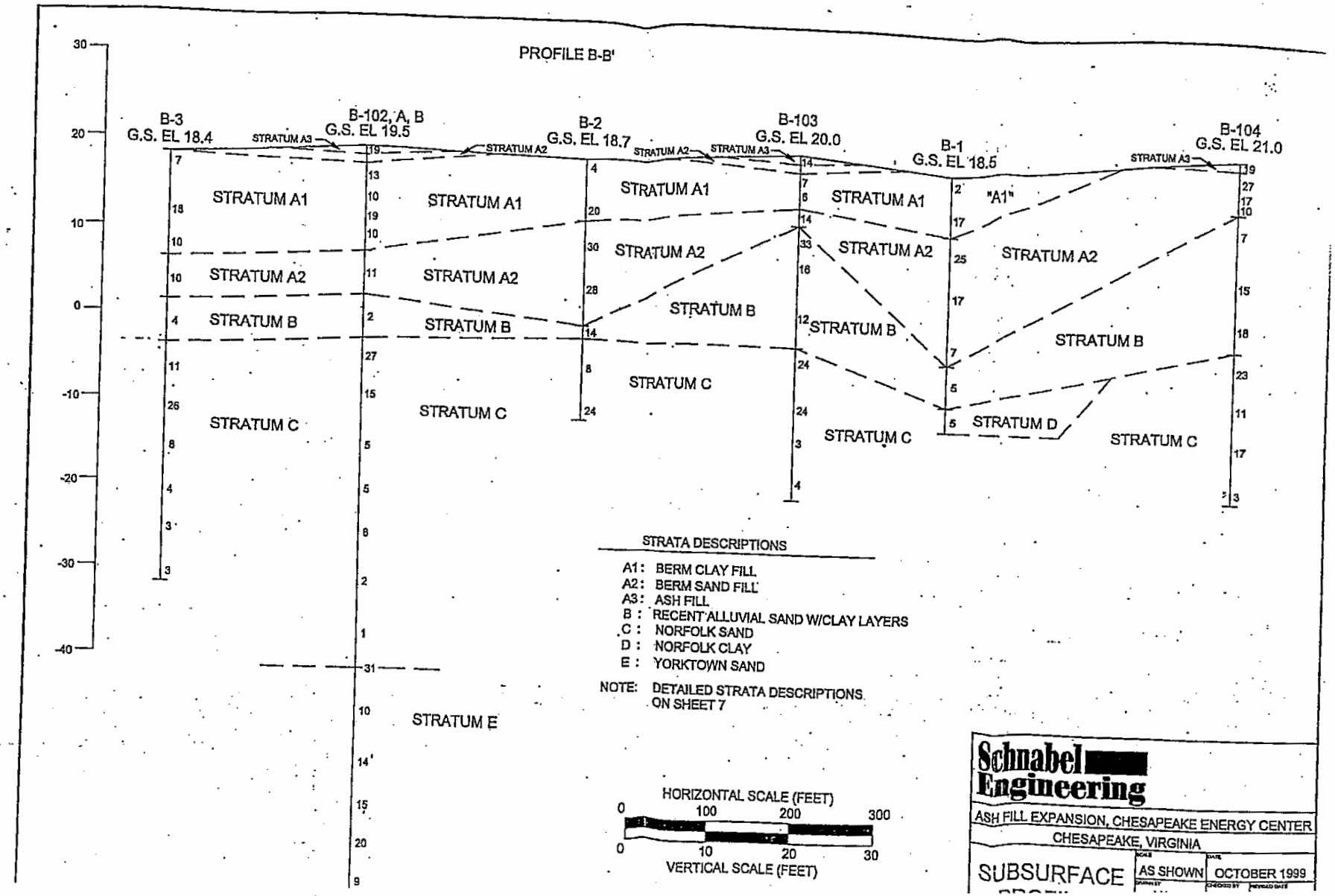
LOCATION PLAN

SCALE	DATE
1"=150'	OCTOBEF
DRAWN BY VAM	CHECKED BY RSH
CONTRACT NO. 993318	FIGURE 2

41852


B-7
G.S. EL 12.0
B-101
G.S. EL 19.5
B-3
G.S. EL 18.4
G.S. EL 18.5
STRATUM A2
STRATUM A3
STRATUM A1
STRATUM B
STRATUM C
STRATUM D
STRATUM E
"B"
WOH/24
WOH
1/12"
10
0
-10
-20
-30
-40
-50
-60
-70
STRATA DESCRIPTIONS
A1 : BERM CLAY FILL
A2 : BERM SAND FILL
A3 : ASH FILL
B : RECENT ALLUVIAL SAND W/CLAY LAYERS
C : NORFOLK SAND
D : NORFOLK CLAY
E : YORKTOWN SAND
NOTE: DETAILED STRATA DESCRIPTIONS ON SHEET 7
HORIZONTAL SCALE (FEET)
0 100 200 300
0 10 20 30
VERTICAL SCALE (FEET)
Schnabel Engineering
ASH FILL EXPANSION, CHESAPEAKE ENERGY CENTER
CHESAPEAKE, VIRGINIA
SUBSURFACE PROFILES
SCALE AS SHOWN
DATE OCTOBER 1999
DRAWN BY VAM
CHECKED BY RSH
REVISED DATE
CONTRACT NO. 993318
FIGURE 3
REVISED DATE

41853


PROFILE B-B'
B-3
G.S. EL 18.4
B-102, A, B
G.S. EL 19.5
B-2
G.S. EL 18.7
B-103
G.S. EL 20.0
B-1
G.S. EL 18.5
B-104
G.S. EL 21.0
STRATUM A3
STRATUM A2
STRATUM A1
"A1"
STRATUM B
STRATUM C
STRATUM D
STRATUM E
30
20
10
0
-10
-20
-30
-40
STRATA DESCRIPTIONS
A1: BERM CLAY FILL
A2: BERM SAND FILL
A3: ASH FILL
B: RECENT ALLUVIAL SAND W/CLAY LAYERS
C: NORFOLK SAND
D: NORFOLK CLAY
E: YORKTOWN SAND
NOTE: DETAILED STRATA DESCRIPTIONS ON SHEET 7
HORIZONTAL SCALE (FEET)
0 100 200 300
0 10 20 30
VERTICAL SCALE (FEET)
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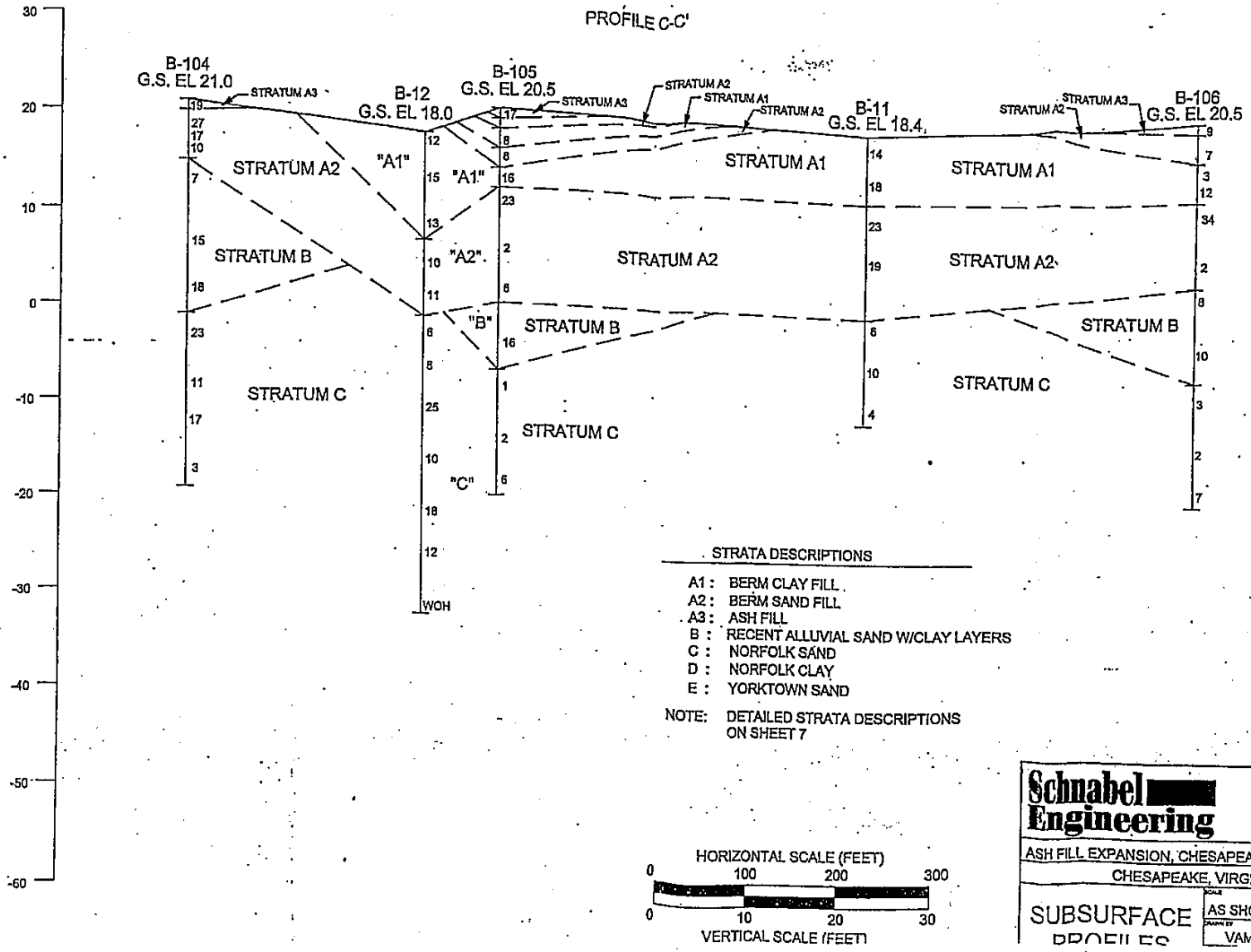
ASH FILL EXPANSION, CHESAPEAKE ENERGY CENTER
CHESAPEAKE, VIRGINIA
SUBSURFACE
AS SHOWN
OCTOBER 1999

41854



STRATA DESCRIPTIONS

A1 : BERM CLAY FILL
A2 : BERM SAND FILL
A3 : ASH FILL
B : RECENT ALLUVIAL SAND W/CLAY LAYERS
C : NORFOLK SAND
D : NORFOLK CLAY
E : YORKTOWN SAND

NOTE: DETAILED STRATA DESCRIPTIONS ON SHEET 7

HORIZONTAL SCALE (FEET)
0 100 200 300
0 10 20 30
VERTICAL SCALE (FEET)

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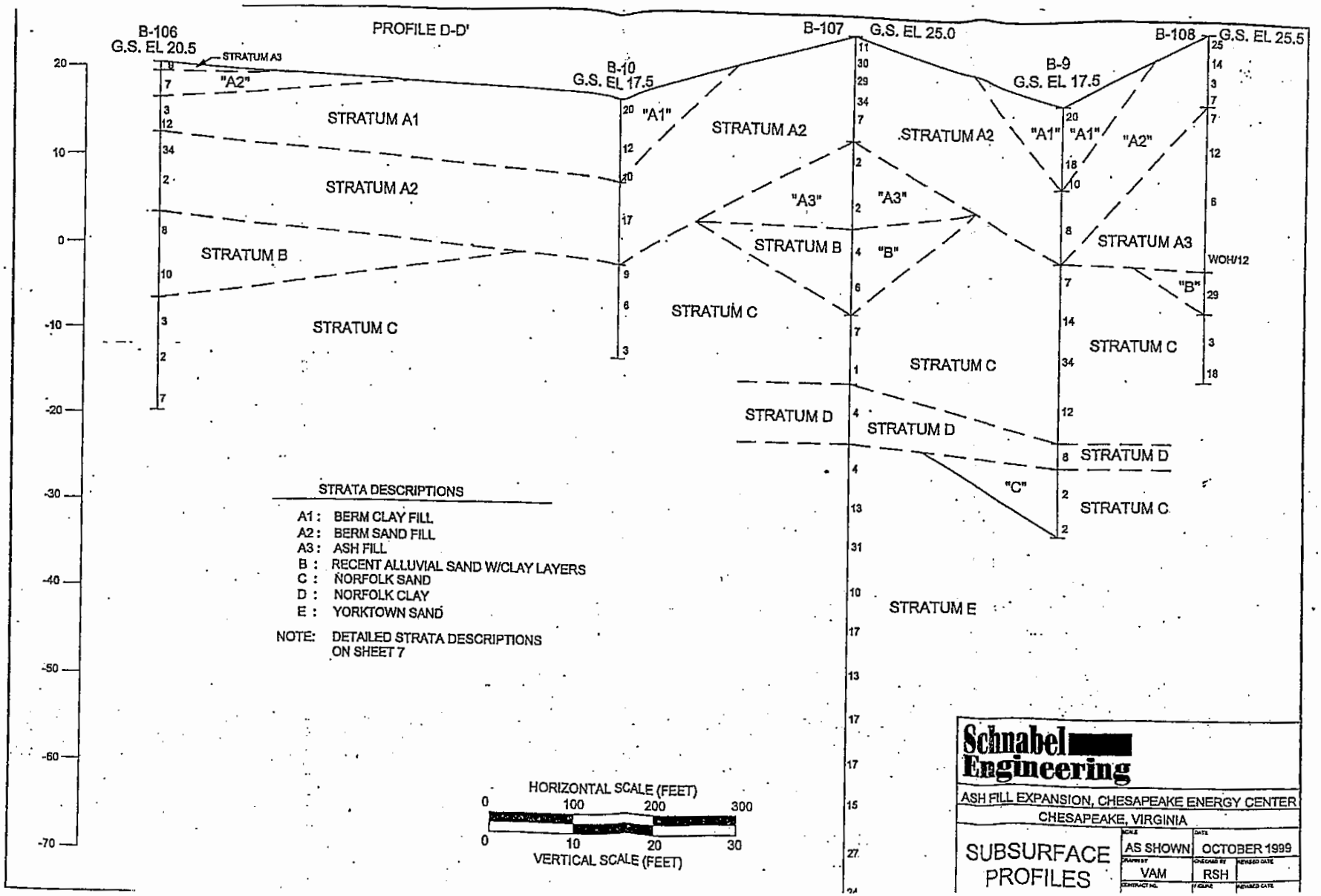
ASH FILL EXPANSION, CHESAPEAKE ENERGY CENTER
CHESAPEAKE, VIRGINIA

SUBSURFACE PROFILES

SCALE	DATE
AS SHOWN	OCTOBER 1999
DRAWN BY VAM	CHECKED BY RSH

41855


PROFILE D-D'
B-106
G.S. EL 20.5
B-10
G.S. EL 17.5
B-107
G.S. EL 25.0
B-9
G.S. EL 17.5
B-108
G.S. EL 25.5
STRATUM A3
"A2"
STRATUM A1
STRATUM A2
STRATUM B
STRATUM C
"A1"
"A3"
"B"
"C"
STRATUM D
STRATUM E
WOH/12
20
10
0
-10
-20
-30
-40
-50
-60
-70
STRATA DESCRIPTIONS
A1 : BERM CLAY FILL
A2 : BERM SAND FILL
A3 : ASH FILL
B : RECENT ALLUVIAL SAND W/CLAY LAYERS
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D : NORFOLK CLAY
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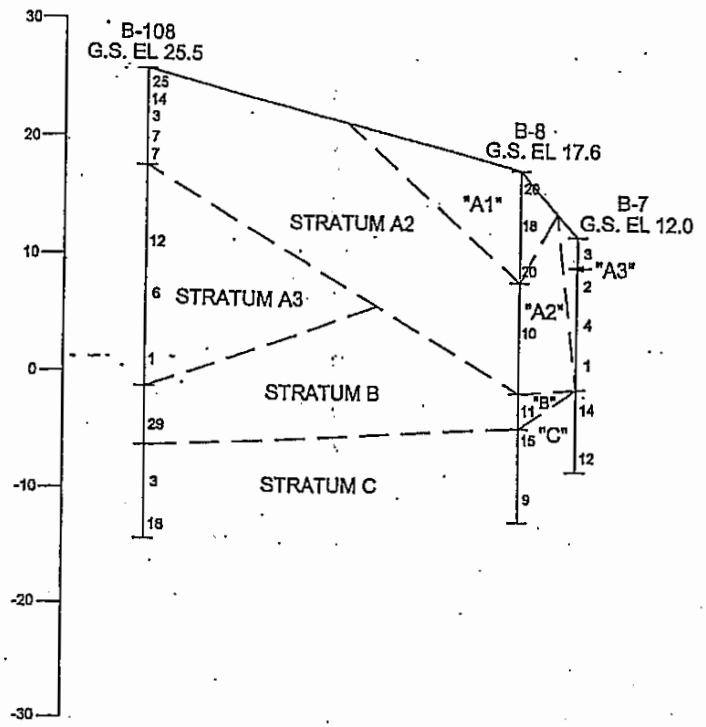
NOTE: DETAILED STRATA DESCRIPTIONS ON SHEET 7
HORIZONTAL SCALE (FEET)
0 100 200 300
0 10 20 30
VERTICAL SCALE (FEET)
Schnabel Engineering
ASH FILL EXPANSION, CHESAPEAKE ENERGY CENTER
CHESAPEAKE, VIRGINIA
SUBSURFACE PROFILES
SCALE AS SHOWN
DATE OCTOBER 1999
DRAWN BY VAM
CHECKED BY RSH

PROFILE E-E'



Stratum A1: (Berm) Soft to stiff consistency sandy lean clay FILL and sandy fat clay FILL containing organic matter and trace gravel. Stratum A1 represents existing Berm Fill.

Stratum A2: (Berm) Very loose to compact density silty sand FILL, clayey sand FILL and poorly graded sand FILL containing organic matter, crushed stone and shell fragments. Stratum A2 represents existing Berm Fill.

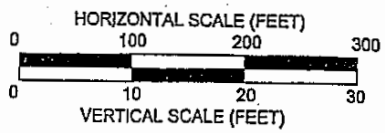
Stratum A3: (Ash) Very loose to firm density silty sand FLY ASH FILL, clayey sand FLY ASH FILL, poorly graded sand FLY ASH FILL and also very soft to very stiff consistency sandy silt FLY ASH FILL containing shell fragments and trace gravel. Stratum A3 represents existing Fly Ash Fill.

Stratum B: (Recent Alluvium) Very loose to firm density SILTY SAND (SM), CLAYEY SAND (SC) and also very soft to stiff consistency LEAN CLAY (CL) AND FAT CLAY (CH) soils containing organic matter. Stratum B represents the Recent Alluvial soils.

Stratum C: (Norfolk) Very loose to compact density CLAYEY SAND (SC), SILTY SAND (SM) and POORLY GRADED SAND WITH SILT (SP-SM) soils. Stratum C represents the coarse-grained portion of the Norfolk Formation.

Stratum D: (Norfolk) Very soft to medium stiff consistency LEAN CLAY (CL) and FAT CLAY (CH) soils with various amounts of sand. Stratum D represents the fine-grained portion of the Norfolk Formation.

Stratum E: (Yorktown) Very loose to compact density SILTY SAND (SM), CLAYEY SAND (SC) and POORLY GRADED SAND WITH SILT (SP-SM) soils. Stratum E represents the coarse-grained portion of the Yorktown Formation.



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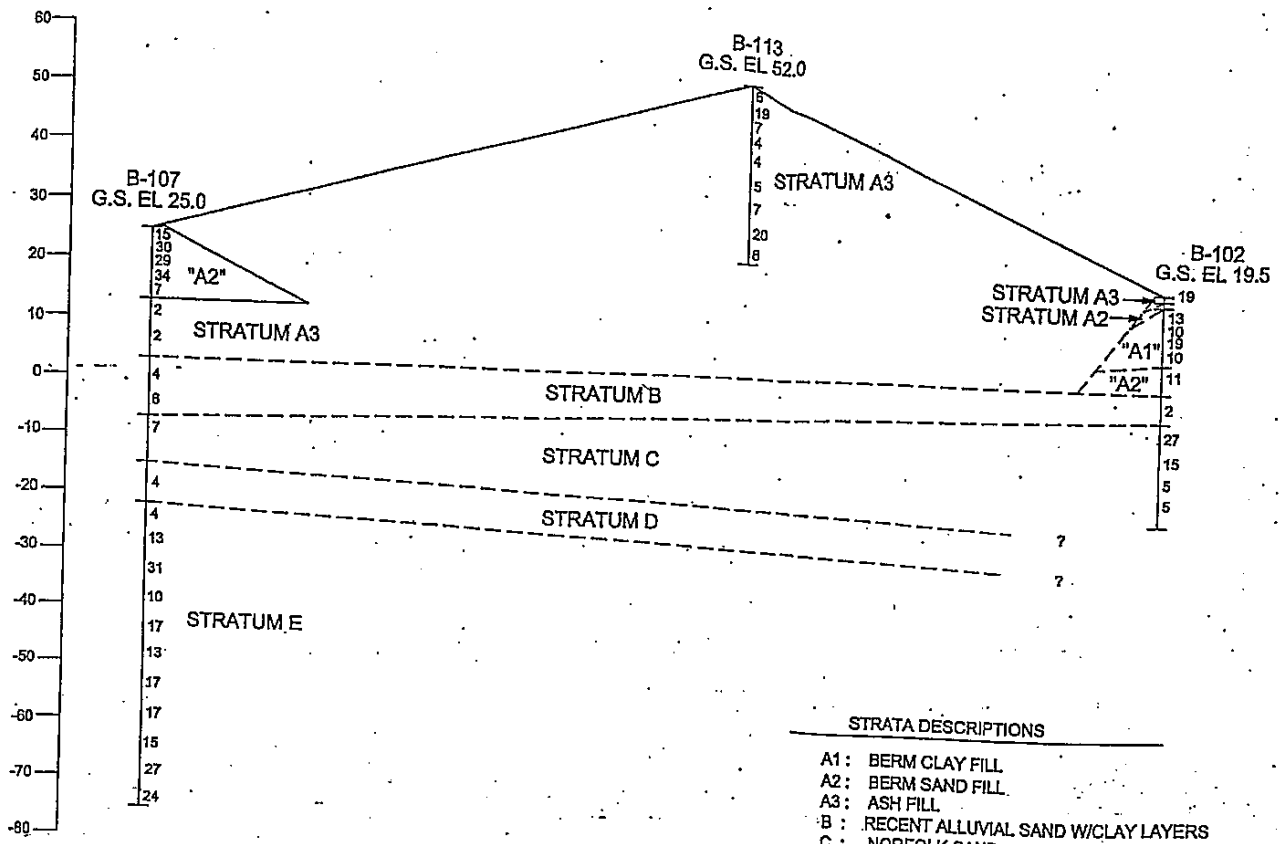
ASH FILL EXPANSION, CHESAPEAKE ENERGY CENTER
CHESAPEAKE, VIRGINIA

SUBSURFACE PROFILES

SCALE	DATE
AS SHOWN	OCTOBER 1999
DRAWN BY: VAM	CHECKED BY: RSH
CONTRACT No.	FIGURE
REVISED DATE	REVISED DATE

41856

PROFILE F-F'



STRATA DESCRIPTIONS

A1 : BERM CLAY FILL
A2 : BERM SAND FILL
A3 : ASH FILL
B : RECENT ALLUVIAL SAND W/CLAY LAYERS
C : NORFOLK SAND
D : NORFOLK CLAY
E : YORKTOWN SAND

NOTE: DETAILED STRATA DESCRIPTIONS ON SHEET 7

HORIZONTAL SCALE (FEET)
0 100 200 300

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ASH FILL EXPANSION, CHESAPEAKE ENERGY CENTER
CHESAPEAKE, VIRGINIA

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SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-101 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/13/99 Finished: 7/13/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 19.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/13	12:20	17.0	--	--
Completion	7/13	12:43	--	--	--
Casing Pulled	7/13	12:47	9.0	--	39.8

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
1.0	Fine to coarse silty sand FLY ASH FILL, moist – black	FILL	18.5	A3		10+10+11+10		
2.0	Fine to medium poorly graded sand FILL, trace silt, moist – tan	FILL	17.5	A2		7+5+3+5 PP=1.5 TSF		
	Fine to coarse sandy lean clay FILL, contains organic matter, moist – dark gray	FILL		A1		2+3+8+8 PP=1.75 TSF		Started mud drilling at 4'
	do, contains shell fragments and silty sand lenses, dark gray and brown				5			
6.0	Fine to coarse sandy fat clay FILL, trace gravel, moist – gray	FILL	13.5			5+8+7+7 PP>4.5 TSF		
	do, contains organic matter and clayey sand lenses					5+4+3+5 PP=2.0 TSF		DIKE FILL
					10			
12.0	Fine to medium silty sand FILL, contains clayey sand lenses and organic matter, moist – dark gray and dark brown	FILL	7.5	A2		2+3+4+4		
					15			
17.0	Fine to medium sandy lean clay, contains organic matter, wet – dark brown	CL	2.5	B1		WOH/18+1 PP<0.5 TSF		ALLUVIUM
					20			
22.0	Fat clay with sand, wet – dark gray	CH	-2.5			1+5+11+11 PP<0.5 TSF		
24.0	Fine to medium poorly graded sand with silt, wet – tan	SP-SM	-4.5	C				NORFOLK FORMATION
					25			
	do, fine to coarse, dark tan					6+4+2+3		
					30			

continued on next page

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-101 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to coarse poorly graded sand with silt, wet – dark tan	SP-SM						
32.0	Fine to medium clayey sand, wet – tan and brown	SC	-12.5	C	35	1+WOH/12+1		NORFOLK FORMATION
38.0	Lean clay with sand, wet – tan and brown	CL	-18.5	D	40	2+1+1+1		
40.0	Boring terminated at 40 ft		-20.5					

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-102 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/13/99 Finished: 7/13/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 19.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/13	10:53	22.0	--	--
Completion	7/13	11:09	--	--	--
Casing Pulled	7/13	11:15	10.0	--	39.0

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
1.0	Fine to coarse silty sand FLY ASH FILL, moist – dark gray	FILL	18.5	A3		8+9+10+8		
2.0	Fine to medium silty sand FILL, moist – tan and brown	FILL	17.5	A2				
	Fine to medium sandy lean clay, trace gravel, moist – dark gray	FILL		A1	5	4+5+8+11 PP=4.25 TSF 3+5+5+8 PP=2.0 TSF 8+7+12+11 PP>4.5 TSF 4+5+5+4		Started mud drilling at 4' DIKE FILL
12.0	Fine to medium poorly graded sand with silt FILL, moist – dark gray	FILL	7.5	A2	10 15	2+3+8+8		
17.0	Fine to medium silty sand, contains organic matter, moist – dark brown	SM	2.5	B2	20	1+1+1+2		ALLUVIUM
22.0	Fine to medium poorly graded sand with silt, wet – dark tan	SP-SM	-2.5	C	25	8+11+16+16		NORFOLK FORMATION
	do, dark tan and brown				30	8+7+8+8		

continued on next page

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-102 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium poorly graded sand with silt, wet – dark tan and brown	SP-SM						
32.0	Fine clayey sand, wet – tan and brown	SC	-12.5	C	35	3+2+3+3		NORFOLK FORMATION
						2+2+3+3		
40.0	Boring terminated at 40 ft		-20.5		40			

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-102A Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/20/99 Finished: 7/20/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 19.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	--	--	--	--	--
Completion	--	--	--	--	--
Casing Pulled	7/20	9:00	--	--	--
5 hr Reading	7/20	1:56	13.0	--	13.5

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRA-TUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Mud Rotary Probe to 43 ft; see Boring B-102 for strata description.							
5								
10								
15								
20								
25								
30								

continued on next page

Comments:
1) Boring backfilled upon 5 hour ground water measurement.
2) Offset Boring B-102A 10' south of Boring B-102.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-102A Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Mud Rotary Probe to 43 ft; see Boring B-102 for strata description.				35 40			
42.0	Fine to medium silty sand, wet – brown and tan	SM	-22.5	C	45 50	3+4+4+3 1+1+1+1		Rod dropped from 53'-80'. See Boring B-102B NORFOLK FORMATION
53.0	Boring terminated at 53 ft		-33.5					

Comments:
1) Boring backfilled upon 5 hour ground water measurement.
2) Offset Boring B-102A 10' south of Boring B-102.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 893318 Boring Number: B-102B Sheet: 1 of 3

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/20/99 Finished: 7/20/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 19.5±

Ground Water Observations	Date	Time	Depth	Casing	Caved
Encountered	7/20	--	--	--	--
Completion	7/20	2:05	--	--	--
Casing Pulled	7/20	2:34	13.5	--	38.4

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Mud Rotary probe to 53 ft; see Boring B-102A for strata description.							
5								
10								
15								
20								
25								
30								

continued on next page

Comments:
1) Boring backfilled upon completion.
2) Offset Boring B-102B 10 ' north of Boring B-102.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-103 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/13/99 Finished: 7/13/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 20.0±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/13	9:17	23.0	--	--
Completion	7/13	9:31	--	--	--
Casing Pulled	7/13	9:38	10.0	--	13.9

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
1.0	Fine to coarse poorly graded sand with silt FLY ASH FILL, trace gravel, moist – dark gray	FILL	19.0	A3		6+7+7+7		DIKE FILL
2.0	Fine to medium poorly graded sand with silt FILL, moist – tan	FILL	18.0	A2		3+3+4+6 PP=3.0 TSF		
	Fine to medium sandy fat clay FILL, moist – dark gray	FILL		A1	5	1+2+4+5 PP=2.0 TSF		Started mud drilling at 4'
6.0	Fine to medium clayey sand FILL, moist – dark gray	FILL	14.0	A2		8+8+8+8		
8.0	Fine to medium silty sand, moist – dark brown and gray	SM	12.0	B2	10	7+10+23+23		ALLUVIUM
	do, contains clayey sand lenses, dark brown and dark gray				15	3+8+8+9		
	do, contains organic matter				20	10+7+5+9		
22.0	Fine silty sand, wet – dark brown gray	SM	-2.0	C	25	7+11+13+16		NORFOLK FORMATION
					30	10+10+14+13		

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Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-103 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium silty sand, contains clayey sand lenses, moist – dark brown and dark gray	SM						
32.0			-12.0					
	Fine to medium clayey sand, wet – tan, brown and gray	SC				1+1+2+1		
				C	35			NORFOLK FORMATION
	do, brown and tan					1+2+2+2		
40.0			-20.0		40			
	Boring terminated at 40 ft							

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-104 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia
Boring Foreman: E. Hester
Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary
Drilling Equipment: CME-45C
SEA Representative: J. Hollowell
Dates Started: 7/13/99 Finished: 7/13/99
Location: See Location Plan, Figure A1

Ground Surface Elevation: 21.0±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/13	2:43	17.0	--	--
Completion	7/13	3:07	--	--	--
Casing Pulled	7/13	3:15	9.0	--	38.5
8 1/2 Day	7/20	10:19	6.6	--	7.7

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
1.0	Fine to coarse poorly graded sand with silt FLY ASH FILL, moist - dark gray	FILL	20.0	A3		5+10+9+11		
2.0	Fine to medium silty sand FILL, moist - dark brown and tan	FILL	19.0	A2		10+12+15+16		DIKE FILL
	Fine to medium poorly graded sand with silt FILL, moist - tan	FILL			5	7+10+7+7		Started mud drilling at 4'
	do, contains shell fragments, tan and dark gray							
6.0	Fine to coarse sandy lean clay, moist - dark gray, dark tan and brown	CL	15.0	B1		4+4+6+6 PP=4.0 TSF		
8.0	Fine to medium clayey sand, contains organic matter, moist - dark gray	SC	13.0		10	1+3+4+8		
12.0	Fine to medium silty sand, moist - dark brown, dark gray and tan	SM	9.0	B2	15	7+7+8+8		ALLUVIUM
					20	5+8+10+9		
22.0	Fine to medium poorly graded sand with silt, wet - tan	SP-SM	-1.0	C	25	8+10+13+11		NORFOLK FORMATION
27.0	Fine to coarse poorly graded sand with silt, contains clayey sand pockets, wet - tan and brown	SP-SM	-6.0		30	5+5+6+7		

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Comments:
Boring backfilled upon 8 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-104 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to coarse poorly graded sand with silt, contains clayey sand pockets, wet – tan and brown	SP-SM						
						7+8+9+9		
				C	35			NORFOLK FORMATION
37.0	Fine to medium clayey sand, wet – tan and brown	SC	-16.0					
						1+1+2+1		
40.0	Boring terminated at 40 ft		-19.0		40			

Comments:
Boring backfilled upon 8 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-105 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia
Boring Foreman: E. Hester
Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary
Drilling Equipment: CME-45C
SEA Representative: J. Hollowell
Dates Started: 7/13/99 Finished: 7/13/99
Location: See Location Plan, Figure A1

Ground Surface Elevation: 19.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/13	4:10	13.0	--	--
Completion	7/13	4:28	--	--	--
Casing Pulled	7/13	4:40	10.5	--	38.4
6 1/2 Day	7/20	10:28	Dry	--	1.0

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
1.0	Fine to coarse poorly graded sand with silt FLY ASH FILL, trace gravel, moist – dark gray	FILL	18.5	A3		5+7+10+8		DIKE FILL
2.0	Fine to medium silty sand FILL, moist – tan and dark brown	FILL	17.5	A2		4+4+4+5 PP=4.25 TSF		
4.0	Fine to medium sandy lean clay FILL, contains organic matter, moist – dark brown	FILL	15.5	A1	5	1+2+4+4		Started mud drilling at 4'
6.0	Fine to medium clayey sand FILL, moist – brown and dark gray	FILL	13.5	A2		5+6+10+7		
8.0	Fine to medium sandy lean clay FILL, moist – dark gray, dark tan and brown	FILL	11.5	A1		5+10+13+16		
	Fine to medium silty sand FILL, contains clayey sand pockets, moist – brown	FILL			10			
14.0	Fine to coarse clayey sand FILL, wet – dark gray	FILL	5.5	A2	15	1+1+1+1		
						3+3+3+3		
20.0	Fine to coarse poorly graded sand with silt, wet – dark brown	SP-SM	-.5	B2	20 25	3+6+10+13		ALLUVIUM
27.0	Fine to medium clayey sand, wet – tan and brown	SC	-7.5	C	30	1+1/12+1		NORFOLK FORMATION

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Comments:
Boring backfilled upon 6 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-105 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRA-TUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium clayey sand, wet - tan and brown	SC						
	do, brown and tan			C	35	2+1+1+2		NORFOLK FORMATION
	do, contains silty sand lenses, dark gray					1+3+3+4		
40.0	Boring terminated at 40 ft		-20.5		40			

Comments:
Boring backfilled upon 6 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-108 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates: Started: 7/14/99 Finished: 7/14/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 20.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/14	9:40	12.0	--	--
Completion	7/14	10:05	--	--	--
Casing Pulled	7/14	10:11	8.5	--	26.0
8 Day	7/20	10:33	10.8	--	11.0

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
1.0	Fine to coarse poorly graded sand FLY ASH FILL, trace silt and gravel, contains shell fragments, moist – dark gray	FILL	19.5	A3		5+4+5+4		DIKE FILL
2.0		FILL	18.5	A2		3+4+3+3		
4.0	Fine to medium silty sand FILL, contains sandy lean clay lenses, moist – dark brown and dark gray	FILL	16.5	A1	5	1/12+3+3		Started mud drilling at 4'
	Fine to medium poorly graded sand with silt FILL, moist – tan							
	Fine to medium sandy lean clay, contains organic matter, moist – dark gray and brown					7+6+6+6 PP=4.5 TSF		
8.0	Fine to medium silty sand FILL, moist – brown	FILL	12.5		10	11+16+18+10		
	do, wet			A2	15	1+1+1+1		
17.0	Fine to medium clayey sand, wet – tan	SC	3.5					ALLUVIUM
19.0	Fine to medium silty sand, wet – tan	SM	1.5		20	1+1+7+10		
	do, gray, dark gray and brown			B2	25	3+5+5+7		
27.0	Fine clayey sand, wet – tan and brown	SC	-6.5	C	30	1+2+1+2		NORFOLK FORMATION

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Comments:
Boring backfilled upon 8 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-107 Sheet: 1 of 3

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/15/99 Finished: 7/15/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 25.0±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/15	9:45	12.0	--	--
Completion	7/15	1:19	--	--	--
Casing Pulled	7/15	1:58	15.5	--	30.5
4 1/2 Day	7/20	10:47	20.0	--	20.3

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DATA	W (%)	REMARKS
	Topsoil	FILL	24.9		3+4+7+8		
1.0	Fine to medium clayey sand FILL, contains organic matter and shell fragments, moist – dark brown	FILL	24.0		10+15+15+15		
	Fine to medium poorly graded sand with silt FILL, moist – tan and brown				3+9+20+19		Started mud drilling at 4'
8.0	Fine to medium silty sand FILL, moist – dark tan	FILL	19.0	A2	20+19+15+13		
	do, contains shell fragments, lean clay pockets and fly ash				2+3+4+4		DIKE FILL
12.0	Silt with sand FLY ASH FILL, wet – dark gray	FILL	13.0	A3	1+1+1+1		SLUICED ASH FILL
					1+1+1+1		
22.0	Fine to medium silty sand, contains organic matter, wet – dark gray	SM	3.0	B2	3+2+2+3		ALLUVIUM
					2+3+3+3		

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Comments:
Boring backfilled upon 4 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-107 Sheet: 2 of 3

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium silty sand, contains organic matter, wet – dark gray	SM		B2				ALLUVIUM
32.0	Fine to coarse silty sand, trace gravel, wet – light gray	SM	-7.0	C	35	2+4+3+5		NORFOLK FORMATION
						WOH/18+1		
40.0	Silt with sand, wet – dark gray	ML	-15.0	D	40			
					45	1+2+2+2 PP=0.5 TSF		
47.0	Fine to medium clayey sand, contains fat clay lenses and shell fragments, wet – dark gray	SC	-22.0		50	1/18+4		YORKTOWN FORMATION
53.0	Fine to medium clayey sand, contains silty sand lenses and shell fragments, wet – dark gray	SC	-28.0		55	5+5+8+11		
59.0	Fine to medium poorly graded sand with silt, contains shell fragments, wet – dark gray and gray	SP-SM	-34.0	E	60	10+13+18+17		
	do, contains clayey sand lenses, gray				65	5+5+5+6		
					70	9+9+8+9		

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Comments:
Boring backfilled upon 4 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-107A Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia
Boring Foreman: E. Hester
Drilling Method: 3 7/8" O.D. Roller Bit Mud Rotary
Drilling Equipment: CME-45C
SEA Representative: J. Hollowell
Dates Started: 7/20/99 Finished: 7/20/99
Location: See Location Plan, Figure A1

Ground Surface Elevation: 25.0±

Ground Water Observations	Date	Time	Depth	Casing	Caved
Encountered	--	--	--	--	--
Completion	--	--	--	--	--
Casing Pulled	7/20	4:42	10.7	--	42.5

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Mud Rotary probe to 12 ft; see Boring B-107 for strata description.				5 10			
12.0	Silt with sand FLY ASH FILL, wet - gray	FILL	13.0	A3		3T 24/15		SLUICED ASH FILL
14.0	Mud Rotary probe to 42 ft; see Boring B-107 for strata description.		11.0		15 20 25 30			

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Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-107A Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Mud Rotary probe to 42 ft; see Boring B-107 for strata description.				35 40			
42.0	Fine to medium sandy fat clay, wet - gray	CH	-17.0	D	45	3T 24/24 3T 24/24		NORFOLK FORMATION
48.0	Boring terminated at 48 ft		-21.0					

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-108 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/14/99 Finished: 7/14/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 25.5±

Ground Water Observations	Date	Time	Depth	Casing	Caved
Encountered	7/14	11:37	22.0	--	--
Completion	7/14	11:52	--	--	--
Casing Pulled	7/14	12:02	10.2	--	38.7

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to coarse silty sand FILL, contains organic matter, crushed stone and shell fragments, moist - dark gray	FILL		A2		8+12+13+14		DIKE FILL
	do, contains lean clay pockets, dark brown					8+8+8+5		
					5	WOH+1+2+2		Started mud drilling at 4'
	do, dark brown and dark gray					2+3+4+4		
8.0	Fine to coarse poorly graded sand FLY ASH FILL, trace silt and gravel, wet - dark gray	FILL	17.5		10	2+3+4+3		
12.0	Fine to medium clayey sand FLY ASH FILL, contains fat clay layers, wet - dark gray	FILL	13.5	A3	15	3+5+7+6		SLUICED ASH FILL
					20	3+3+3+4		
22.0	Fine to medium sandy silt FLY ASH FILL, contains mica, wet - dark gray	FILL	3.5		25	1/12+1/12		
27.0	Fine to medium silty sand, contains organic matter, wet - gray	SM	-1.5	B2	30	12+12+17+9		ALLUVIUM

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Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-108 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium silty sand, contains organic matter, wet - gray	SM		B2				ALLUVIUM
32.0	Fine to medium silty sand, wet - brown and tan	SM	-8.5	C	35	2+2+1/12		NORFOLK FORMATION
37.0	Fine to medium poorly graded sand, wet - dark brown and tan	SP-SM	-11.5			12+11+7+5		
40.0	Boring terminated at 40 ft		-14.5		40			

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-109 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/16/99 Finished: 7/16/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 21.5 ±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/16	9:56	10.0	--	--
Completion	7/16	--	--	--	--
Casing Pulled	7/16	9:20	Dry	--	12.3

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Topsoil	FILL	21.4			5+4+4+5		
2.0	Fine to coarse poorly graded sand with silt FILL, trace gravel, moist – dark gray	FILL	19.5			5+3+3+2		
	Fine to medium silty sand FILL, moist – tan and dark tan					2+2+5+18		
	do, fine to coarse, trace gravel, contains shell fragments, brown			A2	5			DIKE FILL
8.0	Fine to medium poorly graded sand with silt FILL, moist – tan	FILL	15.5			17+25+21+18		
	do, wet					4+3+2+2		
10.0	Fine sandy silt FLY ASH FILL, wet – dark gray	FILL	11.5		10			
						1+1+1+1		
					15			SLUICED ASH FILL
				A3				
						WOH/24		
					20			
22.0	Fine to medium sandy lean clay, contains organic matter, wet – dark gray	CL	-.5			1+1+1+2 PP<0.5 TSF		ALLUVIUM
				B1	25			
27.0	Fine to medium silty sand, wet – gray	SM	-5.5					NORFOLK FORMATION
				C		4+2+4+8		
					30			

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Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-109 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium silty sand, wet – gray.	SM		C				
32.0	Fat clay, trace sand, wet – gray brown	CH	-10.5	D	35	5+1+1+2 PP<0.5 TSF		
37.0	Fine to medium silty sand, wet– light gray and brown	SM	-15.5	C	40	3+2+3+3		NORFOLK FORMATION
42.0	Fat clay, trace sand, contains silty sand lenses, wet – dark gray	CH	-20.5	D	45	3+3+2+3 PP=0.5 TSF		
47.0	Fine to medium clayey sand, wet – gray and brown	SC	-25.5	C	50	1+WOH+1+2		
52.0	Fine to medium silty sand, contains shell fragments, wet – tan	SM	-30.5	E	55	2+3+4+6		YORKTOWN FORMATION
60.0	Boring terminated at 60 ft		-38.5		80	9+10+8+8		

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-109A Sheet: 1 of 3

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/19/99 Finished: 7/19/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 21.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/19	--	--	--	--
Completion	7/19	1:29	--	--	--
Casing Pulled	7/19	2:30	12.5	--	78.5

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRA-TUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Auger Probe to 33 ft; see Boring B-109 for strata description.							
					5			
					10			
					15			
					20			
					25			
					30			
	continued on next page							

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-109A Sheet: 2 of 3

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Auger Probe to 33 ft; see Boring B-109 for strata description.							
33.0	Fat clay, trace sand, moist - gray	CH	-11.5	D	35	3T 24/20 3T 24/18		NORFOLK FORMATION
37.0	Auger Probe to 63 ft; see Boring B-109 for strata description.		-15.5	D	40 45 50 55 60			
63.0	Fine to coarse silty sand, contains shell fragments, wet - tan	SM	-41.5	E	65 70	8+8+7+7 8+4+8+7		YORKTOWN FORMATION

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Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-109A Sheet: 3 of 3

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to coarse silty sand, contains shell fragments, wet – tan	SM						
						10+8+10+10		
					75			
						7+7+7+7		
					80			
	do, gray					8+8+10+9		
				E	85			YORKTOWN FORMATION
						7+5+4+7		
					90			
						12+13+14+16		
					95			
						18+19+18+19		
100.0	Boring terminated at 100 ft		-78.5		100			

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-110 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/14/99 Finished: 7/14/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 25.0±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/14	1:45	10.0	--	--
Completion	7/14	2:08	--	--	--
Casing Pulled	7/14	2:14	10.8	--	27.3

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
2.0	Fine to medium silty sand FILL, contains shell fragments, moist – dark brown and brown	FILL	23.0	A2	5	8+11+15+18 17+12+18+18 3+11+18+15 12+12+11+8		DIKE FILL Started mud drilling at 4'
8.0	Fine to medium poorly graded sand with silt FILL, moist – tan do, contains shell fragments	FILL	17.0	A3	10	1+1+1+1		
12.0	Fine to medium poorly graded sand FLY ASH FILL, trace gravel, moist – dark gray	FILL	13.0		15	1+1+1/12		SLICED ASH FILL
17.0	Silt with sand FLY ASH FILL, wet – dark gray	FILL	8.0	B2	20	1/12+4+4		ALLUVIUM
22.0	Fine to medium silty sand, wet – dark gray	SM	3.0	C	25	6+6+9+8		
27.0	Fine silty sand, wet – dark gray	SM	-2.0		30	6+8+11+13		NORFOLK FORMATION
	Fine to medium poorly graded sand with silt, wet – dark gray and gray	SP-SM						

continued on next page

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-110 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium poorly graded sand with silt, wet – dark gray and gray	SP-SM						
32.0			-7.0					
	Fine to medium poorly graded sand, trace silt, wet – dark gray and gray	SP				3+4+5+5		
				C	35			NORFOLK FORMATION
37.0			-12.0					
	Fine to medium poorly graded sand with silt, moist – tan and red brown	SP-SM				2+5+4+4		
40.0			-15.0		40			
	Boring terminated at 40 ft							

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-111 Sheet: 1 of 3

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia
Boring Foreman: T. Donahue
Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary
Drilling Equipment: CME-45C
SEA Representative: J. Trimyer
Dates Started: 7/15/99 Finished: 7/15/99
Location: See Location Plan, Figure A1

Ground Surface Elevation: 26.0±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/15	--	22.0	--	--
Completion	7/15	--	--	--	--
Casing Pulled	7/15	3:15	--	--	--
4 1/2 Day	7/20	10:50	14.5	--	14.5

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine sandy silt FLY ASH FILL, moist - black	FILL		A3		4+6+7+7 4+5+4+5		
3.7	Fine to medium poorly graded sand, trace silt FILL, moist - tan	FILL	22.3		5	4+8+8+7 5+4+4+4		DIKE FILL
	do, contains shell fragments and sandy silt pockets			A2	10	2+3+3+3		
12.0	Fine sandy silt FLY ASH FILL, moist - black	FILL	14.0		15	11+WOH+1+1		SLICED ASH FILL
				A3	20	WOH/24		No recovery
22.0	Silt with sand FLY ASH FILL, contains organic matter, wet - dark gray	FILL	4.0		25	WOH+/18+1		
29.0	Fine to coarse poorly graded sand with silt, wet - gray brown *continued on next page*	SP-SM	-3.0	C	30	8+8+7+8		NORFOLK FORMATION

Comments:
Boring backfilled upon 4 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-111 Sheet: 2 of 3

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to coarse poorly graded sand with silt, wet – gray brown	SP-SM			35	3+5+5+4		
38.0	Fine to medium clayey sand, moist – tan and brown	SC	-12.0		40	2+2+2+2		
				C	45	1+2+2+1		No recovery
					50	3+7+17+21		NORFOLK FORMATION
53.0	Fine to medium silty sand, wet – gray	SM	-27.0		55	3+5+7+8		
58.8	Fine to medium silty sand, contains shell fragments, moist – gray brown	SM	-32.8		60	12+16+20		
63.0	Fine to medium clayey sand, contains shell fragments, moist – light gray	SC	-37.0	E	65	8+11+9+9		YORKTOWN FORMATION
	do, gray and green gray				70	6+9+12+15		

continued on next page

Comments:
Boring backfilled upon 4 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-111 Sheet: 3 of 3

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium clayey sand, contains shell fragments, moist – gray and green gray	SC						
	do, fine to coarse				75	6+7+7+10		
77.0	Fine to coarse silty sand, contains shell fragments, wet – gray	SM	-51.0					
					80	4+8+9+10		
						3+8+13+14		
				E	85			YORKTOWN FORMATION
						6+15+10+13		
					90			
						5+9+9+13		
					95			
						5+8+11+10		
100.0	Boring terminated at 100 ft		-74.0		100			

Comments:
Boring backfilled upon 4 1/2 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-112 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc. Chesapeake, Virginia
Boring Foreman: E. Hester
Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary
Drilling Equipment: CME-45C
SEA Representative: J. Hollowell
Dates Started: 7/14/99 Finished: 7/14/99
Location: See Location Plan, Figure A1

Ground Surface Elevation: 25.5±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/14	2:51	12.0	--	--
Completion	7/14	3:18	--	--	--
Casing Pulled	7/14	3:27	4.5	--	38.7
8 Day	7/20	1:52	Dry	--	1.0

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium silty sand FLY ASH FILL, contains organic matter, moist - dark gray	FILL		A3		2+2+8+5		DIKE FILL
	do, fine					4+4+3+4		
4.0	Fine to medium silty sand FILL, brown and tan	FILL	21.5		5	WOH+1+2+2		Started mud drilling at 4'
						2+3+5+9		
8.0	Fine to medium poorly graded sand FILL, trace silt, moist - gray and tan	FILL	17.5	A2	10	4+4+5+4		
12.0	Fine silty sand FLY ASH FILL, wet - gray	FILL	13.5		15	WOH+1/12+1		SLUICED ASH FILL
				A3	20	1/12+1/12		
22.0	Silt with sand FLY ASH FILL, wet - dark gray	FILL	3.5		25	WOH/18+1		
27.0	Fine silty sand, wet - dark gray	SM	-1.5	C	30	10+12+11+12		NORFOLK FORMATION

continued on next page

Comments:
Boring backfilled upon 8 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-112 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W. (%)	REMARKS
	Fine silty sand, wet – dark gray	SM						
32.0	Fine to medium poorly graded sand, trace silt, wet – gray	SP	-8.5	C	35	4+7+7+9		NORFOLK FORMATION
37.0	Fine to medium poorly graded sand with silt, wet – tan	SP-SM	-11.5			13+13+13+14		
40.0	Boring terminated at 40 ft		-14.5		40			

Comments:
Boring backfilled upon 8 day ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-113 Sheet: 1 of 1

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 4 1/4" Holly Stem Auger

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/15/99 Finished: 7/15/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 52.0±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/15	--	28.0	--	--
Completion	7/15	4:38	Dry	--	--
Casing Pulled	7/15	4:48	--	--	23.3
18 hr Reading	7/18	8:53	18.5	--	19.0

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Silt with sand FLY ASH FILL, dry - dark gray	FILL				2+2+4+4		
						8+10+9+9		
	do, moist					3+4+3+3		
					5	2+1+3+4		
						2+1+3+4		
					10	3T 24/24	40.7	
	do, fine sandy					2+2+3+3		
				A3	15	3T 24/24	33.9	DRY ASH FILL
						4+3+4+4		
					20	3T 24/0		
						3T 24/24		
						10+7+13+15		
					25			
	do, wet					3+3+3+4		
30.0	Boring terminated at 30 ft		22.0		30			

Comments:
Boring backfilled upon 18 hour ground water measurement.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-114 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/12/99 Finished: 7/12/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 3.5±

Ground Water Observations	Date	Time	Depth	Casing	Caved
Encountered	7/12	9:20	2.0	--	--
Completion	7/12	10:18	--	--	--
Casing Pulled	7/12	10:20	2.0	--	7.2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
.2	Topsoil	SM	3.3			1+2+1/12		
2.0	Fine to medium silty sand, contains organic matter, moist – dark gray and gray	SC	1.5			1+1+1/12		ALLUVIUM
	Fine to medium clayey sand, contains organic matter, wet – dark gray do, contains silty sand lenses			B2	5	WOR/12+WOH+1		Started mud drilling at 4'
6.0	Fine to medium silty sand, contains organic matter, wet – dark brown	SM	-2.5			2+2+3+4		
8.0	Fine to medium poorly graded sand with silt, wet – tan	SP-SM	-4.5		10	2+2+2+3		
12.0	Fine to medium clayey sand, wet – light gray	SC	-8.5	C	15	1+1+1+1		NORFOLK FORMATION
17.0	Fine to medium sandy lean clay, wet – light tan	CL	-13.5	D	20	1+1+1+1 PP<0.5 TSF		
22.0	Fine to medium clayey sand, wet – tan and brown	SC	-18.5	C	25	2+2+2+2		
					30	1+1+1+2		

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Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-114 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium clayey sand, wet – tan and brown	SC						
	do, dark gray			C		1+1+1+1		
35.0	Fat clay with sand, contains mica, wet – dark gray	CH	-31.5		35			NORFOLK FORMATION
				D		2+2+3+4 PP=1.5 TSF		
40.0	Boring terminated at 40 ft		-38.5		40			

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-115 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/12/99 Finished: 7/12/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 9.0±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/12	1:06	8.0'	--	--
Completion	7/12	1:41	--	--	--
Casing Pulled	7/12	1:45	7.3'	--	--

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Topsoil	FILL	8.9			WOH+2+3+3		
	Fine to medium poorly graded sand with silt FILL, moist – brown			A2		4+5+4+4		FILL
4.0			5.0					
	Fine to medium clayey sand, contains organic matter and silty sand lenses, moist – dark gray and gray	SC		B2	5	2+3+4+5		ALLUVIUM
6.0			3.0					
	Fine to medium silty sand, contains organic matter, moist – dark gray and gray	SM				2+3+2+5		
8.0			1.0					
	Fine to medium clayey sand, wet – tan	SC				1+1/12+1		Started mud drilling at 8'
					10			
						2+2+3+4		
					15			
	do, contains mica, tan and gray			C		2+1+1+1		NORFOLK FORMATION
					20			
						1+1+1+1		
					25			
						3+3+2+2		
					30			

continued on next page

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 893318 Boring Number: B-115 Sheet 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine to medium clayey sand, contains mica, wet – tan and gray	SC						
	do, trace gravel, brown and dark gray			C	35	WOH+1+2+4		NORFOLK FORMATION
					40	1+1+1+1		
40.0	Boring terminated at 40 ft		-31.0					

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-118 Sheet: 1 of 2

Boring Contractor: Fishburne Drilling Services, Inc.
Chesapeake, Virginia

Boring Foreman: E. Hester

Drilling Method: 2 15/16" O.D. Roller Bit Mud Rotary

Drilling Equipment: CME-45C

SEA Representative: J. Hollowell

Dates Started: 7/12/99 Finished: 7/12/99

Location: See Location Plan, Figure A1

Ground Surface Elevation: 10.0±

Ground Water Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/12	3:18	4.0	--	--
Completion	7/12	3:44	--	--	--
Casing Pulled	7/12	3:49	7.0	--	38.0

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Topsoil	FILL	9.9			WOH+1+3+3		FILL
	Fine to medium poorly graded sand with silt FILL, moist – tan do, contains shell fragments			A2		8+8+9+9		
4.0	Fine to medium silty sand FILL, wet – brown and dark gray	FILL	6.0		5	1+2+7+8		Started mud drilling at 4'
6.0	Fine to medium clayey sand, contains organic matter and silty sand lenses, wet – dark gray	SC	4.0	B2		3+4+7+5 WOH+3+1		ALLUVIUM
					10			
12.0	Fine to medium silty sand, wet – tan	SM	-2.0	C		3+5+4+8		NORFOLK FORMATION
					15			
						8+2+3+4		
					20			
22.0	Fine clayey sand, contains silty sand lenses, wet – tan	SC	-12.0			2+1+1+1		
					25			
	do, trace gravel, brown and tan					1+2+1+3		
					30			

continued on next page

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS TEST BORING LOG	Project: Ash Fill Expansion Chesapeake Energy Center Chesapeake, Virginia	Contract Number: 993318 Boring Number: B-116 Sheet: 2 of 2

DEPTH (FT.)	STRATA DESCRIPTION	CLASS.	ELEV. (FT.)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	W (%)	REMARKS
	Fine clayey sand, trace gravel, contains silty sand lenses; wet – brown and tan	SC						
	do, fine to medium			C	35	2+1+1+4		NORFOLK FORMATION
37.0	Fine to medium silty sand, wet – dark gray and brown	SM	-27.0					
40.0	Boring terminated at 40 ft		-30.0		40	1+2+2+4		

Comments:
Boring backfilled upon completion.

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	TEST BORING LOG	BORING NO.: B-1

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR: AYERS & AYERS, INC.

SHEET NO. 1 OF 1
JOB NO.: V80072
ELEVATION: 18.5±
CASING SIZE: 3¼"
DATE START: 3/27/80
DATE FINISHED: 3/27/80
DRILLER: C. JAMERSON
INSPECTOR: B. HARRINGTON

DRILL: CME-55	
DRIVE SAMPLER	
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

WATER LEVEL DATA

	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	3/27	3:00	24.0'	–
AFTER CASING PULLED	3/27	3:15	DRY	2.5'
6 DAY READING	4/2	10:30	DRY	5.0'

STRATUM	DEPTH FT.	ELEV 18.5±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
			2+1+1	S	FINE TO MEDIUM SAND, FILL, SOME SILT, MOIST – BROWN (SM)	
	2.0					
A(1)			4+8+9	S	FINE TO MEDIUM SILTY CLAYEY SAND, FILL, MOIST – BROWN (SC)	
	7.0					Tube pressed 24" Recovery = 14"
		10		3"	FINE TO MEDIUM SAND, FILL, TRACE SILT, MOIST – BROWN (SM-SP)	
			7+12+13	S	FINE TO COARSE SILTY CLAYEY SAND, FILL, TRACE GRAVEL – BROWN (SC)	
	12.0					
A(2)			5+9+8	S	FINE TO MEDIUM SAND, MOIST – BROWN (SP)	
		0				FILL
			4+4+3	S		
	22.0					
B			2+2+3	S	3" FINE SAND, TRACE SILT, WITH WOOD AND SAND LENSES, AND ROOTS – MOIST – GRAY (SP-SM)	Tube pressed 24" Recovery = 14" RECENT ALLUVIAL
	27.0					
D		-10			3" FINE TO MEDIUM SANDY SILTY CLAY, WITH LENSES OF SILTY SAND, MOIST – GRAY (CL)	Tube pressed 24" Recovery=24" NORFOLK FORMATION
	30.0		1+1+4	S		

BORING TERMINATED AT 30.0 FT

41897

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	TEST BORING LOG	BORING NO.: B-2

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR: AYERS & AYERS, INC.

SHEET NO. 1 OF 1	
JOB NO.: V80072	
DRILL: CME-55	ELEVATION: 18.7±
DRIVE SAMPLER TYPE: S.S.	CASING SIZE: 24"
DIA.: 2" O.D.	DATE START: 3/28/80
WT.: 140#	DATE FINISHED: 3/28/80
FALL: 30"	DRILLER: C. JAMERSON
	INSPECTOR: B. HARRINGTON

WATER LEVEL DATA

	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	3/28	9:15	23.0'	–
AFTER CASING PULLED	3/28	10:00	12.0'	18.0'
5 DAY READING	4/2	10:30	13.5'	14.5'

STRATUM	DEPTH FT.	ELEV 18.7±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
			2+2+2	S	FINE TO MEDIUM SAND, FILL, TRACE SILT, MOIST – BROWN (SP)	
	3.0					
A(1)			3+10+10	S	FINE TO MEDIUM SILTY CLAYEY SAND, FILL, MOIST – GRAY (SC)	FILL
	7.0					
		10				
			5+13+17	S	FINE TO MEDIUM SAND, FILL, TRACE SILT, MOIST – BROWN (SP)	
A(2)		▼				
			8+14+14	S		
	19.0	0				
B	20.5		5+5+9	S	FINE TO MEDIUM SAND, SOME SILT, WITH ROOTS, MOIST – BROWN (SM)	RECENT ALLUVIAL
			1+4+4	S	FINE TO MEDIUM SAND, SOME SILT, WET – GRAY (SP)	NORFOLK FORMATION
C		-10				
	30.0		9+13+11	S	do, FINE	
					BORING TERMINATED AT 30.0 FT	

41898

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	TEST BORING LOG	BORING NO.: B-3

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR: AYERS & AYERS, INC.
DRILL: CME-55

SHEET NO. 1 OF 1
JOB NO.: V80072
ELEVATION: 18.4±
CASING SIZE: 2½"
DATE START: 4/1/80
DATE FINISHED: 4/1/80
DRILLER: C. JAMERSON
INSPECTOR: B. HARRINGTON

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	4/1	8:15	24.0'	–
AFTER CASING PULLED	4/1	10:15	8.0'	10.0'
24 HR. READING	4/2	10:30	6.5'	9.5'

DRIVE SAMPLER	
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

STRATUM	DEPTH FT.	ELEV 18.4±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
			3+3+4	S	SILTY CLAY, FILL, SOME FINE SAND, MOIST - GRAY (CL)	
			6+9+9	S		
A(1)		▽				
		10.				FILL
			4+5+5	S	do, SANDY	
	12.0					
A(2)			3+5+5	S	FINE TO MEDIUM SAND, FILL, SOME SILT, MOIST - GRAY (SM)	
	17.0	0				
B			2+2+2	S	CLAYEY SILT, TRACE FINE SAND, WITH ORGANIC MATTER, MOIST - GRAY (MH)	RECENT ALLUVIAL
	22.0					
			2+4+7	S	FINE TO MEDIUM SAND, TRACE SILT, WET - GRAY (SP)	
		-10				
			10+12+14	S		
C			3+4+4	S	do, SOME SILT - LIGHT BROWN	NORFOLK FORMATION
		-20				
			3+2+2	S		
			2+1+2	S		
		-30				
	50.0		2+1+2	S		
					BORING TERMINATED AT 50.0 FT	

41899

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	TEST BORING LOG	BORING NO.: B-4

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR: AYERS & AYERS, INC.
DRILL: CME-55

SHEET NO. 1 OF 1
JOB NO.: V80072
ELEVATION: 18.5±
CASING SIZE: 2½"
DATE START: 3/28/80
DATE FINISHED: 3/28/80
DRILLER: C. JAMERSON
INSPECTOR: B. HARRINGTON

WATER LEVEL DATA

	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	3/25	8:15	14.0'	–
AFTER CASING PULLED	3/28	8:30	DRY	1.5'
5 DAY READING	4/2	10:30	6.5'	6.5'

DRIVE SAMPLER	
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

STRATUM	DEPTH FT.	ELEV 18.5±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
A(1)			2+2+3	S	FINE TO MEDIUM SILTY CLAYEY SAND, FILL, MOIST - GRAY (SC)	FILL
			3+12+14	S		
	7.0	10				
A(2)			2+2+4	S	FINE TO MEDIUM SAND, FILL, TRACE FLY ASH WET - GRAY (SP)	
			2+1+2	S		
	19.0	0				
B	20.5		1+3+5	S	FINE TO MEDIUM SAND, SOME SILT, WITH ORGANIC MATTER, WET - BROWN (SM)	RECENT ALLUVIAL
C			6+6+7	S	FINE TO MEDIUM SAND, TRACE SILT, WET-GRAY (SP)	NORFOLK FORMATION
	27.0	-10				
D	30.0		2+4+4	S	CLAY, SOME FINE SAND MOIST - GRAY-GREEN (CH)	
					BORING TERMINATED AT 30.0 FT	

41900

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	HAND AUGER LOG	BORING NO.: B-5

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION								SHEET NO. 1 OF 1
CLIENT: VEPCO								JOB NO.: V80072
BORING CONTRACTOR:					DRILL: H.A.			ELEVATION: 12.5±
WATER LEVEL DATA					DRIVE	SAMPLER		CASING SIZE: H.A.
	DATE	TIME	DEPTH	CAVED	TYPE	S.S.		DATE START: 4/1/80
ENCOUNTERED	4/1	12:00	SURFACE	–	DIA.	2" O.D.		DATE FINISHED: 4/1/80
AFTER CASING PULLED	4/1	12:00	SURFACE	–	WT.	140#		DRILLER: B. HARRINGTON
___HR. READING	BACKFILLED UPON COMPLETION				FALL	30"		INSPECTOR: B. HARRINGTON

STRATUM	DEPTH FT.	ELEV 12.5±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
A(3)		10		2"	FLYASH, FILL, WET – BLACK	Tube Pressed 24" Recovery 18" FILL
	5.5				HAND AUGER TERMINATED AT 5.5 FT	

41901

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	HAND AUGER LOG	BORING NO.: B-6

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION		SHEET NO. 1 OF 1
CLIENT: VEPCO		JOB NO.: V80072
BORING CONTRACTOR:	DRILL: H.A.	ELEVATION: 12.0±
	DRIVE SAMPLER	CASING SIZE: H.A.
	TYPE S.S.	DATE START: 4/1/80
	DIA. 2" O.D.	DATE FINISHED: 4/1/80
	WT. 140#	DRILLER: B. HARRINGTON
	FALL 30"	INSPECTOR: B. HARRINGTON

WATER LEVEL DATA

	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	4/1	10:00	SURFACE	–
AFTER CASING PULLED	4/1	10:00	SURFACE	–
—HR. READING	BACKFILLED UPON COMPLETION			

STRATUM	DEPTH FT.	ELEV 12.0±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
		10		2"	FLYASH, FILL, WET – BLACK	Tube Pressed 24" Recovery 13"
A(3)				J		FILL
	5.5			J		
					HAND AUGER TERMINATED AT 5.5 FT	

41902

SCHNABEL ENGINEERING ASSOCIATES
CONSULTING ENGINEERS

TEST BORING LOG

BORING NO.: B-7

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR: AYERS & AYERS, INC.

SHEET NO. 1 OF 1
JOB NO.: V80072
ELEVATION: 12.0±
CASING SIZE: 2½"
DATE START: 3/31/80
DATE FINISHED: 3/31/80
DRILLER: C. JAMERSON
INSPECTOR: B. HARRINGTON

DRILL: TRIPOD

DRIVE SAMPLER	
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

WATER LEVEL DATA

	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	3/31	1:00	SURFACE	–
AFTER CASING PULLED	3/31	3:30	SURFACE	–
___HR. READING	BACKFILLED UPON COMPLETION			

STRATUM	DEPTH FT.	ELEV 12.0±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
		10	2+1+2	S	2"	Tube Pressed 24" Recovery 24"
A(3)			3+1+1	S	FLYASH, FILL, WET - BLACK	FILL
			3+2+2	S		Tube Pressed 24" No Recovery
				* 2"		
			1+1/12"	S		
		0				
	13.0					
C			8+8+6	S	FINE TO MEDIUM SAND, TRACE SILT, WET - GRAY (SP)	NORFOLK FORMATION
	20.0		10+8+4	S		
					BORING TERMINATED AT 20.0 FT	

41903

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	TEST BORING LOG	BORING NO.: B-8

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR: AYERS AND AYERS, INC.

SHEET NO. 1 OF 1
JOB NO.: V80072
DRILL: CME-55
ELEVATION: 17.6±
CASING SIZE: 2½"
DATE START: 4/1/80
DATE FINISHED: 4/1/80
DRILLER: C. JAMERSON
INSPECTOR: B. HARRINGTON

WATER LEVEL DATA

	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	4/1	11:00	24.0'	–
AFTER CASING PULLED	4/1	11:00	11.5'	12.0'
24 HR. READING	4/2	11:00	8.5'	9.0'

DRIVE SAMPLER	
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

STRATUM	DEPTH FT.	ELEV 17.6±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
			4+8+12	S	SILTY CLAY, FILL, SOME FINE SAND, MOIST - GRAY (CL)	
A(1)			5+7+11	S		
		10				FILL
	9.5		2+9+11	S	FINE TO MEDIUM SAND, FILL, SOME SILT, MOIST - GRAY (SM)	
A(2)			3+5+5	S		
	19.0	0				
B	20.5		3+3+8	S	FINE TO MEDIUM SAND, TRACE SILT WITH ORGANIC MATTER, WET - BROWN (SP)	RECENT ALLUVIAL
	22.0					
C			8+8+7	S	FINE TO MEDIUM SAND, TRACE SILT, WET - GRAY (SP)	NORFOLK FORMATION
		-10				
	30.0		6+5+4	S		
					BORING TERMINATED AT 30.0 FT	

41904

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	TEST BORING LOG	BORING NO.: B-9

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION — SHEET NO. 1 OF 1
CLIENT: VEPCO — JOB NO.: V80072
BORING CONTRACTOR: AYERS & AYERS, INC. — DRILL: CME-55 — ELEVATION: 17.5±
CASING SIZE: 2½"
DATE START: 4/2/80
DATE FINISHED: 4/2/80
DRILLER: C. JAMERSON
INSPECTOR: B. HARRINGTON

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	4/2	8:30	14.0'	–
AFTER CASING PULLED	4/2	9:00	9.5'	10.0'
2 HR. READING	4/2	11:00	8.5'	9.5'

DRIVE SAMPLER	
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

STRATUM	DEPTH FT.	ELEV 17.5±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
A(1)		10	7+10+10	S	SILTY CLAY, FILL, SOME FINE SAND, MOIST - GRAY (CL)	FILL
			4+8+10	S		
A(2)	9.5		4+5+5	S	FINE TO MEDIUM SILTY SAND, FILL, MOIST - GRAY (SM)	
			3+4+4	S	do, SOME CLAYEY SILT	
C	18.0	0	3+3+4	S	FINE TO MEDIUM SAND, TRACE SILT, WET - WHITE (SP-SM)	NORFOLK FORMATION
			5+7+7	S		
		-10				
			10+17+17	S		
			4+6+6	S		
		-20				
D	39.0		5+4+4	S	SILTY CLAY, TRACE FINE SAND, MOIST - GRAY (CL)	
C		-30	WOH+1+1	S	FINE TO MEDIUM SAND, TRACE SILT WITH MICA, WET - GRAY (SP-SM)	
	50.0		1+1+1	S		
					BORING TERMINATED AT 50.0 FT	

41905

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	TEST BORING LOG	BORING NO.: B-10

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION	SHEET NO. 1 OF 1
CLIENT: VEPCO	JOB NO.: V80072
BORING CONTRACTOR: AYERS AND AYERS, INC. DRILL CME-55	ELEVATION: 17.5±
	CASING SIZE: 2½"
	DATE START: 3/28/80
	DATE FINISHED: 3/28/80
	DRILLER: C. JAMERSON
	INSPECTOR: B.HARRINGTON

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	3/28	10:45	19.0'	–
AFTER CASING PULLED	3/28	11:30	DRY	10.0'
___HR. READING	BACKFILLED UPON COMPLETION			

DRIVE SAMPLER	
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

STRATUM	DEPTH FT.	ELEV 17.5±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
			9+9+11	S	SILTY CLAY, FILL, TRACE FINE SAND, GRAY AND BLACK – MOIST (CL)	
A(1)			3+5+7	S		
		10				
	9.5		3+5+5	S	FINE SAND, FILL, SOME SILT, MOIST – GRAY (SM)	FILL
A(2)			7+8+9	S		
		0				
	19.0				do, WET	
			2+4+5	S	FINE TO MEDIUM SAND, TRACE SILT, WET – LIGHT GRAY (SP)	
C			3+3+3	S	do, BROWN (SM-SP)	NORFOLK FORMATION
		-10				
	30.0		1+1+2	S	do, WITH CLAY LAYERS	
					BORING TERMINATED AT 30.0 FT	

41906

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	TEST BORING LOG	BORING NO.: B-11

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION		SHEET NO. 1 OF 1
CLIENT: VEPCO		JOB NO.: V80072
BORING CONTRACTOR: AYERS AND AYERS, INC.	DRILL: CME-55	ELEVATION: 18.4±
WATER LEVEL DATA	DRIVE SAMPLER	CASING SIZE: 2½"

	DATE	TIME	DEPTH	CAVED	TYPE	S.S.	DATE START: 4/1/80
ENCOUNTERED	4/1	2:50	14.0'	–	DIA.	2" O.D.	DATE FINISHED: 4/1/80
AFTER CASING PULLED	4/1	2:50	DRY	9.0'	WT.	140#	DRILLER: C. JAMERSON
20 HR. READING	4/2	10:50	DRY	9.0'	FALL	30"	INSPECTOR: B. HARRINGTON

STRATUM	DEPTH FT.	ELEV 18.4±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
A(1)			6+6+8	S	SILTY CLAY, FILL, SOME FINE SAND, MOIST - GRAY (CL)	FILL
			6+8+10	S		
	7.0	10			FINE TO MEDIUM SAND, FILL, TRACE SILT, MOIST - BROWN (SP)	
A(2)			4+14+9	S		
			6+9+10	S	do, WET - GRAY	
	19.0	0				
C			3+3+3	S	FINE TO MEDIUM SAND, TRACE SILT, WET - GRAY (SP)	NORFOLK FORMATION
			4+4+6	S		
		-10				
	30.0		2+2+2	S	do, SOME SILT - BROWN (SM)	
					BORING TERMINATED AT 30.0 FT	

41907

SCHNABEL ENGINEERING ASSOCIATES CONSULTING ENGINEERS	TEST BORING LOG	BORING NO.: B-12

PROJECT: ASH POND, VEPCO, PORTSMOUTH STATION
CLIENT: VEPCO
BORING CONTRACTOR: AYERS AND AYERS, INC.

SHEET NO. 1 OF 1
JOB NO.: V80072
DRILL: CME-55
ELEVATION: 18.0±
CASING SIZE: 3¼"
DATE START: 4/1/80
DATE FINISHED: 4/1/80
DRILLER: C. JAMERSON
INSPECTOR: B. HARRINGTON

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	4/1	–	–	–
AFTER CASING PULLED	4/1	4:30	DRY	7.0'
18 HR. READING	4/2	10:30	DRY	8.5'

DRIVE SAMPLER	
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

STRATUM	DEPTH FT.	ELEV 18.0±	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
			7+6+6	S	FINE SANDY SILTY CLAY, FILL, MOIST - GRAY (CL)	Tube pressed 24" Recovery = 24"
				3"		
A(1)			3+6+9	S		
		10				
			3+6+7	S		
	11.0					FILL
			3+5+5	S	FINE TO MEDIUM SAND, FILL, TRACE SILT, MOIST - GRAY (SP)	
A(2)				*		
			3+6+5	S		Tube pressed 24" No Recovery
		0				
	19.0					
				*	FINE TO MEDIUM SAND, TRACE SILT, WET - LIGHT GRAY (SP)	Tube pressed 24" No Recovery
			1+3+3	S		
			3+4+4	S	do, SOME SILT - BROWN (SM)	
C		-10				
			8+10+15	S		NORFOLK FORMATION
			3+5+5	S		
	37.0					
		-20				
D			4+9+9	S	FINE TO MEDIUM SILTY CLAYEY SAND, MOIST - GRAY (SC)	
	45.0		3+3+9	S		
C		-30			FINE TO MEDIUM SAND, SOME SILT, MOIST - BROWN (SM)	
	50.0		44+OH/12"	S	do, WET (SP)	
					BORING TERMINATED AT 50.0 FT	

41908

Appendix B

Well Schematic and Boring Logs

Soil Boring Log

Borehole Number: MW-4R

PROJECT INFORMATION		DRILLING INFORMATION	
OJECT:	Dominion - Chesapeake Energy Center	DRILLING CO.:	Parratt Wolff, Inc.
SITE LOCATION:	Chesapeake, Virginia	DRILLER:	Kevin White, George Martincic
JOB NAME:	Chesapeake Energy Center Well Installation	RIG TYPE:	Diedrich Drill Rig
LOGGED BY:	Kevin Goerger	METHOD OF DRILLING	Hollow-stem Auger
PROJECT MANAGER:	Montgomery Bennett	SAMPLING METHODS:	Soil cuttings; 5 foot intervals
DATES DRILLED:	9/14/2006	HAMMER:	None
BOREHOLE NO.:	MW-4R	TOTAL DEPTH:	14

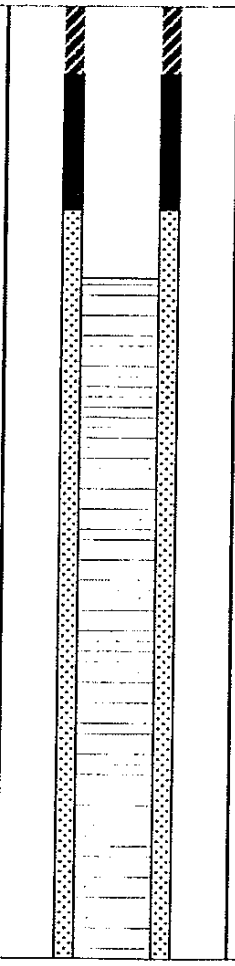
NOTES: Overcast & 70 degrees F

⧗ Water level in completed well

NM = Not measured

Page 1 of 1

DEPTH	SOIL/ROCK SYMBOLS	SOIL DESCRIPTION	PID	WELL CONSTRUCTION	NOTES
0		TOPSOIL	0.0		GES hand cleared to 4 feet below ground surface
		Brown fine grained SAND, loose, dry			
5		Brown fine grained SAND, loose, dry	0.0		Well construction: 10 feet of 4" 10-slot schedule 40 PVC and 4' of 4" schedule 40 riser. 3' stick-up protective riser with 2' by 2' concrete well pad.
⧗		Gray fine grained SAND with trace SILT, sticky, wet			
-10		Gray fine grained SAND with trace SILT, sticky, wet	0.0		



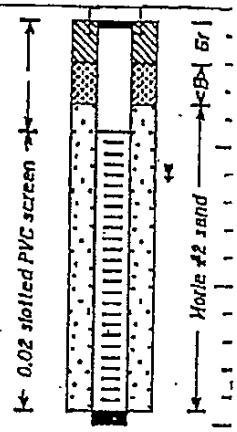
41910

ENSAT
ENVIRONMENTAL SERVICE AND TECHNOLOGY CORPORATION

LOG OF BORING MW-5

PROJECT: *VA Power ODCP*	DRILL METHOD: *Hollow Stem Auger*	DIA.: *10"*
CLIENT: *VA Power*	DRILLED BY: *Connelly Assoc*	LIC. #: *MD-482*
LOCATION: *Chesapeake Energy Center*	SAMPLE METHOD: *Split Spoon*	WELL DEPTH: *14.5 ft.*
JOB NUMBER: *92A-00144*	ELEVATION/COORDINATES:	WELL DIA.: *4"*
DATE STARTED: *12/8/92*	SURFACE FINISH: *Stick-up, 3 ft.*	TOTAL DEPTH: *14.5 f*
DATE COMPLETED: *12/8/92*	LOGGED BY: *AML*	DEPTH TO GW: *8.1*

DEPTH feet	SPLIT SPOON NUMBER	BLOWS/6 In.	FID VALUES	FID PROFILE	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION	LAB SAMPLE #	WELL DIAGRAM
						CL	Grass surface coverage, gray to dark gray fine sandy CLAY with trace to little silt; moist		
5	1	WH WH WH 1	1			CL SC	Tan to gray fine to medium sandy CLAY with trace to little silt; moist to wet Bottom 4" of spoon: gray clayey SAND with trace silt; wet	144-MW5-	
10	2	WH 1 1 1	0			SM	Gray and tan very fine to fine well sorted SAND with trace clay and silt; wet (clay percent increased at bottom of spoon) also, some medium SAND throughout entire spoon		
15	3	NS					Well set @14.5 ft. NH = Weight of Hammer NS = No Sample Recovered		
20									
25									
30									
35									
40									



PO-8

PROJECT VEPCO PORTSMOUTH ASH DISPOSAL POND — PROJECT NO. 83-302

ELEVATION _____ GWL 0 HRS 9.8 FEET — ~~BORING~~ WELL NO. 2

24 HRS 9.8 FEET

DATE 12/8/83 FIELD ENGINEER DUANE R. LENHARDT — PAGE NO. 1 OF 1

FEET	BLOWS PER SIX INCHES OR CORE RECOVERY/RUN	SAMPLE NO., TYPE & RECOVERY OR % ROCK RECOVERY	CASING BLOWS	PROFILE	SOIL DENSITY-CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	MONITORING WELL CONSTRUCTION	REMARKS::
1	2	3	4	5	6	7	8		10
					VERY LOOSE	BRN	FINE & MEDIUM SAND W/ SHELL FRAG.		FEW ROOTS
0			0.8						
					LOOSE	DK. BRN	SILTY-SAND (GROUT)		VERY MOIST
2.0									
			2.3						
3.0					MEDIUM DENSE	YEL. BRN	FINE SAND W/ SOME SILT		MOIST
							(BENTONITE SEAL)		SOME MOTTLING
4.0			3.8						
					LOOSE	DK. BRN GRAY	FINE SAND W/ SOME SILT	4.0 PVC CASING	SOME ORGANIC MATT. SEWAGE TYPE ODOR
5.0									
			5.1						
6.0					VERY LOOSE	DK. GRAY	SILTY-SAND W/ ORGANICS		MOIST SOME ROOTS AND WOODY MATL.
			6.3						
7.0					MEDIUM DENSE	GRAY	SILTY-SAND	SCH 40	
								2 INCH	
8.0							(GRAVEL)		
			8.4					SOLID	
9.0			8.9		VERY LOOSE	BLK.	ORGANIC SILT		
		S-1			LOOSE	BRN	SANDY-SILT		VERY MOIST TO WET
10.0			9.7						STRONG SEWAGE TYPE
		S-2			LOOSE	LT. BRN GRAY	SILTY-SAND		ODOR
11.0									WET
			11.2						
12.0					VERY LOOSE	LT. GRAY	FINE SAND W/ SOME SILT AND SHELL FRAGMENTS	SLOTTED SCREEN	
								.010 INCH	
16.									

REMARKS:::: SITE LOCATED ~ 12 FEET ABOVE RIVER LEVEL. HOLE REMAINED OPEN TO 12.0 FEET. 4 INCH CASING SET AND CLEANED TO 16.0 FEET. 2 INCH PVC CASING INSTALLED WITH SCREEN AS SHOWN. 4 INCH SCH 80 PVC SECTION WITH SCREW CAP INSTALLED FOR SURFACE PROTECTION.

PROJECT NO. 83-302

~~BORING~~ WELL NO. 2

41912

PROJECT VEPCO PORTSMOUTH ASH DISPOSAL POND — PROJECT NO. 83-302

ELEVATION _____ GWL 0 HRS 0.6 FEET, HRS — ~~BORING~~ WELL NO. 3

DATE 12/9/83 FIELD ENGINEER DUANE R. LENHARDT — PAGE NO. 1 OF 1

DEPTH FEET	BLOWS PER SIX INCHES OR CORE RECOVERY/RUN	SAMPLE NO., TYPE & RECOVERY OR % ROCK RECOVERY	CASING BLOWS	PROFILE	SOIL DENSITY-CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	MONITORING WELL CONSTRUCTION	REMARKS**
1	2	3	4	5	6	7	8		10
					LOOSE	BRN	SILTY-SAND w/ SOME FINE GRAVEL		
1.0							(GROUT)		
			1.1		SOFT	LIGHT BRN	SANDY-SILT w/ SOME ORGANICS	2.0 INCH PVC CASING	WET
2.0			1.7		VERY SOFT	BLK TO DK GRAY	ORGANIC SILT (BENTONITE SEAL)	4.0 INCH SCH. 40	ORIGINAL GROUND SURFACE
3.0			2.8						
		S-1			SOFT	DK GRAY/BRN	CLAYEY-SILT w/ SOME ORGANICS	SAND	SOME SOIL MOTTLES
4.0									
5.0			4.6		SOFT	DK GRAY BRN	ORGANIC CLAYEY-SILT		CONTAINED MUCH WOODY MATL AND ROOTS.
6.0			5.8						
					LOOSE	PK. BRN	SILTY-SAND	1 INCH SLOTTED SCREEN	SOME DECOMPOSED ORGANICS
7.0									
			7.2		LOOSE	LT. BRN	SILTY-SAND		
8.0		S-2					(GRAVEL)		
9.0			8.6		VERY LOOSE		FINE SAND w/ SOME SILT		SAND LIQUIFIED AND ROSE UP IN 4 INCH CASING
10.0									7.2'
			10.2						

REMARKS**** SITE LOCATED ~ 2 TO 3 FEET ABOVE RIVER. HOLE REMAINED OPEN W/O CASING TO 9.0 FEET. 4 INCH CASING SET AND CLEANED TO 10.2 FEET. 2.0 INCH PVC CASING INSTALLED WITH SCREEN AS SHOWN. 4.0 INCH, SCH. #80 PVC SECTION WITH SCREW CAP INSTALLED FOR SUMP OF CONSTRUCTION.

PROJECT NO. 83-302

~~BORING~~ NO. 3

41913

PROJECT VEPCO PORTSMOUTH ASH DISPOSAL POND — PROJECT NO. 83-302

ELEVATION _____ GWL 0 HRS 0.2 FEET — ~~BORING~~ WELL NO. 4

24 HRS 0.4 FEET

DATE 12/7/83 FIELD ENGINEER DUANE R. LENHARDT — PAGE NO. 1 OF 1

DEPTH FEET	BLOWS PER SIX INCHES OR CORE RECOVERY/RUN	SAMPLE NO., TYPE & RECOVERY OR % ROCK RECOVERY	CASING BLOWS	PROFILE	SOIL DENSITY-CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	MONITORING WELL CONSTRUCTION	REMARKS**
1	2	3	4	5	6	7	8		
							SURFACE		
					VERY SOFT	DK. BRN	ORGANIC LAYER W/ SOME SILT	2.5' / 3.4'	MANY ROOTS. VERY MOIST TO WET
1.0			0.6		SOFT	BRN	SANDY-SILT (GROUT)	2 INCH PVC CASING	WET
			1.4						
2.0			1.9		SOFT	DRK GRAY	SILTY-SAND & SANDY-SILT	SCH-40	
			2.4		MEDIUM STIFF	GRAY BRN	SANDY-CLAY (BENTONITE)		SOME SOIL MOTTLING
3.0		S-1			MEDIUM STIFF	BRN GRAY	CLAYEY-SAND		STRONG SOIL STRUCT.
4.0			3.6		MEDIUM DENSE	LT. BRN	SILTY-SAND	SOLID 2 INCH	WET
		S-2							
5.0									5.2'
6.0								SLOTTED SCREEN	
			6.4						
7.0					LOOSE	LT. BLUISH GRAY	FINE SAND W/ SOME SILT		SANDS LIQUEFIED AND MOVED UP IN 4 INCH CASING.
8.0									
							(GRAVEL)	0.010 INCH	
9.0									
10.0									10.2'
			10.2						

REMARKS**** SITE LOCATED ~ 3 TO 4 FEET ABOVE RIVER. WATER WITH REDDISH COLOR PONDED ON SURFACE AROUND BORING. HOLE REMAINED OPEN W/O CASING TO 4.5 FEET. 4 INCH CASING SET AND CLEANED TO 10.2 FEET. 2 INCH PVC CASING W/ SCREEN SET AND ANNULAR SPACE BACKFILLED

PROJECT NO. 83-302

~~BORING~~ NO. 4

41914

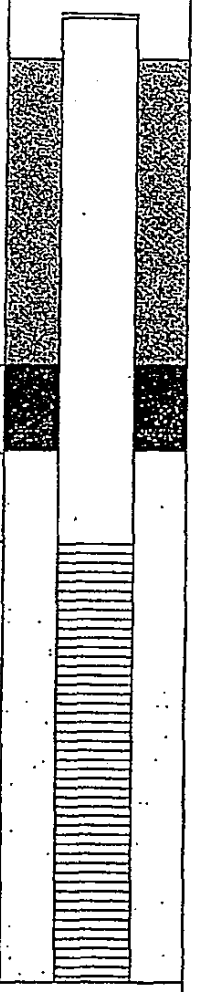
BORING LOG/WELL CONSTRUCTION DIAGRAM

Identification:	PO-11	Location:	Chesapeake Energy Center	Project No.:	95058.35
Drilling Contractor:	Fishburne	Name of Logger:	M Harris	Date:	February 14, 2000
Type: HSA	Total Depth: ~21 ft	Screen/Casing Type:	0.010 Slot 2" PVC	Screened Interval:	21' to 11'

Sample ID. Depth, feet	Blow Counts	Recovery (%)	Description of Material
0-2	N/A	N/A	Black sandy CLAY.
2-4	N/A	N/A	Greenish-gray fine SAND.
4-6	N/A	N/A	Dark gray CLAY.
6-8	5-10-16-17	70%	Dark gray CLAY.
8-10	18-21-18-24	50%	Dark gray CLAY.
10-12	Cuttings damp from ~12'		
12-14			
14-16	3-2-6-4	70%	Dark gray CLAY with some sand. Water at 14'.
16-18			
18-20			
20-22	5-4-4-4	90%	Light gray sandy CLAY.
22-24			
24-26			

Well Construction Detail

Depth: 7', 9', 11', 21'



Notes:

1. PVC Well Riser set in locked metal cover in 2x2' formed concrete pad.

WELL LEGEND

- PVC Riser
- PVC Screen
- Cement Grout
- Bentonite
- No. 2 Morie Sand

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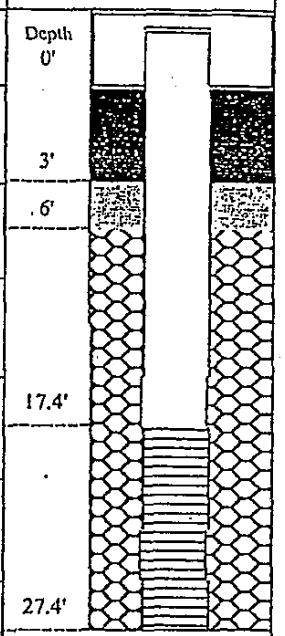
BORING LOG

Identification:	CECW-1	Location:	Chesapeake Energy Center	Project No.:	95058.17
Drilling Contractor:	Fishburne	Name of Logger:	M. Leeper	Date:	25 August 98
Type: HSA	Total Depth: ~27.4'	Screen/Casing Type:	0.010" Slot 2" PVC	Screened Interval:	27.4'-17.4'

Depth (feet)	Sample No. (Depth, ft)	Blow Counts	Recovery (inches)	Description of Material
0	0-2	4-8-11-11	18"	Sandy loam to fine/ medium SAND, to gray, tan sandy loosely compacted medium sand
5	4-6	4-7-14-11	20"	Dark gray silty CLAY, to gray sandy clay
10	9-11	6-6-4-4	22"	Sandy dark gray CLAY, moisture increasing
15	14-16	1-2-2 spoon fell 6"	18"	Light to dark gray sandy CLAY, 70 % organics, intersected water table
20	19-21	1-1 spoon fell 12"	12"	Dark gray sandy to silty CLAY, organics decreasing, saturated
30	24-26	N/A	N/A	Not recovered
35				
40				
50				
55				
60				

Well Construction Details



Not to scale

NOTES:
1. Well riser set in 2' X 2' X 4" concrete pad.
2. Water level is ~ 17.5'.

WELL LEGEND
- PVC Riser
- PVC Screen
- Bentonite
- Cement Grout
- No. 2 Morie Sand

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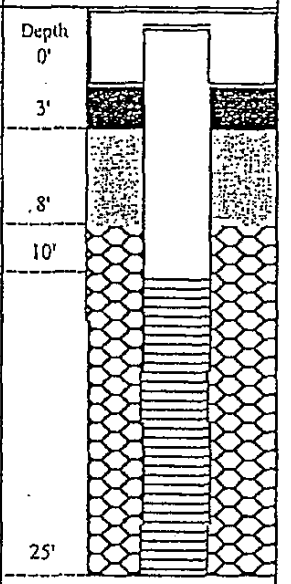
BORING LOG

ntification:	CECW-2	Location:	Chesapeake Energy Center	Project No.:	95058.17
Drilling Contractor:	Fishburne	Name of Logger:	M. Leeper	Date:	25 August 98
Type: HSA	Total Depth: ~25'	Screen/Casing Type:	0.010" Slot 2" PVC	Screened Interval:	25'-10'

Sample Description

Depth (feet)	Sample No. (Depth, ft)	Blow Counts	Recovery (inches)	Description of Material
0				
	0-2	3-4-4-5	12"	Tan medium SAND to tan, brown, orange silty clay
5				
	4-6	4-7-11-14	24"	Gray, brown silty CLAY, to orange, tan sandy clay
10				
	9-11	5-7-8-8	20"	Tan medium SAND to sandy clay to gray medium sand, moisture increasing
15				
	14-16	3-4-4-4	24"	Tan SAND to brown silty clay with 30 % organics, to light gray silty clay, intersected water table
20				
	19-21	1-spoon fell	6"	Brown sandy CLAY to gray medium sand, saturated
30				
35				
40				
50				
55				
60				

Well Construction Details



Not to scale

NOTES:
1. Well riser set in 2' X 2' X 4" concrete pad.
2. Water level is ~ 17.85'.

WELL LEGEND

- PVC Riser
- PVC Screen
- Bentonite
- Cement Grout
- No. 2 Morie Sand

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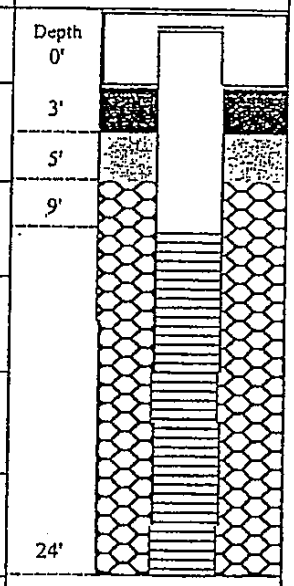
BORING LOG

ntification:	CECW-3	Location:	Chesapeake Energy Center	Project No.:	95058.17
Drilling Contractor:	Fishburne	Name of Logger:	M. Leeper	Date:	25 August 98
Type: HSA	Total Depth: ~24'	Screen/Casing Type:	0.010" Slot 2" PVC	Screened Interval:	24'-9'

Depth (feet)	Sample No. (Depth, ft)	Blow Counts	Recovery (inches)	Description of Material
0	0-2	2-2-3-2	16"	Tan, white medium to fine SAND
5	4-6	3-3-3-1	10"	Tan, white medium to fine SAND with lenses of orange medium sand
10	9-11	1-1 spoon fell	24"	Tan medium to fine SAND to dark gray silty clay, possible ash layer, moisture increasing
15	14-16	1- spoon fell	24"	Dark gray silty CLAY, possible ash layer, intersected water table
20	19-21	1- spoon fell	24"	Dark gray silty CLAY, possible ash layer, saturated
30				
35				
40				
50				
55				
60				

Well Construction Details



Not to scale

NOTES:
1. Well riser set in 2' X 2' X 4" concrete pad.
2. Water level is ~ 18.40'.

WELL LEGEND
- PVC Riser
- PVC Screen
- Bentonite
- Cement Grout
- No. 2 Morie Sand

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41918

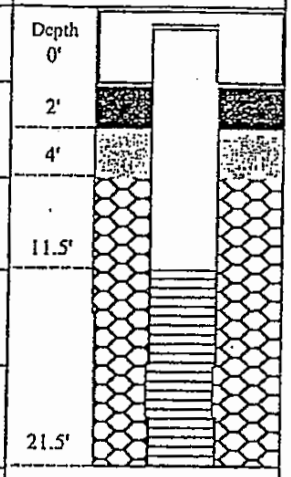
BORING LOG

tification:	CECW-4	Location:	Chesapeake Energy Center	Project No.:	95058.17
Drilling Contractor:	Fishburne	Name of Logger:	M. Leeper	Date:	24 August 98
Type: HSA	Total Depth: ~21.5'	Screen/Casing Type:	0.010" Slot 2" PVC	Screened Interval:	21.5'-11.5'

Sample Description

Depth (feet)	Sample No. (Depth, ft)	Blow Counts	Recovery (inches)	Description of Material
0	0-2	6-6-5-6	10"	Ash fill to interbedded tan, orange and light gray medium SAND
5	4-6	5-6-9-12	20"	Gray silty CLAY with interbedded tan, brown sand, moisture increasing
10	9-11	3-1-2-1	15"	Gray medium to fine SAND to sandy dark gray clay, intersected water table
15	14-16	1-1, spoon fell	6"	Dark gray sandy CLAY, saturated
20				
30				
35				
40				
50				
55				
60				

Well Construction Details



Not to scale

NOTES:
1. Well riser set in 2' X 2' X 4" concrete pad.
2. Water level is ~ 15.4'.

WELL LEGEND

- PVC Riser
- PVC Screen
- Bentonite
- Cement Grout
- No. 2 Morie Sand

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41919

BORING LOG/WELL CONSTRUCTION DIAGRAM

Identification: CECW-5 replacement		Location: Chesapeake Energy Center	Project No.: 95058.35
Drilling Contractor: Fishburne		Name of Logger: M Harris	Date: February 15, 2000
Type: HSA	Total Depth: ~26 ft	Screen/Casing Type: 0.010 Slot 2" PVC	Screened Interval: 26' to 6'

Sample Description				Well Construction Detail
Sample ID. Depth, feet	Blow Counts	Recovery (%)	Description of Material	Depth
0-2	N/A	N/A	Black fine SAND.	1'
	N/A	N/A	Light gray SAND.	
2-4	N/A	N/A	Dark gray CLAY with patches of coarse yellow	3'
4-6	N/A	N/A	Light gray CLAY with fine sand. Cuttings damp at ~4'.	
6-8	6-5-12-13	70%	Dark gray CLAY. Spoon was wet at 5'.	6'
8-10	17-16-16-13	70%	Pale gray silty CLAY. Water present at ~7'.	
10-12				
12-14				
14-16	14-12-15-10	0%	No recovery. Cuttings were wet sandy CLAY.	
16-18				
18-20				
20-22	16-6-3-4	0%	No recovery. Cuttings were wet sandy CLAY.	
22-24				
24-26	10-9-6-6	0%	No recovery. Cuttings were wet sandy CLAY.	26'

Notes:

1. PVC Well Riser set in locked metal cover in 2x2' formed concrete pad.

WELL LEGEND
PVC Riser
PVC Screen
Cement Grout
Bentonite
No. 2 Morie Sand

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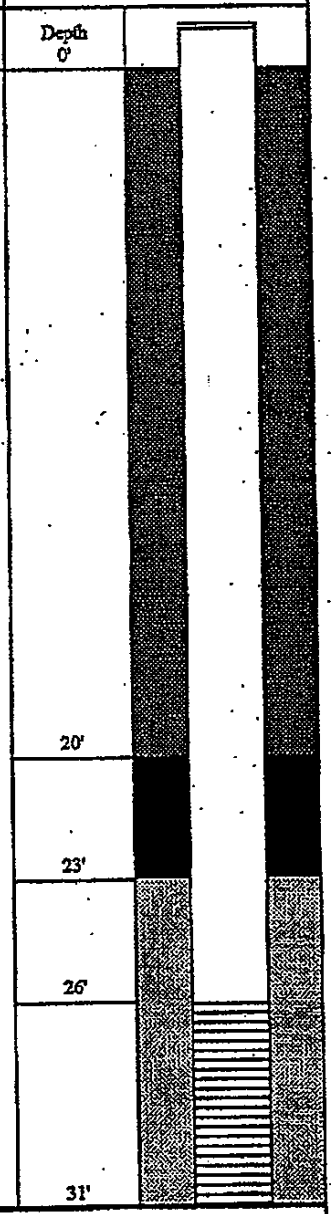
BORING LOG/WELL CONSTRUCTION DIAGRAM

Identification:	CECW-6-I	Location:	Chesapeake Energy Center	Project No.:	95058.41
Drilling Contractor:	Fishburne	Name of Logger:	Martin Harris	Date:	May 10, 2000
Type: HSA	Total Depth: ~31 ft	Screen/Casing Type:	0.010 Slot 2" PVC	Screened Interval:	31' to 26'

Sample Description				Well Construction Detail
Sample ID. Depth, feet	Blow Counts	Recovery (inches)	Description of Material	Depth 0'

Well adjecent to CECW-6-D. No logging carried out.



Notes:

1. PVC Well Riser set in locked metal cover in 2x2' formed concrete pad.

WELL LEGEND

- PVC Riser
- PVC Screen
- Cement Grout
- Bentonite
- No. 2 Morie Sand

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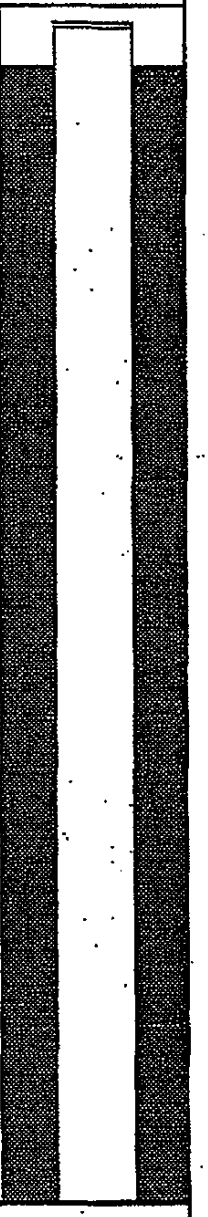
BORING LOG/WELL CONSTRUCTION DIAGRAM (Page 1 of 2)

Identification:	CECW-6-D	Location:	Chesapeake Energy Center	Project No.:	95058.41
Drilling Contractor:	Fishburne	Name of Logger:	Martin Harris	Date:	May 8, 2000
Type: HSA	Total Depth: ~42 ft	Screen/Casing Type:	0.010 Slot 2" PVC	Screened Interval:	42' to 37'

Sample ID. Depth, feet	Blow Counts	Recovery (inches)	Description of Material
0-2	2-3-4-4	10	Dark gray SAND and SILT.
2-4	5-5-4-4	16	4" dark gray CLAY, then 8" light gray SAND, then 4" dark gray CLAY.
4-6	3-3-4-4	24	20" dark gray CLAY, then 4" light gray SAND.
6-8	2-1-1-2	12	1" light gray SAND, then 11" yellow sand.
8-10	2-3-3-4	20	Dark gray CLAY.
10-12	5-5-5-3	12	8" dark gray CLAY, then 4" dark gray SAND.
12-14	1-1-1-1	22	20" Dark gray SAND, then 2" dark gray CLAY. Water at ~11'.
14-16	1-1-3-4	18	8" dark gray CLAY, then 10" dark gray SAND.
16-18	7-14-15-12	24	Dark gray coarse SAND.
18-20	2-1-1-1	12	8" dark gray CLAY, then 4" dark gray SAND.
20-22	4-5-8-8	20	2" dark gray CLAY, then 18" light gray SAND.
22-24	3-4-5-6	12	Light gray SAND.
24-26	3-4-5-3	16	Light gray SAND.
26-28	4-2-2-2	24	Light gray coarse SAND.

Well Construction Detail

Depth



28'

Notes:

1. PVC Well Riser set in locked metal cover in 2x2' formed concrete pad.

WELL LEGEND

- PVC Riser
- PVC Screen
- Cement Grout
- Bentonite
- No. 2 Morie Sand

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Appendix C

Chain of Custody Form

CHEMICAL ANALYSIS ORDER - SYSTEM LABORATORY

Location: CHESAPEAKE	*Requested by:*	*Priority:*
Required Date:	*Phone:*	*Date Anal. Comp.:*
Comment:	*Sampled by:*	*Date Appvd. Release:*

X - PLACE AND "X" IN THE BOX FOR SAMPLES TO BE SUBMITTED NOTE:

System Lab Number	X	Sample ID	Sample Date	Sample Time	Comp.	Grab	# Bottles	Project Code	Analyses/Remarks
		PO8							
		PO9							
		PO10							
		P011							
		MW4R							
		MW5							
		CECW6I							
		CECW1							
		CECW2							
		CECW3							
		CECW4							
		CECW5							

Relinquished by: *(Signature)*	*Date* *Time*	*Received by:* *(Signature)*	*Date* *Time*
Relinquished by: *(Signature)*	*Date* *Time*	*Received by:* *(Signature)*	*Date* *Time*

41924

Appendix D

Field Sheets

CHESAPEAKE ASH SITE LOW-FLOW MONITORING

SEMI-ANNUAL arrival time _____ departure time _____ Well Sampling Order

INFORMATION

check-in Paul Dickson _____

well #	MW4R	_____	weather obs	MW5
date		_____		PO8
sampled by		inst.#	Date	CECW5
Instrument calibration		_____		CECW6I

MW4

MEASUREMENT

a) well depth	14.5	_____	benchmark elevation	14.12
b) depth to water		_____	b) depth to water	_____
		_____	corrected water level	_____
Electronic Tape		X		
Immiscible Layer		y n		
Time well purged		_____		

PO9 CECW4 CECW3 PO10 CECW2 CECW1 PO11

SAMPLING

time	_____
temperature	_____
conductivity	_____
ph	_____
Equipment decon	_____

BOTTLE ORDER

	size of sample	preservative
1.TOTAL METALS	1000 ml	1:1 HNO3
2.SULFIDE	500 ml	6N NaOH/zinc acetate
3.Acenapthene and Dibenzofuran------		outside lab

rinse water level indicator with D.I. Water prior to next use Turbity value 32 ntu

WELL LOCKED ____

Notes

Take three readings prior to sample

	TIME	PH	CONDUCTIVTY	Turbidity	DRAWDOWN
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

****PLEASE USE INK PEN****

For low protocol

pH <0.1 units Conductivity +/- 3%of value Tu +/- 10% ideal less than 10

41926

CHESAPEAKE ASH SITE LOW-FLOW MONITORING

SEMI-ANNUAL

INFORMATION

well # MW5

date _____

sampled by _____

weather obs

Well Sampling Order

MW4
MW5
PO8
CECW5
CECW6I
PO9
CECW4
CECW3
PO10
CECW2
CECW1
PO11

MEASUREMENT

a) well depth 14.5

b) depth to water _____

_____

Electronic Tape X

Immiscible Layer y n

Time well purged _____

benchmark elevation 14.43

b) depth to water _____

corrected water level _____

SAMPLING

time _____

temperature _____

conductivity _____

ph _____

Equipment decon _____

rinse water level indicator with D.I. Water prior to next use

BOTTLE ORDER

	size of sample	preservative
1.TOTAL METALS	1000 ml	1:1 HNO3
2.SULFIDE	500 ml	6N NaOH/zinc acetate
3.Acenaphthene and dibenzofuran------outside lab		
	Turbity value	15 NTU

WELL LOCKED ____

Notes

Take three readings prior to sample

	TIME	PH	CONDUCTIVTY	Turbidity	DRAWDOWN
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

****PLEASE USE INK PEN****

For low protocol

pH <0.1 units Conductivity +/- 3%of value Tu +/- 10% ideal less than 10

CHESAPEAKE ASH SITE LOW-FLOW MONITORING

SEMI-ANNUAL

Well Sampling Order

MW4
MW5
PO8
CECW5
CECW6I
PO9
CECW4
CECW3
PO10
CECW2
CECW1
PO11

INFORMATION

well # P08
date _____
sampled by _____
weather obs

MEASUREMENT

a) well depth 16
b) depth to water _____
_____
Electronic Tape X
Immiscible Layer y n
Time well purged _____

benchmark elevation 14.68
b) depth to water _____
corrected water level _____

SAMPLING

time _____
temperature _____
conductivity _____
ph _____
Equipment decon _____
rinse water level indicator with D.I. Water prior to next use

BOTTLE ORDER

	size of sample	preservative
1.TOTAL METALS	1000 ml	1:1 HNO3
2.SULFIDE	500 ml	6N NaOH/zinc acetate
3. Acenaphthene and Dibenzofuran------outside lab		
Turbity value		32 ntu

WELL LOCKED ____

Notes

	TIME	PH	CONDUCTIVTY	Turbidity	DRAWDOWN
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

****PLEASE USE INK PEN****
For low protocol
pH <0.1 units Conductivity +/- 3%of value Tu +/- 10% ideal less than 10

CHESAPEAKE ASH SITE LOW-FLOW MONITORING

SEMI-ANNUAL

INFORMATION

well # CECW5

date _____

sampled by _____

weather obs

Well Sampling Order

MW4
MW5
PO8
CECW5
CECW6I
PO9
CECW4
CECW3
PO10
CECW2
CECW1
PO11

MEASUREMENT

a) well depth 26

b) depth to water _____

_____

Electronic Tape X

Immiscible Layer y n

Time well purged _____

benchmark elevation 21.87

b) depth to water _____

corrected water level _____

SAMPLING

time _____

temperature _____

conductivity _____

ph _____

Equipment decon _____

rinse water level indicator with D.I. Water prior to next use

BOTTLE ORDER

	size of sample	preservative
1.TOTAL METALS	1000 ml	1:1 HNO3
2.SULFIDE	500 ml	6N NaOH/zinc acetate

3. Acenaphthene and dibenzofuran-----outside lab

Turbity value 14 NTU

WELL LOCKED ____

Notes

	TIME	PH	CONDUCTIVTY	Turbidity	DRAWDOWN
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

****PLEASE USE INK PEN****

For low protocol

pH <0.1 units Conductivity +/- 3%of value Tu +/- 10% ideal less than 10

CHESAPEAKE ASH SITE LOW-FLOW MONITORING

SEMI-ANNUAL

Well Sampling Order

MW4
MW5
PO8
CECW5
CECW6I
PO9
CECW4
CECW3
PO10
CECW2
CECW1
PO11

INFORMATION

well # CECW6 I

weather obs

date _____

sampled by _____

MEASUREMENT

a) well depth 34 benchmark elevation _____

b) depth to water _____ b) depth to water _____

_____ corrected water level _____

Electronic Tape X

Immiscible Layer y n

Time well purged _____

SAMPLING

time _____

temperature _____

conductivity _____

ph _____

Equipment decon _____

rinse water level indicator with D.I. Water prior to next use

BOTTLE ORDER

	size of sample	preservative
1.TOTAL METALS	1000 ml	1:1 HNO3
2.SULFIDE	500 ml	6N NaOH/zinc acetate

3.Acenaphthene and Dibenzofuran------outside lab

Turbity value 24

WELL LOCKED ____

Notes

	TIME	PH	CONDUCTIVTY	Turbidity	DRAWDOWN
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

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For low protocol

pH <0.1 units Conductivity +/- 3%of value Tu +/- 10% ideal less than 10

CHESAPEAKE ASH SITE LOW-FLOW MONITORING

SEMI-ANNUAL

Well Sampling Order

MW4
MW5
PO8
CECW5
CECW6I
PO9
CECW4
CECW3
PO10
CECW2
CECW1
PO11

INFORMATION

well # PO9
date _____
sampled by _____

weather obs

MEASUREMENT

a) well depth 10
b) depth to water _____

benchmark elevation 9.99
b) depth to water _____
corrected water level _____

Electronic Tape X
Immiscible Layer y n
Time well purged _____

SAMPLING

time _____
temperature _____
conductivity _____
ph _____
Equipment decon _____
rinse water level indicator with D.I. Water prior to next use

BOTTLE ORDER

	size of sample	preservative
1.TOTAL METALS	1000 ml	1:1 HNO3
2.SULFIDE	500 ml	6N NaOH/zinc acetate
3.Acenaphthene and dibenzofuran----outside lab		

Turbity value 10 NTU

WELL LOCKED ____

Notes

	TIME	PH	CONDUCTIVTY	Turbidity	DRAWDOWN
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

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For low protocol
pH <0.1 units Conductivity +/- 3%of value Tu +/- 10% ideal less than 10

CHESAPEAKE ASH SITE LOW-FLOW MONITORING

INFORMATION

well # CECW4 _____ weather obs

date _____

sampled by _____

well sampling order
MW4R
MW5
PO8
CECW5
CECW6I
PO9
CECW4
CECW3
PO10
CECW2
CECW1
PO11

MEASUREMENT

a) well depth _____ benchmark elevation _____

b) depth to water _____ b) depth to water _____

_____ corrected water level _____

Electronic Tape X

Immiscible Layer _____

_____

SAMPLING

time _____

temperature _____

conductivity _____

ph _____

Equipment decon _____

rinse water level indicator with D.I. Water prior to next use

WELL LOCKED ____

Notes

	TIME	PH	CONDUCTIVTY	Turbidity	DRAWDOWN
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

****PLEASE USE INK PEN****

For low protocol

pH <0.1 units Conductivity +/- 3%of value Tu +/- 10% ideal less than 10

CHESAPEAKE ASH SITE LOW-FLOW MONITORING

SEMI-ANNUAL

INFORMATION

well # CECW3

date _____

sampled by _____

weather obs

Well Sampling Order

MW4
MW5
PO8
CECW5
CECW6I
PO9
CECW4
CECW3
PO10
CECW2
CECW1
PO11

MEASUREMENT

a) well depth 24

b) depth to water _____

_____

Electronic Tape X

Immiscible Layer y n

Time well purged _____

benchmark elevation 28.75

b) depth to water _____

corrected water level _____

SAMPLING

time _____

temperature _____

conductivity _____

ph _____

Equipment decon _____

rinse water level indicator with D.I. Water prior to next use

BOTTLE ORDER

	size of sample	preservative
1.TOTAL METALS	1000 ml	1:1 HNO3
2.SULFIDE	500 ml	6N NaOH/zinc acetate
3.acenaphthene and dibenzofuran-----outside lab		
	Turbity value	27 NTU

WELL LOCKED ____

Notes

	TIME	PH	CONDUCTIVTY	Turbidity	DRAWDOWN
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

****PLEASE USE INK PEN****

For low protocol

pH <0.1 units Conductivity +/- 3%of value Tu +/- 10% ideal less than 10

CHESAPEAKE ASH SITE LOW-FLOW MONITORING

SEMI-ANNUAL

INFORMATION

well # PO10

date _____

sampled by _____

weather obs

Well Sampling Order

MW4
MW5
PO8
CECW5
CECW6I
PO9
CECW4
CECW3
PO10
CECW2
CECW1
PO11

MEASUREMENT

a) well depth 10 benchmark elevation 7.49

b) depth to water _____ b) depth to water _____

corrected water level _____

Electronic Tape X

Immiscible Layer y n

Time well purged _____

SAMPLING

time _____

temperature _____

conductivity _____

ph _____

Equipment decon _____

rinse water level indicator with D.I. Water prior to next use

BOTTLE ORDER

	size of sample	preservative
1.TOTAL METALS	1000 ml	1:1 HNO3
2.SULFIDE	500 ml	6N NaOH/zinc acetate
3.Acenaphthene and Dibenzofuran-----outside lab		
	Turbity value	>10 NTU

WELL LOCKED ____

Notes

	TIME	PH	CONDUCTIVTY	Turbidity	DRAWDOWN
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

****PLEASE USE INK PEN****

For low protocol

pH <0.1 units Conductivity +/- 3%of value Tu +/- 10% ideal less than 10

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CHESAPEAKE ASH SITE LOW-FLOW MONITORING

SEMI-ANNUAL

INFORMATION

well # CECW2

date _____

sampled by _____

weather obs

Well Sampling Order

MW4
MW5
PO8
CECW5
CECW6I
PO9
CECW4
CECW3
PO10
CECW2
CECW1
PO11

MEASUREMENT

a) well depth 25

b) depth to water _____

_____

Electronic Tape X

Immiscible Layer y n

Time well purged _____

benchmark elevation 23.35

b) depth to water _____

corrected water level _____

SAMPLING

time _____

temperature _____

conductivity _____

ph _____

Equipment decon _____

rinse water level indicator with D.I. Water prior to next use

BOTTLE ORDER

	size of sample	preservative
1.TOTAL METALS	1000 ml	1:1 HNO3
2.SULFIDE	500 ml	6N NaOH/zinc acetate
3.Acenaphthene and dibenzofuran------		outside lab
	Turbity value	>10 NTU

WELL LOCKED ____

Notes

	TIME	PH	CONDUCTIVTY	Turbidity	DRAWDOWN
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

****PLEASE USE INK PEN****

For low protocol

pH <0.1 units Conductivity +/- 3%of value Tu +/- 10% ideal less than 10

CHESAPEAKE ASH SITE LOW-FLOW MONITORING

SEMI-ANNUAL

INFORMATION

well # CECW1

date _____

sampled by _____

weather obs

Well Sampling Order

MW4
MW5
PO8
CECW5
CECW6I
PO9
CECW4
CECW3
PO10
CECW2
CECW1
PO11

MEASUREMENT

a) well depth 27.4 benchmark elevation 22.94

b) depth to water _____ b) depth to water _____

_____ corrected water level _____

Electronic Tape X

Immiscible Layer y n

Time well purged _____

SAMPLING

time _____

temperature _____

conductivity _____

ph _____

Equipment decon _____

rinse water level indicator with D.I. Water prior to next use

BOTTLE ORDER

	size of sample	preservative
1.TOTAL METALS	1000 ml	1:1 HNO3
2.SULFIDE	500 ml	6N NaOH/zinc acetate
3.Acenaphthene and dibenzofuran-----outside lab		
	Turbity value	>10 NTU

WELL LOCKED ____

Notes

	TIME	PH	CONDUCTIVTY	Turbidity	DRAWDOWN
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

****PLEASE USE INK PEN****

For low protocol

pH <0.1 units Conductivity +/- 3%of value Tu +/- 10% ideal less than 10

CHESAPEAKE ASH SITE LOW-FLOW MONITORING

SEMI-ANNUAL

INFORMATION

well # PO11

date _____

sampled by _____

weather obs

Well Sampling Order

MW4
MW5
PO8
CECW5
CECW6I
PO9
CECW4
CECW3
PO10
CECW2
CECW1
PO11

MEASUREMENT

a) well depth 21

b) depth to water _____

benchmark elevation 24.42

b) depth to water _____

corrected water level _____

Electronic Tape X

Immiscible Layer y n

Time well purged _____

SAMPLING

time _____

temperature _____

conductivity _____

ph _____

Equipment decon _____

rinse water level indicator with D.I. Water prior to next use

BOTTLE ORDER

	size of sample	preservative
1.TOTAL METALS	1000 ml	1:1 HNO3
2.SULFIDE	500 ml	6N NaOH/zinc acetate
3.Acenaphthene and Dibenzofuran-----outside lab		
	Turbity value	>10 NTU

WELL LOCKED ____

Notes

	TIME	PH	CONDUCTIVTY	Turbidity	DRAWDOWN
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

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For low protocol

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Appendix E

Technical Paper: Data Analysis for Solid Waste Facilities (VA DEQ March 2008)

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

TECHNICAL PAPER: DATA ANALYSIS FOR SOLID WASTE FACILITIES

The purpose of this document is to address common questions for the solid waste staff pertaining to the statistical analysis of groundwater samples at solid waste facilities. This document should be used in conjunction with the groundwater monitoring and sampling analysis plan. The statistical methods covered in this document include the most common statistical analyses used for groundwater monitoring samples at solid waste sites. For additional details, please refer to the EPA guidance documents listed on page 7 of this document.

INTRODUCTION

Statistical analysis of the groundwater data presented in monitoring reports for submission to the Virginia Department of Environmental Quality (VADEQ), Division of Waste Coordination should address the following:

A. Design of experiment
B. Outliers
C. Missing data
D. Evaluation of data below detection limits or quantitation limits
E. Checking assumptions (distributions, homogeneity of variances)
F. Selection of statistical method
G. Verification sampling strategy

A. DESIGN OF EXPERIMENT

The results of the statistical analysis can tell you only what the experiment was designed to explain. For example, up-gradient to down-gradient statistical comparisons will indicate if groundwater concentrations for a particular constituent are different up gradient of the landfill compared to down gradient of the landfill. This difference could be due to the landfill or due to natural site conditions. The facility must ensure that the design of the monitoring network and statistical experiment are designed to be able to detect a release of solid waste constituents from the landfill.

The facility should address natural spatial variation of groundwater constituents at a site when designing the monitoring network and type of statistical comparisons which will be performed. Two acceptable ways of dealing with spatial variability are to perform intra-well statistical comparisons only or to install additional up gradient or side gradient wells to account for natural variations at the site. If the facility possesses reliable pre-waste data (which have not been impacted by site activities) or can adequately demonstrate that inorganic constituent concentrations in wells which

are located down gradient from the landfill have not been impacted by site activities, the facility may petition the VADEQ for a variance from inter-well statistical comparisons. The variance petition should be written in accordance with 9 VAC 20-80-750 (Virginia Solid Waste Management Regulations (VSWMR)) and include hydro-geologic information about the site, a demonstration that inorganic constituent concentrations in down gradient wells have not been impacted by the landfill, information regarding the date waste was originally placed in the landfill, and the best estimate possible of groundwater flow at the site. If the facility is an older site, or it cannot be determined that inorganic constituent concentrations in groundwater from wells located down gradient of the landfill are not impacted by the landfill activities, the facility can install additional up gradient (or side gradient) wells to attempt to get a better estimate of natural variation at the site. Please note that the location of the additional up gradient or side gradient wells must be approved by VADEQ permitting staff.

The facility should also determine the number of background samples which will be necessary for the planned statistical analysis method and ensure that an adequate number of samples have been collected prior to the statistical comparisons required by the VSWMR. The facility should collect an adequate number of background dataset for inter-well statistical comparisons within one year, and an adequate number of background samples for intra-well statistical comparisons within two years. Background for inter-well statistical comparisons can be updated with each sampling event, unless there is an indication that background wells have been impacted by the landfill. Background for intra-well statistical comparisons can be updated every two years, unless there is indication of a release in the down gradient well. Please note that for intra-well comparison a two-year time window should be left between background for intra-well comparisons and compliance samples to ensure that samples associated with a slow release are not included in the background dataset.

The facility must sample for all constituents required by the VSWMR, unless it has been specified in the permit or a variance granted by the VADEQ that a facility may sample for constituents other than the full list required by the VSWMR.

B. OUTLIERS

Inconsistently large or small values (outliers) can be observed due to errors from sampling, laboratory, transportation, transcription, or actual extreme values. The historical background dataset should be screened for each well and constituent for the existence of outliers (USEPA 1992, section 6.2) using the method described by Dixon (1953) or another method approved by the VADEQ. Background observations, which are considered to be outliers, should not be included in the statistical analysis to preserve the power of the test to detect a release from the facility. If an extreme value occurs in compliance well during the compliance sampling event, the facility should collect a re-sample within the compliance period of the initial sample. This will enable the VADEQ to distinguish between an extreme value in a compliance well and an indication of a release from the facility. Background observations should be

evaluated to determine if data is normally distributed prior to running the outlier test.

C. MISSING DATA

If a sampling event results in a missing data value, an attempt to re-sample for the missing value should be made within the compliance period of the initial sampling event. It is recommended that the re-sample be collected as close to the initial sampling event as possible to minimize the effects of variation due to the differences in sample collection time and to allow additional time for a verification sample if one is needed.

D. DATA BELOW DETECTION LIMITS

The facility should use laboratory derived limits of detection and quantitation in the statistical analyses of groundwater data, as opposed to the detection and quantitation limits which have been published for a particular analytical method.

For data where the percentage of data below the laboratory limit of detection or laboratory limit of quantitation is less than 25 percent, the facility should replace the non-detects or non-quantified values with half the laboratory limit of detection or quantitation. However, when the percentage of non-detects or non-quantified values is greater than 25 percent and less than 50 percent, the mean and standard deviation should be adjusted using either Aitchison's adjustment (USEPA 1992 section 2.2.2 and Aitchison, 1955) or Cohen's adjustment (USEPA 1989 section 8.1.3 and Cohen, 1961). Extensive tables and computational details for Cohen's adjustment are also provided in Gibbons, 1994a. The approach for selection between the two methods is described in USEPA (1992) section 2.2.1.

E. CHECKING ASSUMPTIONS ASSOCIATED WITH THE TEST METHOD

Parametric statistical test methods assume that the data follow a certain distribution, for groundwater statistics the distributions usually are the normal and the log-normal distributions. The facility must verify that the distributional assumptions of a particular test method are valid prior to applying the statistical test method.

No testing of normality is needed when the percentage of non-detects or non-quantified values is greater than 50%, since a non-parametric statistical test method should be applied. Most parametric statistical tests for environmental data will assume the data are normally or log-normally distributed. The Shapiro-Wilk test, multiple group Shapiro-Wilk test or Filliben's correlation coefficient test should be applied to the dataset to determine the distributional form. To test for log-normality, the natural logarithms of the original data should be taken and tested for normality. The facility may use any other appropriate method for testing the distributional assumptions with approval by the VADEQ.

When the detection frequency is less than 50% or transformation fails to bring about normality, a non-parametric method should be used.

Non-parametric two- or multi-sample comparisons, such as the Wilcoxon rank sum test or the Kruskal-Wallis test assume that the dispersion for each group in the comparison is similar. This can be checked by comparing boxplots of each group.

F. SELECTION OF STATISTICAL METHOD

The facility should apply an appropriate statistical method consistent with the Virginia Solid Waste Management Regulations, 9 VAC 20-80-300.D.

Two- or Multi- Sample Comparisons

If a facility chooses to perform statistical comparisons using a two- or multi-way statistical test method (i.e. t-test, ANOVA, Wilcoxon rank sum, Kruskal-Wallis), the facility will need to collect a minimum of four samples per compliance period. As specified in the VSWMR the level of significance when performing these tests for individual well comparison shall be no less than 0.01 and no less than 0.05 for multiple comparisons. Due to the number of samples which need to be collected per compliance period most facilities prefer to apply the interval methods for statistical analysis associated with a compliance sampling event. However, when the intent of the statistical analysis is to show that mean/median concentration levels are similar between the background and compliance area (i.e. a first determination for an industrial or CDD landfill) the two- or multi-sample comparison statistical methods can be useful.

The facility should check distributional assumptions for both background and compliance datasets and check assumptions of homogeneity of variances prior to applying these tests.
The ANOVA test assumes data are normally or log-normally distributed and variances are homogeneous across groups. The CABF and Welch's t-tests assume data are normally or log-normally distributed and variances don't differ dramatically across groups (these tests account for some differences between variances). The Wilcoxon rank sum and Kruskal-Wallis tests assume that the distributions of the two groups are similar (though undetermined).

Interval Method

Statistical interval methods commonly applied in groundwater data analysis are the confidence interval, prediction interval, and tolerance interval. Prediction and tolerance intervals are often applied for compliance sampling events in Detection, Assessment, Phase I, and Phase II monitoring programs and for establishing background-based, groundwater protection standards, since only one initial sample per well is required during the compliance period. Confidence intervals are often applied for comparisons to a groundwater protection standard which is based on a mean or median value.

For all interval methods, the facility should check the normality or log-normality of the background dataset and the percentage of non-detects in the background dataset. If the background dataset is normally or log-normally distributed, and there are less than 50% non-detects, then a parametric interval can be calculated. If a distribution cannot be established for the background dataset or 50% or more of the data are non-detects, the facility should apply a non-parametric statistical limit.

Suggested sample sizes for the parametric and non-parametric versions of the above interval methods are provided in the attached table. Please note that these methods can lead to a higher false positive rate or lower statistical power with a smaller sample size. However, a statistical analysis can be conducted with a smaller dataset than the suggested size at any time.

It is the responsibility of the facility to collect an adequate number of background samples for the proposed statistical interval methods prior to the statistical analysis event required by the VSWMR. False positive and false negative rates associated with confidence, prediction and tolerance intervals must be protective of human health and the environment. If the facility chooses to apply a false positive rate of less than .01, the facility must include in the report a demonstration that a lower false positive rate will provide adequate statistical power to detect a release from the facility. Adequate statistical power is the ability to detect a three standard deviation increase above the mean with 50% power and a four standard deviation increase above the mean with 80% power.

Control Charts

The Shewhart-CUSUM control chart can be applied as an intra-well statistical test method. Please note that a variance from inter-well statistical comparisons must be granted by the VADEQ prior to applying an intra-well only monitoring program. Details of how to apply Shewhart-CUSUM control charts can be found in EPA 1992 (section 7). Please note that the background dataset can be updated every two years if there is no indication of an impact from the facility (increasing trend or significant result). The facility should leave a two-year time window between the background dataset and the compliance event to ensure that data associated with a slow release from the facility are not incorporated into the background dataset.

Other Methods

In the event the facility has selected any other method listed in the Virginia Solid Waste Management Regulations, the facility will collect the appropriate number of samples and shall maintain an appropriate level of significance mentioned above. If the facility prefers to apply a statistical method that is not in listed in the VSWMR, the facility must receive approval from the VADEQ prior to applying the test method.

Comparison of Compliance Well Data To A Standard During Assessment Or Corrective Action Monitoring

In accordance with sections 9 VAC 20-80-300.B.3 and 300.C.4 (VSWMR) the compliance data shall be compared to the groundwater protection standard (GWPS) if down gradient well concentrations exceed established background concentrations for Table 5.1 constituents. If a maximum contaminant level (MCL) is promulgated or alternate concentration limit (ACL) is established for a constituent, and the ACL or MCL is greater than the background limit (or statistically determined background level), the ACL or MCL is the ground-water protection standard. All new concentrations in the assessment or corrective action wells should be compared to the standard (i.e., ACL or MCL) using the lower normal confidence limit computed from at least four sampling values collected during the compliance period. The level of confidence of the interval should be 80% for a sample size of 4-7, and 90% for a sample size of 8-10 to ensure that the comparison has adequate power to detect an exceedance above the groundwater protection standard.

If the groundwater protection standard for a constituent is based on background data and exceeds the MCL or ACL, then the individual point of compliance

measurements will be compared to the background limit and not the MCL or ACL.

However, for a particular sampling event, if the established groundwater protection standard is less than the VADEQ accepted quantitation limit (QL) then the QL becomes the standard for that sampling event, and the compliance well data will be compared to the QL.

G. VERIFICATION SAMPLING

The principal advantage of taking a verification sample is to maintain an acceptable site-wide false positive rate while the statistical test has adequate power to detect a release from the facility if it occurs. A verification sampling strategy involves collection of a pre-planned number of additional samples. A facility may choose to apply verification samples as follows:
The 1-of-m approach was initially suggested by Davis and McNichols (1987). The facility can take as many as m samples during the compliance period of the initial sampling event and if the 1-of-m (usually m=1 to 3) sample is below a prediction or tolerance limit, the constituent is said to have "passed" the test at that well. If the facility chooses to apply the verification sampling strategy, the alpha value should be modified as following:

a. Select a default value for $\alpha =$ 0.01
$$\alpha = 0.01$$
b. Pass the first or one of one verification resamples, adjust alpha
$$\alpha = (1 - .95^{\frac{1}{k}})^{\frac{1}{2}}$$
c. Pass the first or one of two verification resamples, adjust alpha
$$\alpha = (1 - .95^{\frac{1}{k}})^{\frac{1}{3}}$$
d. Pass the first or two of two verification resamples, adjust alpha
$$\alpha = \sqrt{1 - 0.95^{\frac{1}{k}}}\sqrt{\frac{1}{2}}$$

Where k is the number of comparisons and α is the site-wide false positive rate. Please note that alpha can not be less than 0.01 unless the facility shows that the statistical comparison has at least as much statistical power as the EPA reference power curves (EPA 1992, Appendix B). Since the verification sampling is pre-planned, the facility can adjust the upper statistical limit calculated for background to account for the fact that the verification samples will be collected. Please note that the regulations do not allow a facility to disregard the statistical evaluation in a situation when the facility is unable to collect a verification sample. Therefore, if the facility would like to take a verification sample, it should be taken during the compliance period of the initial sampling event and the statistical result must include the verification sample prior to submitting it to the VADEQ. The verification sample must be independent from the initial sample.

For questions or comments, please contact:
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Statistican
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(804) 698-4246

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Approved by: _____

Director
Office of Waste Technical Suopport

Date: 3/25/08

Note: This doccument has been reviewed by Waste Division staff.

TABLE 1
SUGGESTED MINIMUM BACKGROUND SAMPLES

	Parametric	Non-parametric	Non-parametric Interval % Confidence
CABF/Welch's T-test	4	NA	NA
Wilcoxon Rank Sum	NA	5	NA
Confidence Interval	4	NA	NA
Tolerance Interval	8	19	95%
Prediction Interval	8	13	99%#
Shewhart CUSUM Chart+	8	NA	NA

* The above tests can be used with fewer samples, however it will increase the false positive rate.
# Includes one verification re-sample, use 19 samples for a 95% Prediction Interval with no verification resamples.
+ For Intra-well testing only.
NA Not Applicable.

Appendix F

Field Equipment Manufacture Calibration Guidance

HYDROLAB®

Multiparameter Water Quality Monitoring Instruments

– Operating Manual –

HYDROLAB®

41948

PART THREE
MAINTENANCE and CALIBRATION

3.1 Parameter Selection

Not all Transmitters have the full complement of sensors, so select from the information of Part Three that which pertains to your SVR3 system. The Transmitter label shows your options. Use *FIGURE 3.1* to identify the sensors.

Remember that the calibration points for a SVR3 system are stored in the Transmitter (which may be a Hydrolab H20 or a Hydrolab DataSonde 3). This allows one Display/Logger to calibrate several Transmitters if those Transmitters are to be used later without a Display/Logger (for instance, if you are using the SVR3 Display/Logger to calibrate DS3s before their deployment). It also means that any Transmitter can be used with any Display/Logger, without recalibration. In other words, the Transmitters are interchangeable.

Fundamentally, the Transmitter is calibrated by pouring a calibration standard into the Calibration Cup (or immersing the entire Transmitter in a bucket of standard) and watching the readings (for the parameter to be calibrated) in Screen 1 or 2.

When the readings stabilize (meaning that step-response and/or temperature transients have disappeared), the Basic Menu is accessed by hitting the Display/Logger's Space key. Typing a C will then produce the Calibrate menu, from which the particular parameter value can be set. (Section 2.5 has more menu-specific information for calibration.)

Alternatively, you can use the Calibrate macro keys (see section 2.1.4) for calibrating time, pH, specific conductance, salinity, dissolved oxygen, and depth.

You might notice that the Transmitter has built-in checks for calibration acceptance. If a sensor's response is nowhere near what it should be for the calibration value you type in, the calibration value will not be accepted. For example, if you type in 7.02 for a pH calibration, but have accidently immersed the sensors in a buffer of value 9.18, you are notified that the calibration is not acceptable and are returned to the Screen 1 or 2. If for any reason you cannot complete calibration for any parameter, the Transmitter will continue to use the calibration from the last time that particular parameter was calibrated. However, you should try to determine why the proposed new calibration is not acceptable (faulty sensor, bad standard, low batteries (see section 3.11), mis-typed standard value, etc.).

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If any parameter values are accompanied by an asterisk (*), those value are based on default calibration settings. This means that the Transmitter has no calibration information for that particular sensor, and has replaced it with (i.e, defaulted to) a nominal calibration setting. So, the sensor must be calibrated. Note that some calibrations affect other parameters. For example, lack of calibration information for specific conductance will cause an asterisk annotation for specific conductance, salinity, dissolved oxygen (ppm), and depth readings, since each is calculated from, or influenced by, the specific conductance reading.

3.2 Sage Remarks Concerning Sensor Preparation

Sensor preparation is probably the most important action you can take to maintain or improve the quality of your field measurements. A contaminated, worn-out, or damaged sensor simply will not produce a reliable reading. It is well worth your time to set up a routine in which all sensors are serviced frequently and then allowed to rest in tap water overnight before calibration.

3.3 Temperature

Because of the unvarying nature of the temperature sensor and its conditioning circuitry, the temperature calibration is factory-set and requires no recalibration. The sensor itself requires no maintenance.

3.4 Specific Conductance and Salinity

Specific Conductance ranges are divided to maximize measurement resolution. The Fresh Water cell block (see FIGURE 3.1) provides the ranges 0 to 0.15, 0.15 to 1.5, and 1.5 to 10 milliSiemens/cm. The Salt Water cell block (see FIGURE 3.1) provides the ranges 0 to 1.5, 1.5 to 15, and 15 to 100 milliSiemens/cm. The Salt Water cell block should be used only if specific conductances greater than 10 mS/cm are anticipated.

To maintain the sensor, remove the white cell block covering the six pin-shaped nickel electrodes of the specific conductance sensor. Remove the six small o-rings that are slipped over the electrodes and polish all of the exposed surface of the electrodes with the emery cloth supplied in the Maintenance Kit, or with #400 wet/dry sandpaper. Be sure to polish the ends of the electrodes, but be careful not to touch the nearby pH glass electrode with the abrasive. Clean the electrodes and the cell block with an alcohol-soaked swab.

Re-install the six o-rings (replace the o-rings if they have been flattened-out by long service). Re-install the white cell block, tightening the screws just enough to make sure the cell block is seated flat against the specific conductance sensor body. Once the sensor has been rinsed well with deionized water, it can be calibrated. It is good practice, however, to let the sensor soak in tap water overnight to allow freshly-polished electrode surfaces to re-equilibrate with an aqueous environment.

When calibrating specific conductance, use a standard whose specific conductance is near that of your field samples; for instance, don't use 1M KCl to calibrate for fresh-water work. Unless you are practiced in quantitative preparations, or know someone who is, you are better off purchasing prepared specific conductance standards. The following table shows several potassium chloride solutions and their specific conductance values:

KCl Molar Concentration	Specific Conductance in mS/cm
0.5	58.64
0.2	24.82
0.1	12.90
0.05	6.668
0.02	2.767
0.01	1.413
0.005	0.718
0.002	0.292
0.001	0.147
0.0005	0.074

For calibration, first make sure that the Transmitter knows which cell block is employed (see section 2.6.2). Next, make sure the sensor is clean and serviced. Then:

1) Thoroughly rinse the sensors several times by half-filling the calibration cup with deionized water and shaking the Transmitter to make sure each sensor is free from contaminants that might alter your specific conductance standard.
2) In a similar manner, rinse the sensors twice with a small portion of the specific conductance standard to be used for calibration, each time discarding the rinse.
3) With the Calibration Cup screwed onto the Transmitter, sensors pointed toward the ceiling, pour in standard to within a centimeter of the top of the cup, making sure there are no bubbles in the bores of the cell block.
4) Watch the specific conductance readings until they have stabilized; the sensor is now ready for calibration.
5) Select specific conductance from the Calibrate menu, type in the calibration standard value, and press Enter to set the calibration and return to Screen 1 or 2.

Because the salinity parameter is algorithm-generated (see section 5.5) from the specific conductance reading, once you have calibrated specific conductance, you have also calibrated salinity. However, if your field work requires salinity rather than specific conductance readings, you should calibrate salinity instead of specific conductance. Simply access salinity instead of specific conductance from the calibrate menu and type in the value (in parts per thousand at 25°C) of your salinity (i.e, sea water) standard. Note that calibrating salinity simultaneously calibrates specific conductance. You can calibrate only one of salinity, TDS, resistivity, and specific conductance.

3.5 pH

The pH glass electrode requires maintenance only when obviously coated with oil, sediment, or biological growth. Clean the glass with a very clean, soft, non-scratching cloth wet with rubbing alcohol (a cotton ball will do).

Servicing the reference electrode mainly involves replacing the electrolyte by gently pulling the entire covering sleeve away from the Transmitter

body. Empty the remaining electrolyte from the reference sleeve, and refill the sleeve to the top with standard electrolyte: three- or four-molar KCl saturated with silver chloride.

With the Transmitter sensors pointed toward the floor, push the full reference sleeve back onto its mount until the sleeve has just covered the o-ring located on the mount (just behind the silver electrode). Now turn the Transmitter so that the sensors point toward the ceiling and push the sleeve the rest of the way onto its mount. Notice that while you are seating the sleeve, you are purging any air trapped in the electrolyte chamber, and are using the air and excess electrolyte to flush and clean the porous junction on the tip of the sleeve. This junction is the most important part of the pH system; make sure it is clean and passes electrolyte readily. If not, replace it with the spare in the maintenance kit.

The pH system can now be calibrated. However, it is a good idea to let the electrodes re-equilibrate overnight in tap water after being cleaned, especially if you have used alcohol.

pH calibration is accomplished by filling the Calibration Cup first with the "zero" buffer (value between 6.8 and 7.2) and then with a "slope" buffer whose pH is near that of the anticipated samples to be measured (but not between 6.8 and 7.2). For each buffer, once the reading has stabilized, follow the calibration procedure detailed in section 2.5.1. Always rinse the sensors thoroughly with deionized water between buffers.

The general-purpose Hydrolab reference electrode is designed for normal field application: measurement of middle-range ionic strength waters to about 200 meters depth. For use in very low ionic-strength waters (generally, those under 0.2 mS/cm specific conductance), measurement reliability can often be enhanced by the LISRE (an optional one-piece, white, bullet-shaped "low ionic-strength reference electrode" that does not require electrolyte replacement). The LISRE requires a maintenance procedure different from that prescribed for the rebuildable Hydrolab reference.

First, and most importantly, the tip of the LISRE should be soaked in 4-molar potassium chloride whenever the system is not in use; for instance, overnight when the instrument is in daily use. Fill with KCl the black cap provided with the LISRE (or a similar cap) and install it on the LISRE for this storage procedure, since the other sensors, such as the pH glass itself, should be stored in plain tap water. This step facilitates a reference junction that is homogeneously saturated with strong electrolyte, a condition necessary for stable and accurate readings in dilute samples. Be sure to remove the black cap for calibration or field use.

As a rule of thumb, make sure the LISRE reference electrode is soaked in KCl as long, per week, as it is exposed to sample waters.

Second, always keep the LISRE clean by rinsing with soapy water to remove visible contamination, and by wiping the sensor occasionally with a cloth soaked in rubbing alcohol to remove oils and grease that might have accumulated. The sensor should be soaked in KCl at least 24 hours after cleaning, then recalibrated before field use.

Third, check the sensor's span frequently by calibrating with standard buffers and then checking performance with a standard whose ionic strength approximates that of the anticipated field samples. Calibration with standard buffers alone is no guarantee of measurement quality in low ionic-strength samples. (See section 5.9)

Slow response or non-reproducible measurements are signs that the electrodes have become coated or clogged.

The pH glass electrode is susceptible to coating by many substances. The speed of response, normally 95% of the reading in less than 90 seconds, is dramatically changed. Usually a rinse with methyl alcohol will remove any films on the glass and restore the speed of response.

If the methanol rinse does not restore the response, soak the electrode in 0.1 Molar HCl for five minutes. Remove and rinse the electrode with water and rinse the electrode in pH buffer for 10 minutes. This should improve the response.

See section 3.11 for information on pH "warm-up".

3.6 Redox

Generally the Redox sensor requires the same infrequent cleaning procedure as the glass pH electrode. Should the platinum band at the tip of the Redox sensor get really dirty and discolored, it can be polished with a clean cloth and a very mild abrasive, such as toothpaste. After polishing, the sensor should be allowed to soak overnight in tap water so that the platinum surface can restabilize.

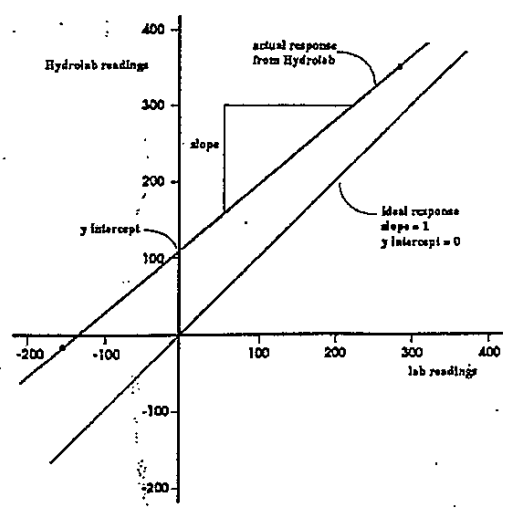
As long as the platinum band of the Redox sensor and the reference electrode are kept properly serviced, you may not need to frequently check

the Redox system calibration. However, you can verify your Redox system performance by dissolving a few grams of quinhydrone in 500 ml of 4- and 7-pH buffers. For the temperatures of 20°, 25°, and 30°C, respectively, the Redox values for the pH 4 solution are 470, 462, and 454; for the pH 7 solution 295, 285, and 275. These Redox values are in millivolts (European sign convention) and are based on the standard hydrogen reference electrode. Note that Hydrolab uses a silver-silver chloride reference electrode instead of the hydrogen reference electrode. This means that, without calibration, each of your readings will differ by about +200 millivolts from the traditional values that are based on the hydrogen electrode. Calibration, however, removes this offset.

Alternatively, you can calibrate with any solution (with a stable Redox) by reading the Redox on a trusted laboratory meter, and using this solution for your standard. Remember that the laboratory meter is likely to use a silver-silver chloride reference electrode; add 200 millivolts to its readings if you want your Hydrolab readings to be based on the hydrogen standard. Select a standard value near that of your field samples. See section 2.5.5 for more information on Redox calibration.

See section 3.11 for information on Redox "warm-up".

Standardizing Redox Readings: The Redox values of quinhydrone solutions vary with pH. So, two quinhydrone solutions of suitably different pH's can be used to "calibrate" Redox readings. Suppose, after plenty of time for sensor equilibration, a trusted laboratory instrument gave readings of 275 and -150 milliVolts for two quinhydrone solutions. At the same temperature, a properly-maintained Hydrolab gave readings of 350 and -30 mV, respectively. The figure below shows the plotted results.



The line created by the two Hydrolab readings showed a y-intercept of about 104 and a slope of about 0.89. These numbers are calculated as follows:

slope = (350 + 30)/(275 + 150) = 0.894 (from m = rise/run)

y intercept = -30 - 0.894(-150) = 104 (from y = mx + b)

Thus, the Hydrolab readings must first be decreased by 104 mV, and then divided by 0.894 to get the correct reading (that is, the reading that matches the laboratory instrument's reading). For instance, suppose the Hydrolab gave an equilibrated reading of 350 mV for some field sample. The "corrected" reading would be:

350 - 104 = 246, and then 246/(0.894) = 275 mV

We know that this is the right answer, because 350 and 275 are two of the comparison points from the original quinhydrone solutions.

However, assuming that the laboratory instrument is using a silver-silver chloride reference electrode, the corrected Hydrolab reading must be increased by about 200 mV to match it to the standard hydrogen reference electrode (the basis upon which most published half-reaction potentials are based):

275 + 200 = 475 mV.

Thus, the real Redox potential of the solution is not 350, but 475 mV.

3.7 Dissolved Oxygen

DO sensor maintenance is usually required only when calibration becomes impossible or when the membrane covering the cell becomes wrinkled, bubbled, torn, dirty, or otherwise damaged. It is, however, good practice to replace the membrane on a regular schedule, before trouble becomes visible. Frequent electrolyte changes will maximize the life of the sensor.

Please read APPENDIX 1 for information on the two methods available in the Transmitter for measurement of DO.

To change membranes, remove the white DO sensor guard and the o-ring securing the membrane. Shake out the old electrolyte, rinse with deionized water, and refill with fresh electrolyte (provided in the Maintenance Kit, or use 2M potassium chloride) until there is a perceptible meniscus of electrolyte rising above the entire electrode surface of the sensor. Make sure that there are no bubbles in the electrolyte. Hold one end of a new membrane (either Standard or LoFlow) against the body of the DO sensor with your thumb and with a smooth, firm motion, stretch the other end of the membrane over the sensor surface and hold it in place with your index finger. Secure the membrane with the o-ring. There should be no wrinkles in the membrane or bubbles in the electrolyte. Trim away the excess membrane extending below the o-ring.

Be careful not to over-stretch the membrane; this will cause readings that are too high to calibrate. Stretch the membrane just enough so that it conforms to the shape of the top of the DO cell.

The DO sensor is now ready for calibration, but you should let it soak overnight to give the membrane time to relax to its final shape (i.e, calibration condition).

To calibrate DO:

1) With the Transmitter oriented so that the sensors are pointed toward the ceiling, fill the Calibration Cup with tap water (specific conductance less than 0.5 mS/cm) until the water is just level with the o-ring used to secure the membrane.
2) Carefully remove any water droplets from the membrane with the corner of a tissue.
3) Turn the white Calibration Cup lid upside down (concave upward) and lay it over the top of the Calibration Cup.
4) The sensor is ready for calibration once the readings have stabilized. Just follow the instructions printed by the Transmitter; refer to section 2.5.4 for calibration menu details.

You can also calibrate the DO system in a well-stirred bucket of temperature-stable, air-saturated water. This situation more closely resembles the actual field measurement conditions.

Remember that the two batteries in the Transmitter can power the oxygen sensor (and the pH and Redox circuits) continuously, so that a stable reading is always available quickly. (Generally, the polarizing batteries are used only with the LoFlow Membrane.) If you know that the Transmitter is not going to be in use for an extended period, say a week or more, you can extend the life of the two cells and of the oxygen sensor by removing the

sensor's membrane, removing all of the sensor's electrolyte, and installing a membrane over the dry sensor. For best results, replace the electrolyte and membrane the day before calibration for the next deployment.

When using the polarizing batteries, you can greatly prolong the life of the sensor by changing the electrolyte frequently (twice or more a month), and/or by removing the electrolyte when the sensor is not to be used for a week or more.

3.8 Depth

Generally, the depth (or level) sensor needs no maintenance. Occasionally, you may wish to squirt a very weak acid (such as acetic) into the depth sensor port (the hole in the face of the Bottom Cap just below the conductivity cell block) with a hypodermic syringe if you notice deposits (calcium, biological growth, etc.) forming in the port. Calibration access information is found in section 2.5.7 in PART TWO.

Normally, calibration is done by simply entering zero for the standard at the water's surface. However, if you have another method, such as a carefully-marked cable, you can type in any number you wish when calibrating.

Because the density of water varies with its specific conductance, the depth readings must be corrected for specific conductance. This correction is applied linearly from zero specific conductance (no correction) to 100 mS/cm. At 52 mS/cm (seawater's specific conductance), the correction reduces the actual reading by 3 percent.

Note that there are two depth sensors: 0 to 100 meters (330 feet) and 0 to 10 meters (33 feet). The former is usually used to determine the depth at which readings of the other parameters are being made. The latter is often used to detect stage changes, such as those accompanying tidal flows or rainfalls. **The level sensor should be protected from depths over 20 meters (66 feet) by installing the sealing screw (found in the Maintenance Kit) in the face of the bottom cap.**

HYDROLAB®
A HACH COMPANY BRAND

Quanta®

Water Quality Monitoring System

Operating Manual
February 2002
(Revision C)

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3.3 Circulator

The Transmitters are optionally equipped with a circulator to assist with reliable dissolved oxygen measurements. The circulator also continuously supplies fresh sample to all sensors, and tends to keep the sensors clean by sweeping debris away. The circulator also speeds sensor response by ensuring rapid temperature equilibration.

From **Screen 1** or **Screen 2** on the Display, press **Esc** ∞ to toggle the circulator state. Alternately, select **Setup, Circ,** and **On** or **Off** to set the circulator state. From an SDI-12 datalogger, issue the '*a*XSS0!' command to turn the circulator off and the '*a*XSS1!' command to turn the circulator on.

Remember to turn the circulator on during field deployment. Generally, the circulator should be on except during calibration.

Notes:

- The circulator's impeller (part #005306), impeller screw (part #005307), and impeller bearing (part #003594) are non-warranty consumables, which require regular replacement.
- In SDI-12 operation, both the sensors and the circulator must be turned on for the circulator to operate. The sensors are automatically turned on with standard SDI-12 measurement commands. The '*a*X1!' and '*a*X0' commands are available to force the sensors on and off through the transparent mode.
- If equipped with the turbidity option, the Transmitter will occupy two SDI-12 addresses. All parameters except turbidity are on one SDI-12 address and turbidity is on another SDI-12 address.
- The Transmitter's factory default SDI-12 address is '0' for all parameters except turbidity and '1' for turbidity. In this manual, '*a*' refers to the SDI-12 address for all parameters except turbidity and '*b*' refers to the SDI-12 address for turbidity.

3.4 Calibration

Fundamentally, the Transmitter is calibrated by pouring a calibration standard into the calibration cup or by immersing the entire Transmitter in a bucket of standard. Then, watching the readings for the parameter to be calibrated. When the readings stabilize, send the calibration information to the Transmitter via the Display or SDI-12 datalogger. Then confirm the data calibration.

Note: You may notice that the Transmitter has built-in checks for calibration acceptance. If for any reason you cannot complete calibration for any parameter, the Transmitter will continue to use the calibration from the last time that particular parameter was calibrated successfully. However, you should try to determine why the Transmitter did not accept the new calibration (faulty sensor, bad standard, low battery, mistyped standard value, incorrect units, etc.).

3.4.1 Calibration with the Display

If the circulator is on, press the **Esc** ∞ key to toggle the circulator off, so that it doesn't splash your calibration standard. Place the sensors in the appropriate calibration standard for the parameter being calibrated. Monitor the parameter's stability on **Screen 1** and/or **Screen 2**, select **Calib**, then the item to calibrate. Enter the one or two values as required to complete calibration. If the Transmitter rejects the calibration, the Display LCD shows 'FAIL' before returning to the **Calib**

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screen. Return to **Screen 1** and/or **Screen 2** to confirm calibration. See Section 2.2.3 for details on using the Display to perform calibrations.

The following table details what can be calibrated with the Display.

Calibration	First Value	Second Value
Salinity	PSS	-
Specific Conductance	mS/cm	-
TDS	Scale Factor (0.64 default)	-
DO/BP	mg/L	mmHg
DO%/BP	100% (fixed)	mmHg
ORP	mV	-
pH	units	-
Barometric Pressure (BP)	mmHg	-
Depth	m or ft	-
Turbidity	NTU	-

3.4.2 Calibration with an SDI-12 Datalogger

If using an SDI-12 datalogger for calibration, you must enter transparent mode. Please see your datalogger manual for instructions on how to use transparent mode.

Within the datalogger's transparent mode, issue the '*a*X1!' command to turn the Transmitter's non-turbidity sensors on and, if turbidity installed, issue the '*b*X1!' command to turn the turbidity sensor on. If the circulator is on, issue the '*a*XSS0!' command to turn the circulator off, so that it doesn't splash your calibration standard.

Repeatedly issue the '*a*R0!' and '*a*R1!' commands and, if turbidity installed, the '*b*R0!' command to monitor the stability of the parameter being calibrated. Once stable, issue the '*c*XC*d*+*value*!' command with '*c*' being the SDI-12 address, '*d*' the code letter of item to calibrate and '*value*' being the numeric value of the calibration standard. Again, issue the '*a*R0!' and '*a*R1!' commands and, if turbidity installed, the '*b*R0!' command to confirm calibration.

Finally, issue the '*a*X0!' command and, if turbidity installed, the '*b*X0' command to turn the Transmitter's sensors off and, if needed, issue the '*a*XSS1!' command to turn the circulator back on.

The following table details the SDI-12 calibration commands available.

Calibration	SDI-12 Command	Units for *value*
Salinity	'*a*XCS+*value*!'	PSS
Specific Conductance	'*a*XCC+*value*!'	mS/cm
TDS	'*a*XCt+*value*!'	Scale Factor (0.64 default)
DO (must calibrate BP first!)	'*a*XCO+*value*!'	mg/L

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Calibration	SDI-12 Command	Units for *value*
DO%	'*a*XC%+*value*!'	mmHg
ORP	'*a*XCR+*value*!'	mV
pH	'*a*XCP+*value*!'	units
Barometric Pressure (BP)	'*a*XCB+*value*!'	mmHg
Depth	'*a*XCD+*value*!'	m or ft (per depth setup)
Turbidity	'*b*XCT+*value*!'	NTU

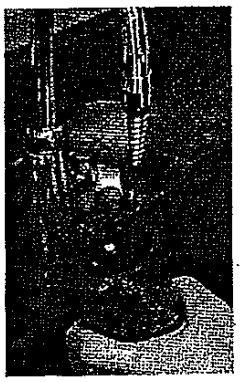
Notes:

- Both the sensors and the circulator must be turned on for the circulator to operate.
- If equipped with the turbidity option, the Transmitter will occupy two SDI-12 addresses. All parameters except turbidity are on one SDI-12 address and turbidity is on another SDI-12 address.
- The Transmitter's factory default SDI-12 address is '0' for all parameters except turbidity and '1' for turbidity. In this manual, '*a*' refers to the SDI-12 address for all parameters except turbidity and '*b*' refers to the SDI-12 address for turbidity.

3.4.3 Calibration Preparation

The following is a general outline of the steps required to calibrate all the sensors:

- **Select a calibration standard whose value is near that of your field samples**.
- Remove the Storage Cup from the Transmitter.
- **Clean and prepare the sensors** as detailed in Sections 3.4.4 through 3.4.9.
- Attach the Calibration Cup.
- Using the Calibration Cap, thoroughly **rinse the sensors several times** by half-filling the calibration cup **with deionized water** and shaking the Transmitter to make sure each sensor is free from contaminants that might alter your calibration standard.



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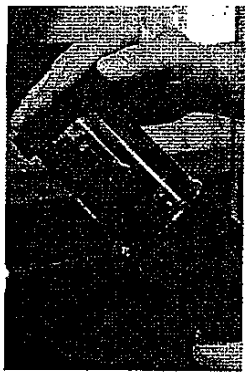
- In a similar manner, **rinse the sensors twice with a small portion of the calibration standard**, each time discarding the rinse.



- With the Transmitter sensors pointing up (toward the ceiling), **fill the Calibration Cup with the calibration standard**. See Sections 3.4.4 through 3.4.8 for sensor specific details.

- **Complete the calibration as per Sections 3.4.1 and/or 3.4.2**.
- Finally, **discard used calibration standards** appropriately. Do not attempt to reuse calibration standards.

Warning: **Sensor preparation is probably the most important action you can take to maintain or improve the quality of your field measurements.** A contaminated, worn-out, or damaged sensor simply will not produce a reliable reading. It is well worth your time to set up a routine in which all sensors are serviced frequently and then allowed to rest in tap water overnight before calibration.

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Generally, you should calibrate all Quanta parameters as often as your accuracy requirements dictate. If you want exceptionally accurate data, you must calibrate frequently. Calibration requirements also vary with deployment conditions – in very turbid or biologically-active waters, for instance, generally require more frequent calibrations than do cleaner waters

Notes:

- The optional turbidity sensor has a rotating sealed shaft to make maintenance of other sensors easier. With the storage cup, calibration cup, and guard removed, the turbidity sensor rotates ≈135° in each direction before engaging the internal stop. This feature makes maintenance of the other sensors easier. After maintenance of these other sensors, insure the turbidity sensor is rotated back to the nominal position before reinstalling the storage cup, calibration cup, or guard. **Do not use excessive force or sensor will break!**

3.4.4 Temperature

Cleaning and Preparation

- Soap or rubbing alcohol may be used to remove grease, oil, or biological material.
- Rinse with water.

Calibration Standard

- Factory-set and no recalibration required.

3.4.5 Specific Conductance, Salinity, and TDS

Cleaning and Preparation

- **Clean the oval measurement cell** on the specific conductance sensor with a small, non-abrasive brush or cotton swab.
- Soap or rubbing alcohol may be used to remove grease, oil, or biological material.
- **Rinse with water.**

Calibration Standard

- Pour the specific conductance or salinity standard to within a centimeter of the top of the cup.
- Make sure there are **no bubbles** in the measurement cell of the specific conductance sensor.

Notes:

- TDS measurements are based on specific conductance and a user defined scale factor. For TDS calibrations, first calibrate specific conductance, then calibrate the Transmitter with a site-specific scale factor. The factory default scale factor is 0.64 g/L / mS/cm.

3.4.6 Dissolved Oxygen %Saturation and mg/L

Cleaning and Preparation

- Remove the o-ring securing the DO membrane.
- Shake out the old electrolyte and rinse with fresh DO electrolyte.
- Refill with fresh DO electrolyte until there is a perceptible meniscus of electrolyte rising above the entire electrode surface of the sensor.
- Make sure there are **no bubbles** in the electrolyte.

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- Hold one end of a new membrane against the body of the DO sensor with your thumb and with a smooth, firm motion, stretch the other end of the membrane over the sensor surface and hold it in place with your index finger.
- Secure the membrane with the o-ring.
- Make sure there are **no wrinkles in the membrane or bubbles** in the electrolyte.
- Trim away the excess membrane extending below the o-ring.
- Ideally, let the sensor soak overnight to allow the membrane to relax to its final shape.

DO %Saturation Calibration Standard (Saturated-Air Method)

- Fill the Calibration Cup with deionized or tap water (specific conductance less than 0.5 mS/cm) until the water is just level with the o-ring used to secure the membrane.
- Carefully remove any water droplets from the membrane with the corner of a tissue.
- Turn the black calibration cup cover upside down (concave upward) and lay it over the top of the Calibration Cup.
- Determine the barometric pressure for entry as the calibration standard. See Section 5.1.3 for computation details on barometric pressure.

Notes:

- Calibration of DO %Saturation also calibrates DO mg/L.
- DO can also be calibrated in a well-stirred bucket of temperature-stable, air-saturated water. This situation more closely resembles the actual field measurement conditions, but is more difficult to accomplish reliably. Be sure the circulator is turned on when calibrating in a water bath.

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DO mg/L Calibration Standard (Known Concentration Method)

- Immerse the sensor in a water bath for which the DO concentration in mg/L is known (for instance by Winkler titration). This calibration method is more difficult to perform than the saturated-air method.
- Make sure the circulator is turned on.
- Determine the barometric pressure for entry as the calibration standard. See Section 5.1.3 for computation details on barometric pressure.

Notes:

- Calibration of DO mg/L also calibrates DO% Saturation.
- If there is a change in barometric pressure after calibration (for instance, if barometric pressure drops as you move the calibrated Transmitter to a higher elevation for deployment), the readings for DO %Saturation will not be correct. You must enter a new barometric pressure. However, the readings for DO mg/L will be correct regardless of changes in barometric pressure.

3.4.7 pH and ORP (Redox)

Cleaning and Preparation of pH

- If the pH sensor is obviously coated with oil, sediment, or biological growth, clean the glass with a very clean, soft, non-scratching cloth wet with rubbing alcohol (a cotton ball will do).
- Rinse with tap water.

Cleaning and Preparation of ORP

- If the platinum band at the tip of the ORP sensor gets dirty and/or discolored, polish it with a clean cloth and a very mild abrasive, such as toothpaste; or use a fine polishing strip.
- Rinse with water.
- Soak the sensor overnight in tap water to allow the platinum surface to restabilize.

Cleaning and Preparation of Standard Reference

- Gently pull the entire reference sleeve away from the Transmitter. The reference sleeve is the clear blue tube with a porous Teflon® Reference Junction attached.
- Discard the old electrolyte from the reference sleeve.
- Drop two KCl salt pellets (#005376) or two KCl salt rings (#005309) into the reference sleeve.
- Refill the sleeve to the top with reference electrolyte.
- With the Transmitter sensors pointed toward the floor, push the full reference sleeve back onto its mount until the sleeve has just covered the first o-ring located on the mount (just behind the silver electrode).
- Turn the Transmitter so that the sensors point toward the ceiling and push the sleeve the rest of the way onto its mount.
- Rinse with tap water.

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See Section 5.1.3

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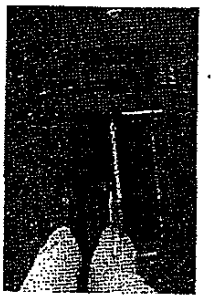
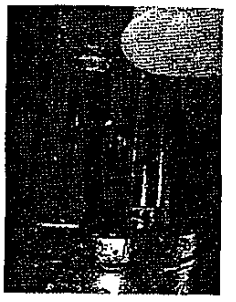

Notes:

- **The porous Teflon® Reference Junction is the most important part of the pH and ORP performance.** Make sure it is clean and passes electrolyte readily. If not, replace it with the spare provided with the pH option. Replacement Reference Junctions are part #003883.
- When seating the reference sleeve, **trapped air and excess electrolyte is purged.** This **purging flushes and cleans the porous Teflon® Reference Junction.**
- The Standard Reference is designed for waters with specific conductances ≥ 0.2 mS/cm. For measurements in waters with specific conductances < 0.2 mS/cm, Hydrolab offers the LISRef as a factory installed option to improve measurements in very low-ionic strength waters.

Cleaning and Preparation of Low-Ionic Strength Reference (LISRef)

- **Remove the plastic LISRef soaking cap. Save the cap!**
- Inspect the LISRef sensor tip.
- If necessary, rinse with soapy water to remove visible contamination and rinse with tap water.
- If necessary, wipe with a cloth soaked in rubbing alcohol to remove oils and grease and rinse with tap water.
- Following cleaning, fill the plastic LISRef soaking cap with reference electrolyte, reinstall over the LISRef tip, and soak overnight.
- **Remove the plastic LISRef soaking cap before calibration or field use. Save the cap!**

Notes:

- **The LISRef Reference is the most important part of the pH and ORP performance.**
- **Whenever the Quanta Transmitter is not in use, fill the plastic LISRef soaking cap with reference electrolyte and reinstall over the LISRef tip.**
- The LISRef Reference is designed for low-ionic strength waters. During normal use, the LISRef Reference is consumed and cannot be rebuilt. Replacement LISRef tips are part #003333.
- For measurements in waters with specific conductances ≥ 0.2 mS/cm, the Standard Reference is preferred due to lower purchase and maintenance costs. Hydrolab offers the Standard Reference as a factory installed option.

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Calibration Standard

- Pour the pH or ORP standard to within a centimeter of the top of the cup.

Notes:

- pH is a two-point calibration. A pH standard between 6.8 and 7.2 is treated as the "zero" and all other values are treated as the "slope". First calibrate "zero", then calibrate "slope".

3.4.8 Depth

Cleaning and Preparation

- Soap or rubbing alcohol may be used to remove grease, oil, or biological material.
- Rinse with water.

Calibration Standard

- Enter zero for the standard at the water's surface.

Notes:

- If the depth is known by another method, such as a carefully-marked cable, type the actual depth value as the standard when calibrating.
- The density of water varies with its specific conductance. Depth readings are corrected for specific conductance. See Section 5.3 for details.
- Recheck the 10m vented depth option for sensor drift with a precision pressure gauge at least once a month. A 'zero' drift is quickly corrected through calibration, but a 'slope' drift requires factory recalibration. Factory calibration includes characterization over temperature and pressure. Contact Hydrolab's Customer Service for the current recalibration price and scheduling of a factory recalibration.

3.4.9 Turbidity

Cleaning and Preparation

- Soap or rubbing alcohol may be used to remove grease, oil, or biological material.
- Use a non-abrasive, lint-free cloth to clean the quartz glass tube. Scratched glass reduces the sensor's accuracy.
- Rinse with water.

Calibration Standards

- Calibrate turbidity with primary standards ('turbid-free' water, Formazin, and/or polystyrene beads) and check with a secondary standard (Quick-Cal Cube).
- Use 'turbid-free' water to calibrate the "zero".
- Use Formazin and/or polystyrene beads to calibrate the "slope".
- Primary standards must completely fill the optical area of the turbidity sensor plus ¼" (6 mm) of standard on both sides of the PVC body by filling the calibration cup to the top. Alternately, pour ≈1-¼" (32 mm) of standard into the storage cup and place the inverted sensors into the standard with bayonets disengaged.
- After calibration with primary standards, the value of the optional Quick-Cal Cube secondary standard, if used, must be determined and recorded for each individual instrument. The Quick-Cal Cube value is determined by removing the storage/calibration cups, wiping the optical areas, both sensor and cube, clean and dry with a non-abrasive, lint-

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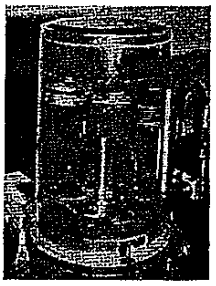
free cloth, and placing the ceramic glass cube into the turbidity sensor's optical area. Align the Quick-Cal Cube 's pin with the turbidity sensor's recessed hole and, for optimum repeatability, rotate the Quick-Cal Cube clockwise to remove mechanical play in the pin/hole.

- To test for drift between primary calibrations, reinstall the Quick-Cal Cube .



Notes:

- 'Turbid-free' water is available for purchase from chemical supply houses. However, it is far less expensive to make by passing reagent-grade water through a 0.1 µm or smaller filter.
- Formazin and polystyrene beads are primary standards as defined by the EPA. Quick-Cal Cubes are secondary standards, which must be rechecked, and value recorded, after each primary standard calibration with each instrument. However, Quick-Cal Cubes save resources, both time and money, by allowing inexpensive and frequent calibration checks between permit and/or standard operating procedure required primary calibrations.
- Formazin requires daily preparation.
- Polystyrene beads are instrumentation specific and beads formulated for one instrument design often read differently on a different instrument design. Hydrolab has polystyrene beads formulated for the Quanta Turbidity sensor. Please contact Customer Service or www.hydrolab.com for ordering information.
- When using liquid standards, insure no bubbles in the optical area. The optical properties of bubbles affect the turbidity calibration. Gentle agitation easily dislodges bubbles.
- When using Quick-Cal Cube standards, insure no water droplets in the optical area. The optical properties of water droplets affect the calibration check. Remove droplets with a non-abrasive, lint-free cloth.
- Turbidity is a two-point calibration. A turbidity standard of 0.0 is treated as the "zero" and all other values are treated as the "slope". First calibrate "zero", then calibrate "slope".

3.5 Care of the Transmitter

In addition to normal sensor maintenance, clean the Transmitter with soap and water. **During storage or transportation, always use the calibration cup/cap or the storage cup filled with a ¼" of tap water to protect the sensors from damage and drying out.** Never deploy the

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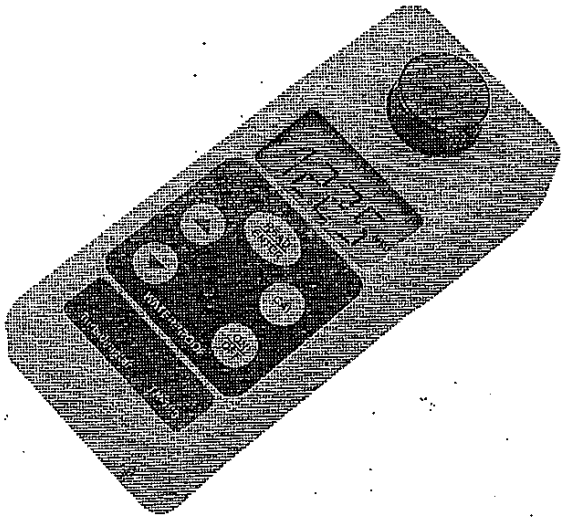
Instruction Manual

TN-100/ T-100

Portable Turbidimeter



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2 TURBIDITY CALIBRATION

The TN-100/ T-100 turbidimeter was calibrated and tested prior to leaving the factory. Therefore, it is possible to use the instrument directly out of the box. However, re-calibration of the instrument is recommended to help you become familiar with the operation of the instrument and the calibration procedures. In addition, re-calibration is recommended at least once every month for optimum accuracy.

It is recommended that you perform a full calibration using all 4 standards provided to ensure full-range accuracy. However, the TN-100/ T-100 turbidimeter provides flexibility for you to calibrate at selected ranges suitable for your application.

In addition, the instrument comes with a light shield cap to shield off stray light during calibration and measurements.

2.1 Calibration Standards

We recommend that you use the following materials during calibration to achieve the accuracy stated in this manual:

- **CAL 1:** 800 NTU Calibration Standard
- **CAL 2:** 100 NTU Calibration Standard
- **CAL 3:** 20.0 NTU Calibration Standard
- **CAL 4:** 0.02 NTU Calibration Standard

It is well known that diluted Formazin is unstable. If you choose to use Formazin to calibrate the instrument, ensure that you are using a fresh stock suspension of Formazin to achieve the accuracy quoted for the instrument. Calibration standards offered are more stable than Formazin and have a limited shelf life of 12 months. If you use the supplied calibration standards to calibrate the instrument, review the expiration date (indicated on cap label) to ensure that the standards have not expired.

It is important that the calibration standards are not violently shaken or agitated because air entrapment in the fluid introduces an error factor during calibration which subsequently will lead to an inaccurate measurement. Also, do not store in freezing temperatures which causes irreversible shrinkage of the standards' particles thus resulting to inaccurate calibration and measurement.

2.2 Indexing

Due to the high quality of the glass vials provided, indexing is not required. You only need to align the mark on the vial with the mark on the meter. However, in order to achieve a better accuracy of the measurement, you can proceed with indexing of the vials. See Section 8.5 - Indexing a Vial on page 20 for more information.

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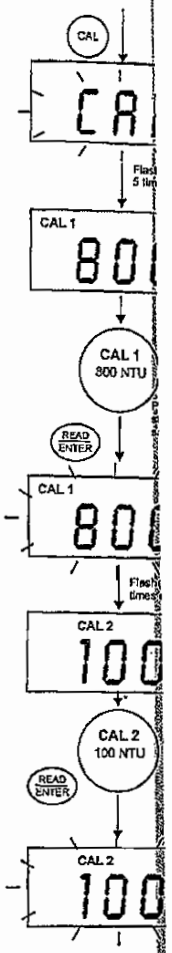
2.3 Calibration Procedure

1. Place TN-100/ T-100 turbidimeter on a flat and level surface.
2. Select the calibration function of the instrument by pressing the CAL button once. The [CAL] annunciator will blink momentarily and the meter will prompt for the first calibration standard CAL 1 standard (800 NTU).
3. Insert the CAL 1 standard (800 NTU) into the sample well, aligning the mark on the vial with the mark on the meter. See Figure 10 on page 12.
4. Press down until the vial snaps fully into the instrument.
5. Cover the vial using the light shield cap.
6. Press READ/ENTER key.
7. The [CAL 1 800 NTU] annunciator will blink for about 12 seconds. When the instrument has completed calibration for this point, it prompts you to insert the next calibration standard into the sample well [CAL 2 (100 NTU).
8. Repeat the calibration sequence for each calibration standard.
9. After you successfully calibrate the CAL 4 standard (0.02 NTU), the display will show [STbY].
10. The meter is now ready to perform next measurement.

Figure 4 shows the complete calibration sequence.

NOTES:

1. *If you wish to exit the calibration mode you may do so at the end of any step by pressing the CAL key. The meter will accept only the values calibrated prior to exiting.*
2. *You can skip a calibration point by pressing ▲ or ▼ keys and move on to the next calibration point.*
3. *After a successful calibration of one point, it will auto select the next calibration point. It will automatically exit calibration mode after the fourth calibration point.*
4. *If an error occurs during calibration, the display will present an error message. The meter will abort calibration and return to the measurement mode without saving the last calibration value.*
5. *For a list of error messages, refer to Section 4: Troubleshooting Guide on page 15.*



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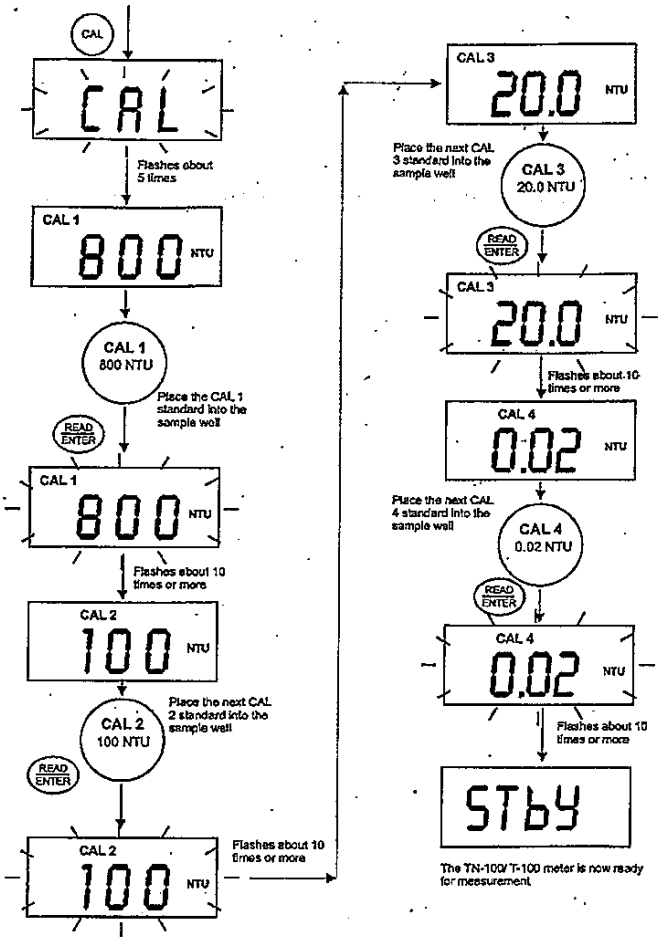

Figure 4: Calibration Sequence

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Appendix G

Sampling, Preservation, and Analytical Procedures (Tables 1A – 1H)

SAMPLING, PRESERVATION & ANALYTICAL PROCEDURES

Tables 1A through 1H summarize Test Methodology, Sample Container, Preservative, Holding Time, and identity of each analytical parameter listed in Appendix 5.1 of the Virginia Solid Waste Management Regulations.

NOTES

EPA is continually updating analytical methods. In the event that the referenced test method becomes outdated, the most recent or equivalent method identified in the current EPA SW-846.

The Laboratory Limit of Quantitation (LOQ) is the laboratory specific level above which quantitative analytical results may be obtained with a specified degree of confidence. Each laboratory develops its own LOQs on a periodic basis, and LOQs are subject to change over time and between laboratories. The LOQ is a multiple of the method detection limit which is derived from seven replicate measurements, and is determined periodically for each parameter by the laboratory performing the analysis. For these reasons it is impractical to specify LOQs in this GMP.

Laboratories providing chemical analyses for groundwater samples collected at this facility must identify their LOQ on the Certificate of Analysis. The LOQ should not exceed the performance goal, which is the EPA published Estimated Quantification Limit (EQL) for the parameter being tested.

TABLE 1A

Parameters: Metals
Container: 1 polyethylene 1000 ml
Preservative: HNO_3
Holding Time: 6 months

Metals	Method SW 846
Antimony	7041
Arsenic	7060A
Barium	7081
Beryllium	7091
Cadmium	7131A
Chromium	7191
Cobalt	7201
Copper	7211
Lead	7421
Nickel	7521
Mercury	7470A
Selenium	7740
Silver	7761
Thallium	7841
Vanadium	7911
Zinc	7950

All metals analyses are for total (not dissolved) metals; therefore, samples are to be preserved but not filtered.

TABLE 1B

Method:	Volatile Organic Compounds - SW846 Method 8260A*
Container:	3 40 ml VOA vials
Preservative:	HCL, Cool to 4oC, No Headspace
Holding Time:	14 days

Parameters	
Acetone	1,2-dichloroethane
Acetonitrile (methyl cyanide)	1,1-Dichloroethylene
Acrolein	cis-1,2-Dichloroethylene
Acrylonitrile	trans-1,2-Dichloroethylene
Allyl chloride (3-Chloropropene)	1,2-Dichloropropane
Benzene	1,3-Dichloropropane
Bromochloromethane	2,2-Dichloropropane
Bromodichloromethane	1,1-Dichloropropene
Bromoform	cis-1,3-Dichloropropene
Bromomethane	trans-1,3-Dichloropropene
2-butanone (Methyl ethyl ketone)	Ethylbenzene
Carbon disulfide	Ethyl methacrylate
Carbon tetrachloride	2-Hexanone/ Methyl butyl ketone
Chlorobenzene	Isobutyl alcohol
Chloroethane; Ethyl chloride	Methacrylonitrile
Chloroform; Trichloromethane	Methylene chloride
Chloroprene	Methyl iodide
Chloromethane (Methyl chloride)	Methyl methacrylate
Dibromochloromethane; Chlorodibromomethane	2-Methyl-2-pentanone (Methyl isobutyl ketone)
Dibromomethane (Methylene bromide)	Propionitrile
1,2-Dichlorobenzene (o-Dichlorobenzene)	Styrene
1,3-Dichlorobenzene (m-Dichlorobenzene)	1,1,1,2-Tetrachloroethane
1,4-Dichlorobenzene (p-Dichlorobenzene)	1,1,2,2-Tetrachloroethane
trans-1,4-Dichloro-2-butene	Tetrachloroethylene (PCE)
Dichlorodifluoromethane	Toluene
1,1 Dichloroethane	1,2,4-Trichlorobenzene

TABLE 1B	
Method:	Volatile Organic Compounds - SW846 Method 8260A*
Container:	3 40 ml VOA vials
Preservative:	HCL, Cool to 4oC, No Headspace
Holding Time:	14 days

Parameters	
1,1,1-Trichloroethane	1,2,3-Trichloropropane
1,2,3-Trichloroethane	Vinyl Acetate
Trichloroethene	Vinyl Chloride
Trichlorofluoromethane (CFC-11)	Xylenes (Total)

TABLE 1C	
Method:	EDB/DBCP - SW846 Method 8011*
Container:	2 40 ml VOA vial
Preservative:	HCL, Cool to 4oC
Holding Time:	14 days

Parameters
1,2-Dibromoethane (EDB)
1,2-Dibromo-3-chloropropane (DBCP)

TABLE 1D	
Method:	Semi-Volatile Organic Compounds - SW846 Method 8270A*
Container:	1 1000 ml Amber Glass
Preservative:	Cool to 4oC
Holding Time:	7 days to extraction, 40 days after extraction

Parameters	
Acenaphthene	Dibenzofuran
Acenaphthylene	3,3' Dichlorobenzidine
Acetophenone	2,4 Dichlorophenol
2-Acetylaminofluorene	2,6 Dichlorophenol
4-Aminobiphenyl	Diethylphthalate
Anthracene	0,0-Diethyl 0-2-pyrazinyl (thiozanin)
Benzo (a) anthracene	Dimethoate
Benzo (a) pyrene	p-(Dimethylamino) azobenzene
Benzo (b) fluoranthene	7,12 Dimethylbenz (a) anthracene
Benzo (k) fluoranthene	3,3 Dimethylbenzidine

TABLE 1D

Method:	Semi-Volatile Organic Compounds - SW846 Method 8270A*
Container:	1 1000 ml Amber Glass
Preservative:	Cool to 4oC
Holding Time:	7 days to extraction, 40 days after extraction

Parameters	
Benzo (ghi) perylene	2,4-Dimethylphenol
Benzyl alcohol	Dimethylphthalate
4-Bromophenyl phenyl ether	Di-n-butylphthalate
Butyl benzyl phthalate	1,3-Dinitrobenzene
4-Chloroaniline	4,6-Dinitro-2-methylphenol
Chlorobenzilate	2,4-Dinitrophenol
bis (2-Chloroethoxy) methane	2,4 Dinitrotoluene
bis (2-Chloroethyl) ether	2,6-Dinitrotoluene
bis (2-Chloroisopropyl) ether	Di-n-octyl phthalate
4-Chloro-3-methylphenol	Diphenylamine/N-nitrosodiphenylamine
2-Chloronaphthalene	Disulfoton
2-Chlorophenol	Ethyl methanesulfonate
4-Chlorophenyl phenyl ether	bis (2-ethylhexyl) phthalate
Chrysene	Famphur
Diallate	Fluoranthene
Dibenzo (a,h) anthracene	Fluorene
Hexachlorobenzene	N-Nitrosodimethylamine
Hexachlorobutadiene	N-nitorsodi-n-butylamine
Hexachlorocyclopentadiene	N-nitorsodi-n-propylamine
Hexachloroethane	N-nitorsomethylethylamine
Hexachloropropene	N-nitorsopiperidine
Indeno (1,2,3-cd) pyrene	N-nitrosopyrrolidine
Isodrin	Parathion
Isophorone	Pentachlorobenzene
Isosafrole	Penatchloronitrobenzene
Methapyriline	Phenacetin

TABLE 1D	
Method:	Semi-Volatile Organic Compounds - SW846 Method 8270A*
Container:	1 1000 ml Amber Glass
Preservative:	Cool to 4oC
Holding Time:	7 days to extraction, 40 days after extraction

Parameters	
3-Methylcholanthrene	Phenol
Methyl methanesulfonate	p-Phenylenediamine
2-Methylnaphthalene	Phorate
Methyl parathion	Pronamide
2-Methylphenol (o-Cresol)	Pyrene
3,4-Methylphenol (m,p Cresol)	Safrole
Naphthalene	1,2,4,5-Tetrachlorobenzene
1,4-Naphthaquinone	2,3,4,6-Tetrachlorophenol
1-Naphthylamine	o-Toluidine
2-Naphthylamine	2,4,5- Trichlorophenol
2-Nitroaniline	2,4,6-Trichlorophenol
Nitrobenzene	0,,0,0-Triethyl phosphorothioate
5-Nitro-o-toluidine	sym-Trinitrobenzene
2-Nitrophenol	
4-Nitrophenol	
N-Nitrosodiethylamine	

TABLE 1E	
Method:	Organochloride Pesticides and PCBs - SW846 Method 8081A
Container:	1 1000 ml amber glass
Preservative:	Cool to 4oC
Holding Time:	7 days to extraction, 40 days after extraction

Parameters	
Aldrin	Endrin Aldehyde
alpha-BHC	Heptachlor
beta-BHC	Heptachlor epoxide
delta-BHC	Kepone

TABLE 1E	
Method:	Organochloride Pesticides and PCBs - SW846 Method 8081A
Container:	1 1000 ml amber glass
Preservative:	Cool to 4oC
Holding Time:	7 days to extraction, 40 days after extraction

Parameters		
gamma-BHC	Methoxychlor	
Chlordane	Toxaphene	
4,4'-DDD	*PCBs as Arochlors*	
4,4'-DDE		Arochlor 1016
4,4'-DDT		Arochlor 1221
Dieldrin		Arochlor 1232
Endosulfan I		Arochlor 1242
Endosulfan II		Arochlor 1248
Endosulfan Sulfate		Arochlor 1254
Endrin		Arochlor 1260

TABLE 1F	
Method:	Cyanide - SW846 Method 9010B
Container:	1 1000 ml polyethylene
Preservative:	NaOH, Cool to 4oC
Holding Time:	14 days
Parameters	
Cyanide	

TABLE 1G	
Method:	Sulfide - SW846 Method 9034
Container:	1 500 ml polyethylene
Preservative:	NaOH and zinc acetate, Cool to 4oC, No Headspace
Holding Time:	7 days
Parameters	
Sulfide	

TABLE 1H	
Method:	Chlorinated Herbicides - SW846 Method 8151*
Container:	1 1000 ml Amber Glass
Preservative:	Cool to 4oC
Holding Time:	7 days, prior to extraction, 40 days after extraction
Parameters	
2,4-D	
Dinoseb	
2,4,5-TP	
2,4,5-T	
Pentachlorophenol	

PERMIT MODULE XI

PHASE II MONITORING

PERMIT MODULE – XI

PHASE 2 and MODIFIED MONITORING
9 VAC 20-80-300.A, C.4, and C.5

Phase 2 monitoring is designed to ensure the earliest possible recognition of a leachate release to groundwater from a regulated solid waste management unit (SWMU) at levels which exceed groundwater protection standards.

Modified monitoring is designed to ensure that continuing exceedances of Phase 1 indicator parameters do not represent a release from a regulated solid waste management unit (SWMU).

XI.A. GROUNDWATER COMPLIANCE POINT

XI.A.1 Uppermost Aquifer

The compliance point for groundwater monitoring is the uppermost aquifer on site [9 VAC 20-80-300.A.2.a]. The uppermost aquifer encompasses the entire thickness between the first encounter with groundwater (not to include any perched water) and the first encounter with a confining unit forming the lower boundary of the uppermost aquifer [9 VAC 20-80-300.A.3.f.(1).(b)].

XI.A.2 Monitoring Well Locations

All wells in the monitoring network shall be installed within the permitted facility boundary [9 VAC 20-80-770.A], screened within the uppermost aquifer, and located at, or as close as practical to, the SWMU boundary [9 VAC 20-80-300.A.3.a] unless a variance meeting the requirements of 9 VAC 20-80-770.B has been granted. No monitoring well serving the function defined under 9 VAC 20-80-300.A.3.a can be located more than 500 feet away from the SWMU boundary [9 VAC 20-80-770.A].

XI.B. MONITORING NETWORK REQUIREMENTS

XI.B.1 Performance Standards

XI.B.1.a The Permittee shall install a groundwater monitoring network that meets the requirements of 9 VAC 20-80-300.A.2 and A.3.

XI.B.1.b All wells utilized in the monitoring network shall at a minimum meet the requirements of 9 VAC 20-80-300.A.3.c and f.(1).

XI.B.1.c Any wells that require abandonment shall be sealed and abandoned in accordance with existing EPA Resource Conservation and Recovery Act guidance as well as any applicable state or local

requirements.

XI.B.1.d If any wells require replacement due to non-performance, the Permittee shall:

XI.B.1.e.(1) Within 30 days of recognizing the non-performance, notify the Department of the need to replace the non-performing well. Within that notification, provide for Department review [9 VAC 20-80-570.C.1], the proposed location for the new well shown on a site plan.

XI.B.1.e.(2) Install the replacement well, prior to the next regularly scheduled groundwater sampling event unless the Director has granted an extension to meeting the monitoring system compliance requirements under 9 VAC 20-80-300.A.3.a.

XI.B.2 Operations and Maintenance

The Permittee shall operate and maintain all wells in the monitoring network in a manner meeting the requirements of 9 VAC 20-80-300.A.3.e.

XI.B.3 Well Designations

At a minimum, the monitoring network installed shall meet the requirements of 9 VAC 20-80-300.A.3.f.(2). The following wells are included in the monitoring network:

Upgradient Well(s)	Downgradient Wells		Piezometers
MW-4R	PO-8	CECW-2	N/A
MW-5	PO-9	CECW-3	
	PO-10	CECW-4	
	PO-11	CECW-5	
	CECW-1	CECW-6I	

XI.C AQUIFER INFORMATION

XI.C.1 Aquifer Data Acquisition - Requirements and Response

XI.C.1.a Static groundwater elevations shall be:

XI.C.1.a.(1) measured in all monitoring wells in a manner that

meets the requirements of 9 VAC 20-80-300.A.4.c.

XI.C.1.a.(2) measured to an accuracy of 0.01 foot.

XI.C.1.a.(3) obtained from all wells in the network within a single 24 hour period from sampling to avoid temporal variations/fluctuations in the groundwater table.

XI.C.1.b Each time groundwater is sampled on site, the Permittee shall determine the groundwater flow rate and direction [9 VAC 20-80-300.A.4.c] in the uppermost aquifer using methods accepted for use in EPA RCRA programs.

XI.C.1.c The Permittee shall evaluate the function of each of the wells included in the monitoring network using the static groundwater elevation data obtained each time groundwater is sampled. If the evaluation shows that one or more of the monitoring wells no longer functions in a manner that meets the requirements of 9 VAC 20-80-300.A.3.e, the Permittee shall:

XI.C.1.c.(1) Within 30 days of recognizing the non-performance, notify the Department of the need to modify the number, location, or depth of the monitoring wells, and provide for Department review, proposed locations for new (replacement) monitoring wells keyed to a site plan.

XI.C.1.c.(2) Complete additions or modifications to the network, prior to the next regularly scheduled groundwater sampling event, unless an extension has been granted by the Director for meeting the monitoring system compliance requirements under 9 VAC 20-80-300.A.3.a.

XI.D. SAMPLING REQUIREMENTS

The Permittee shall meet the following:

XI.D.1 Field sampling and laboratory procedures shall at a minimum meet the requirements of 9 VAC 20-80-300.A.4.a.

XI.D.2 Sampling and analytical methods shall at a minimum meet those set forth in EPA SW-846 as amended [9 VAC 20-80-300.A.4.b].

XI.D.3 Samples shall not be filtered prior to analysis.

XI.D.4 In Phase 2 monitoring, the Permittee shall sample the groundwater for the Phase 2 monitoring constituents referenced under 9 VAC 20-80-300.C.4.a. In Modified monitoring, the Permittee shall sample groundwater for the full Table 5.1 constituent list [9 VAC 20-80-300.C.5.a] and the Phase I indicator parameters, as applicable, based on the Table 5.1 results [9 VAC 20-80-300.C.5.b.(1)].

XI.E SAMPLING FREQUENCY

XI.E.1 Unless otherwise required when sampling to determine background for the Phase 2 programs [9 VAC 20-80-300.C.4.b.(1) or c.(4)], the Permittee shall, during the active life and post-closure care periods sample and analyze all monitoring wells on at least a semi-annual basis [9 VAC 20-80-300.C.4.a and c.(1) or 300.C.5.b.(1)].

XI.E.2 Upon triggering the need for Phase 2 monitoring, the initial Phase 2 sampling event shall be completed in a timeframe consistent with 9 VAC 20-80-300.C.3.d.(4)b. Upon triggering the need for Modified monitoring, the initial Modified sampling event shall be completed in a timeframe consistent with 9 VAC 20-80-300.C.5.a.

XI.E.3 The semi-annual sampling period shall meet the requirements of 9 VAC 20-80-10.

XI.F DETERMINATION OF BACKGROUND & GROUNDWATER PROTECTION STANDARDS

XI.F.1 In Phase 2 Monitoring, the Permittee shall establish site-specific background values for all detected Table 5.5 Phase 2 monitoring constituents in a manner consistent with the requirements of 9 VAC 20-80-300.A.4.d – f and timeframes of 9 VAC 20-80-300.C.4.b. If required by 300.C.4.b.(3).(b), the Permittee shall establish site-specific background values for all detected Table 5.1 Phase 2 monitoring constituents in a manner consistent with the requirements of 9 VAC 20-80-300.A.4.d through f and timeframes of 9 VAC 20-80-300.C.4.b and c.(4).

XI.F.2 The Permittee shall propose and establish Groundwater Protection Standards (GPS) for each detected Phase 2 monitoring constituent as follows:

XI.F.2.a proposed within timelines that meet the requirements of 9 VAC 20-80-300.C.4.d, and

XI.F.2.b established using the process defined under 9 VAC 20-80-300.C.4.d.(1).

XI.F.3 Groundwater Protection Standards become effective as follows:

XI.F.3.a Federal Maximum Contaminant Level-based GPS are effective immediately on the date GPS are proposed by the Permittee [9 VAC 20-80-300.C.4.d.(1)].

XI.F.3.b Background-based GPS are effective on the date Director approval is issued [9 VAC 20-80-300.C.4.d.(1).(c)],

XI.F.3.c Alternate Concentration Limit-based GPS are effective on the date the Director approved variance is issued [9 VAC 20-80-300.C.4.d.(1).(d); and 760.C.1].

XI.G. STATISTICAL PROCEDURES

When evaluating the groundwater sampling event results, the Permittee shall complete the following actions:

XI.G.1 use a statistical test meeting the requirements of 9 VAC 20-80-300.D.

XI.G.2 within 30 days of completion of the laboratory analysis for each sampling event [9 VAC 20-80-300.A.4.h.(2)], determine whether or not there is a statistically significant increase over site background for each monitoring constituent using a method meeting the requirements of 9 VAC 20-80-300.A.4.h.(1) and 300.A.4.g.

XI.G.3 For the purpose of this Permit, laboratory analysis is considered complete upon issuance of the analytical report under laboratory signature.

XI.G.4 Statistical comparisons are not required during the collection of background data during the First Determination period [9 VAC 20-80-300.C.4.b] or Phase 2 background period [9 VAC 20-80-300.C.4.c.(4)].

XI.H ADDRESSING GPS AND MODIFIED PROGRAM EXCEEDANCES

If the statistical comparisons required under the monitoring program show no exceedances, the Permittee shall continue monitoring groundwater within the current program [9 VAC 20-80-300.C.4.e.(2)] or as required under actions associated with the First Determination Report [9 VAC 20-80-300.C.4.b.(3).(a)].

Actions concerning the results of the *First Determination Report* submission are discussed in detail under Section XI.L.4 of this Module. For those Permittees who remain in Phase 2 monitoring and determine there has been an exceedance over GPS for one or more of the Table 5.1 monitoring constituents, the Permittee shall:

XI.H.1 upon the end of the 30-day SSI determination period allowed by 9 VAC 20-80-300.A.4.h.(2), notify the Director within the timeframe of 9 VAC 20-80-300.C.4.e.(3). The notification shall indicate which groundwater monitoring constituents have shown statistically significant increases over GPS and specify initiation of Corrective Actions required by 9 VAC 20-80-310.A and, if applicable, submittal of an Alternate Source Demonstration in accordance with 9 VAC 20-80-300.A.5 as follows:

XI.H.1.a Corrective Actions described under 9 VAC 20-80-310.A shall be initiated within the timeframes specified in 9 VAC 20-80-300.C.4.e.(3).(a).(iv), including defining the horizontal and lateral extent of the GPS exceeding release and notifying any impacted landowners as required under 9 VAC 20-80-300.C.4.e.(3).(a). Alternate Source Demonstration submitted pursuant to 9 VAC 20-80- 300.C.4.e.(4) shall meet the content requirements and timeframe of 9 VAC 20-80-300.A.5. Unless Director approval of the demonstration is obtained, the Permittee shall follow the requirements and timeframes of 9 VAC 20-80-300.B.3.g.(1).

Modified Monitoring: When a Permittee has determined there has been an exceedance over Phase 1 site background during the initial Modified program sampling event for one or more of the monitoring parameters, the Permittee shall notify the Director of the exceedance within 14-days of completion of the statistical work. The notification shall indicate that the Permittee shall sample all wells for the Table 5.1 list of constituents within 90-days of the notification. Based on the results of the initial Modified program Table 5.1 sampling event, the Permittee shall:

XI.H.1.a.(1) in those cases where no Table 5.5 constituents are found to exceed background, and no other Table 5.1 constituents are detected, continue to conduct semi-annual sampling for the Phase 1 parameters and report any exceedances to the Director as required under **X.H.1** above and

XI.H.1.a.(2) conduct biennial sampling (once every two years) for the full Table 5.1 constituent list until such time as conditions in **X.H.1.a.(3)** are met.

XI.H.1.a.(3) in those cases where one or more Table 5.5 constituents are found to exceed background and/or one or more Table 5.1 constituents are detected, proceed from the Modified program back to the Phase 2 program and conduct semi-annual sampling for the Phase 2 constituents and determine background [9 VAC 20-80-300.C.5.b.(2)] as required under 9 VAC 20-80-300.C.4.c..(4) using the date of the Table 5.1 sampling event as the trigger date for the 18 month background period.

XI.I. RECORD-KEEPING REQUIREMENTS

The Permittee shall retain all records identified under 9 VAC 20-80-300.E.1 as well as 9 VAC 20-80-570.B.1 and B.2 throughout the active life (including closure) and post-closure care period.

The records shall be retained at the facility or another location approved by the Director.

XI.J REPORTING REQUIREMENTS

XI.J.1 By March 1st of each calendar year, the Permittee shall submit to the Director *Annual groundwater reports* containing at a minimum the content described under 9 VAC 20-80-300.E.2.b,

XI.J.2 Within 180 days of each semi-annual (or quarterly) sampling event, the Permittee shall submit to the Department, *Semi-annual groundwater evaluations* containing at a minimum, the groundwater flow rate and direction determinations required under 9 VAC 20-80-300.A.4.c and the results of the statistical comparisons required under 9 VAC 20-80-300.C.4.e XI.J.3 While background is being established, the Permittee shall report to the Director, within 15 days of receipt of the data from the laboratory, the *laboratory analytical results* [9 VAC 20-80-300.E.2.a] for each background sampling event.

XI.J.3 Within 30 days of establishing facility background in either the Phase 1 or Phase 2 programs, or re-establishing background due to the installation of new monitoring wells, or a change in sampling technique, the Permittee shall report the background values and statistical computations necessary to determine the values in a report entitled *Facility Background Determination Report*. While in Phase 2 program, the report shall be submitted in the timeframe defined under 9 VAC 20-80-300.C.4.c.(5).

XI.J.5 Within 44 days of well completion, the Permittee shall supply the Director a *Well Installation Report* containing the well number, surveyed elevation, boring log, casing length, total depth, and a completion diagram for each monitoring well, along with a certification from a qualified groundwater scientist that the monitoring wells have been installed in accordance with the submitted plans [9 VAC 20-80-300.A.3.d; 300.A.3.f.(3), and 300.E.1.c].

XI.J.6 Within 44 days of well abandonment, the Permittee shall supply the Director a *Well Abandonment Report* containing information including field methods utilized, and a certification from a qualified groundwater scientist verifying the well abandonment activities met all applicable requirements [9 VAC 20-80-300.E.1.c].

XI.J.7 Upon issuance of GPS, the Permittee shall place the GPS listing in the operating record and update that record as needed upon any changes in GPS.

X.K NOTIFICATION REQUIREMENTS

X.K.1 Within the timeframes noted under 9 VAC 20-80-300.A.4.h.(2) and C.4.e.(3), the Permittee shall submit to the Director the *GPS SSI Notifications*

X.K.2 Within 30 days of recognizing the non-performance of one or more wells, the Permittee shall submit to the Director *Well Non-Performance Notifications* pursuant to 9 VAC 20-80-570.C.1 - 3.

XI.K.3 Within the timeframes noted under 9 VAC 20-80-300.C.4.c.(2), the Permittee shall submit to the Director *Table 5.1 Detect Notifications*

XI.K.4 Within 14-days of identifying groundwater plume impacts, the Permittee shall submit *Off-site Plume Notifications* to the affected landowner [9 VAC 20-80-300.C.4.e.(3).(a).(iii)] and copy the Director

XI.L. MISCELLANEOUS ALLOWANCES

XI.L.1 Alternate Site Background. The Permittee may request the Director allow site background to be developed using wells that are not hydrologically upgradient of the SWMU. The request shall address the technical criteria contained under 9 VAC 20-80-300.A.4.e, and be certified by a qualified groundwater scientist. Until such time as Director approval is obtained, background shall be determined by sampling wells which are upgradient of the SWMU and meet the requirements of 9 VAC 20-80-300.A.3.f.(2).

XI.L.2 Alternate Statistical Method. The Permittee may request the Director allow the use of an Alternate Statistical Method. The request shall demonstrate the

alternate method meets the technical criteria defined under 9 VAC 20-80-300.D.2. Until such time as Director approval is obtained, the statistical test applied to site groundwater data shall be in conformance with 9 VAC 20-80-300.D.1.a through d. The facility *Groundwater Monitoring Plan* shall reflect the applicable statistical method pursuant to 9 VAC 20-80-300.A.4.g.

XI.L.3 Verification Sampling. The Permittee, at any time within the 30 day statistical determination period defined under 9 VAC 20-80-300.A.4.h.(2), may obtain verification samples if the initial review of analytical data suggests results which might not be an accurate reflection of groundwater quality. Undertaking verification sampling is a voluntary action and shall not alter the timeframes associated with determining or reporting a statistically significant increase as otherwise defined under 9 VAC 20-80-300.A.4.h.(2).

XI.L.4 Data Validation. The Permittee may at any time within the 30 day statistical determination period defined under 9 VAC 20-80-300.A.4.h.(2), undertake third-party data validation of the analytical data received from the laboratory. Undertaking such validation efforts are a voluntary action and shall not alter the timeframes associated with determining or reporting a statistically significant increase as otherwise defined under 9 VAC 20-80-300.A.4.h.(2).

XI.L.5 Sanitary Landfill Participation. Sanitary landfills which meet the criteria of 9 VAC 20-80-300.C.1.a may monitor groundwater under the provisions of 9 VAC 20-80-300.C.3, 4, or 5 designed for CDD and Industrial landfills.

XI.L.6 5.1 Detect Deletions. The Permittee may request the Director allow previously detected Table 5.1 constituents to be dropped from the semi-annual Phase 2 monitoring list provided the request is certified by a qualified groundwater scientist and verifies that the Table 5.1 constituent(s) in question have not been detected for a period of two years [9 VAC 20-80-300.C.4.e.(5)].

XI.L.7 Return to Phase I. The Permittee may request the Director allow a return to Phase 1 monitoring provided the request is certified by a qualified groundwater scientist and verifies that all Table 5.1 constituent(s) have been found to be statistically at or below background levels for two consecutive Table 5.1 sampling events [9 VAC 20-80-300.C.4.e.(1)].

XI.M. MISCELLANEOUS DEMONSTRATIONS

XI.M.1 To address an exceedance which is the result of something other than a release of solid waste constituents from the SWMU, a successful demonstration by the Permittee shall be made within 90 days of noting a statistically significant increase. The demonstration can be submitted in the form of a report entitled *Alternate Source Demonstration*, certified by a qualified groundwater

scientist. The submission and approval timeframe can be extended by the Director for good cause [9 VAC 20-80-300.A.5].

XI.M.1.a If a successful demonstration of an alternate source for the noted increase is made by the Permittee and approved by the Director within the 90 day timeframe, the Permittee may continue in the Detection monitoring program as defined in this Permit Module.

XI.M.1.b If a successful demonstration of an alternate source for the noted increase is not made by the Permittee within the 90 day timeframe, the Permittee shall take actions required under 9 VAC 20-80-300.C.4.e.(4) under the Regulatory timeframes unless an extension has been granted by the Director.

XI.M.2 The Permittee may submit to the Director, a *Multi-unit Groundwater Monitoring System Demonstration* containing the content defined under 9 VAC 20-80-300.A.3.b and certified by a qualified groundwater scientist, to demonstrate s that the implementation of such a monitoring system is equally or more protective of human health and the environment as individual systems.

XI.M.2.a If a successful demonstration is made and approved by the Director, the Permittee may discontinue use of individual monitoring systems and institute the monitoring of a multi-unit system.

XI.M.2.b If a successful demonstration is not made, the Permittee shall initiate (or continue) to monitor individual networks under Detection monitoring.

XI.M.3 The Permittee may request the Director suspend groundwater monitoring requirements by submitting a *No-Potential-Migration Demonstration,* certified by a qualified groundwater scientist, and meeting the technical requirements of 9 VAC 20-80-300.A.1.c.

XI.M.3.a If a successful demonstration is made and approved by the Director, the Permittee may suspend groundwater monitoring actions.

XI.M.3.b If a successful demonstration is not made, the Permittee shall continue Phase 2 monitoring as required under 9 VAC 20-80-300.C.4 or Modified monitoring under 9 VAC 20-80-300.C.5.

XI.M.4 Within 21 months of entering Phase 2 monitoring, the Permittee shall submit

to the Director a demonstration called a *First Determination Report,* certified by a qualified groundwater scientist, meeting the technical requirements of 9 VAC 20-80-300.C.4.b.(1) and timeframes of 9 VAC 20-80-300.C.4.b.(2).

XI.M.4.a If a successful demonstration is made that no Table 5.5 constituents exceed background levels [9 VAC 20-80-300.C.4.b.(3).(a)] and the demonstration is approved by the Director, the Permittee may suspend Phase 2 monitoring and re-enter Phase 1 monitoring defined under 9 VAC 20-80-300.C.3.

XI.M.4.b If a successful demonstration is not made, the Permittee shall:

XI.M.4.b.(1) continue monitoring as required under 9 VAC 20-80-300.C.4.(c), undertaking the initial Table 5.1 sampling event within the timeframes of 9 VAC 20-80-300.C.4.c.(2) or,

XI.M.4.b.(2) submit an alternate source demonstration meeting the requirements of 9 VAC 20-80-300.A.5 and undertake the actions which may be required under 9 VAC 20-80-300.C.4.b.(3).(c) based on the approval or denial of the demonstration.

XI.N MODULE ATTACHMENTS

As required under 9 VAC 20-80-520.C, the Permittee shall have an Operations Plan that includes detailed instructions concerning groundwater monitoring [9 VAC 20-80-520.C.2.a]. These detailed groundwater monitoring instructions shall at a minimum cover the items listed under 9 VAC 20-80-300.A.4.a. The document containing these instructions, called the *Groundwater Monitoring Plan*, shall be attached as Attachment X-1 to this Module.

It shall be the responsibility of the Permittee to update this Plan as needed, which may include a Permit amendment action as defined under 9 VAC 20-80-620.A through F, if changes to the monitoring program have taken place since original Plan development. The Permittee shall update the existing plan if applicable under 9 VAC 20-80-300.C.4.d.(2) including any related amendment actions noted under 9 VAC 20-80-300.C.4.d.(3 or 4) unless the condition under 9 VAC 20-80-300.C.4.d.(2) is found applicable.

XI.O LIMITATIONS

Solid waste shall not be deposited in or permitted to enter any surface waters or groundwater [9 VAC 20-80-250.C.10].

The groundwater monitoring and reporting requirements set forth here are minimum requirements. The Director may require, by amending the Permit, any owner or operator to install, operate, and maintain a groundwater monitoring system and program that contains requirements more stringent than those of the Regulations whenever it is determined that such requirements are necessary to prevent significant adverse effects on public health or the environment [9 VAC 20-80-300.A.2.c].

Should information contained in any Permittee authored attachment to this Module conflict with any requirement or condition contained herein, or language found within 9 VAC 20-80-10 et seq., as amended; the Module condition and/or Regulatory requirement shall prevail over the language in the Permittee supplied attachment [see 9 VAC 20-80-60.D and 550.E] unless it can be demonstrated that a Variance from that regulatory requirement has been granted by the Director under 9 VAC 20-80-730 et seq.

When the Permittee recognizes a failure to submit any relevant facts or has submitted incorrect information in any groundwater monitoring report to the Director, he shall, within 7-days, promptly submitted such omitted facts or the correct information with a full explanation [9 VAC 20-80-570.E].

PERMIT MODULE XIV

ADSORPTION BASED GROUNDWATER CORRECTIVE ACTION MODULE

PERMIT MODULE
XIV
ADSORPTION BASED
GROUNDWATERCORRECTIVE ACTION [9 VAC 20-80-310]

XIV.A PURPOSE

This Permit Module describes the adsorption-based ground water remediation technology to be implemented on site as a result of the statistically significant exceedance of the arsenic and sulfide groundwater protection standards (GPS).

Attachments to this Module include:

- Corrective Action Plan
- Corrective Action Groundwater Monitoring Plan

XIV.B INTERIM MEASURES [9 VAC 20-80-310.C.1.c]

At any time during the Corrective Action process, the Permittee or Director may determine that interim measures are required. Nothing in this Permit shall preclude the Permittee from performing interim measures at any time if required to reduce or eliminate the risk to human health and the environment, provided the interim measures are consistent with the goals of the Corrective Action Plan.

If interim measures are required by the Director, the Permittee shall respond with a plan for interim measures within 60 days of the Director's notification of the need for the requirement.

XIV.C REMEDY REQUIREMENTS [9 VAC 20-80-310.B.2]

The remedy proposed for the impacted aquifer shall: 1] gain control of the source of the release, 2] comply with the standards for the management of waste, 3] be protective of human health and the environment, and 4] achieve all groundwater protection standards.

XIV.D REMEDY DESCRIPTION

The site-wide remedy consists of natural in-situ adsorption. Long term groundwater monitoring shall be implemented to measure the effectiveness of natural adsorption of arsenic and sulfide within the aquifer, a process catalyzed by iron, as further explained in Attachment **XIV-1**.

XIV.E REMEDY IMPLEMENTATION [9 VAC 20-80-310.C.1.b and 620.F.3]

XIV.E.1 Implementation of the attached Corrective Action Plan and its related monitoring program begins within 30 days after the date the Permit is amended to incorporate this Permit Module.

XIV.E.2 Any changes in the implementation of the remedy design or groundwater monitoring program shall require an amendment to the facility's Permit as noted under Table 7.2 to the VSWMR.

XIV.E.3 The Director has the authority to amend the Permit for any changes to Corrective Action if any conditions of 9 VAC 20-80-620.E.5 or E.8, & 9 VAC 20-80-310.C.2 are found to be applicable.

XIV.F ALTERNATE REMEDY ACTIONS [9 VAC 20-80-310.A.4.c; C.2]

Adsorption has been selected as the remedy of choice on site.

The Permittee or Director may determine, based on information obtained after Corrective Action has been implemented, that compliance with the requirements of 9 VAC 20-80-310.B.2 or C.5 are not being achieved by the remedy selected. In such cases, the Permittee shall within 90-days of the determination:

XIV.F.1 (unless the alternate remedy is already described in the Corrective Action Plan), submit a revised Corrective Action Plan describing the alternate remedy for Department review,

XIV.F.2 if the alternate remedy is already described in the existing Corrective Action Plan, submit any detailed design plans or monitoring component changes to the Department for review,

XIV.F.3 amend the facility's Permit to implement an alternate remedy, unless the Permittee submits the demonstration allowed under 9 VAC 20-80-310.C.3.

XIV.G REMEDY PERFORMANCE MONITORING [9 VAC 20-80-310.A.2; A.4.d; C.1.a]

The groundwater remediation effort shall be coupled with a monitoring system designed to demonstrate:

XIV.G.1 the areal extent (both vertical and horizontal) of the plume at concentrations which exceed background. Because both the horizontal and vertical aspects of the plume shall be monitored, the well network shall include wells installed to a depth appropriate to intersect all groundwater flow paths in the aquifer.

XIV.G.2 the effectiveness of the implemented Corrective Action Program.

XIV.G.3 compliance with the groundwater protection standard.

XIV.G.4 whether the plume remains on site.

XIV.G.5 successful arsenic adsorption catalyzed by iron.

The Permittee shall operate and maintain the groundwater monitoring wells on site as specified below, in a manner which is at a minimum consistent with 9 VAC 20-80-300.A.3.e and 310.A.2.a.

Upgradient Wells	Compliance Wells	Associated Performance Wells	Associated Sentinel Wells	Surface Water Sampling Point
MW-4R	CECW-1	CECW-1D		SW-4
MW-5	CECW-2	CECW-2D		SW-3
	CECW-3	CECW-3D	CECW-10	
			CECW-15	
	CECW-4			SW-2
	CECW-5			
	CECW-6I		CECW-6D	
	PO-8	PO-8D		SW-1

	PO-9			
	PO-10	PO-10D	CECW-8D	
			CECW-8	
	PO-11			

XIV.G.6 Well Definitions

XIV.G.6.a Upgradient wells are designed to provide site-specific background data and are monitored as part of the normal monitoring program identified and described in Permit Module XI.

XIV.G.6.b Compliance wells are monitored to determine whether the landfill has impacted groundwater quality at the waste management unit boundary as part of the normal groundwater monitoring program described in Permit Module XI.

XIV.G.6.c Sentinel wells are monitored to ensure there is no expansion of the plume or impact to sensitive receptors as a result of changes in plume migration post remedy implementation. These wells shall intercept groundwater which at a minimum shows no GPS exceedances, and preferably no (or only minimal) exceedances over background such that the data obtained from them can assist in delineating the full extent of the landfill-impacted groundwater.

XIV.G.6.d Performance wells are defined as wells monitored to help measure or quantify the success of in-situ arsenic adsorption. These wells, installed downgradient of each GPS exceeding well, shall intercept groundwater which displays GPS exceedances. Data obtained from these wells is used to measure the 'performance' of the adsorption remedy as well as to draw a line around that portion of the aquifer which continues to exceed GPS and thus requires remediation

XIV.G.6.e The Sentinel and Performance wells shall be positioned in a manner consistent with providing data required to measure the progress or effectiveness of adsorption in reducing the arsenic concentrations to GPS levels. The aquifer data required to demonstrate arsenic adsorption includes that which: (1) demonstrates the oxidation state of the aquifer within the plume of contamination and at the 'precipitation/oxidation' boundary, (2) can measure the relationship of other aquifer parameters in assisting or hindering chemical adsorption (i.e. total sulfide, total and dissolved iron, etc.), (3) identify the adsorbed forms of arsenic (4) verifies the plume is not expanding either vertically or horizontally, (5) verifies no unacceptable impact to on site or off site receptors, (6) can detect any new releases to the environment, and (7) verifies clean-up goals have been met.

XIV.G.6.f Sentinel and Performance wells shall be located along the same groundwater flow path as the corresponding impacted compliance well. Any inferences about adsorption based on decreases in contaminant concentrations in the downgradient direction may prove incorrect unless wells are located along the same downgradient groundwater flow path. Because both the horizontal and vertical aspects of the plume shall be monitored, the well network shall include wells installed to a depth appropriate to intersect all groundwater flow paths.

XIV.G.7 Well Certification

The adequacy (correct placement) of the Corrective Action performance and sentinel wells shall be certified by a qualified groundwater professional. A copy of this certification shall be supplied to the Director within 90-days of final installation of the wells listed in this Module.

XIV.G.8 Well Operations & Maintenance

XIV.G.8.a The Permittee shall operate and maintain the Corrective Action groundwater monitoring wells on site in a manner which is at a minimum, meets 9 VAC 20-80-300.A.3.e and allows the network to be operated as designed for the length of the Corrective Action Program.

XIV.G.8.b Any new wells installed on site shall be constructed to meet the requirements of EPA's RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD). All boring logs and well completion diagrams/reports shall be transmitted under signature of a qualified groundwater professional to the Department within 30-days of completion of installation activities [9 VAC 20-80-300.A.3.d].

XIV.G.8.c The Director shall be notified prior to the abandonment of any site wells utilized during Corrective Action. Wells shall be abandoned following the general requirements of EPA's RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD) and a well abandonment report shall be transmitted under signature of a qualified groundwater professional to the Department within 30-days of completion of field activities.

XIV.H MONITORING CONSTITUENTS

XIV.H.1 Requirements - The Permittee shall monitor all wells utilized during the Corrective Action Program for the constituents and frequencies defined below:

<table>
<tr><th>MONITOR WELL TYPE</th><th>MONITORING FREQUENCY</th><th>CONSTITUENT LIST</th><th>RESULTS COMPARED TO</th></tr>
<tr><td>Compliance & Background Wells</td><td colspan="2">As required under Permit Module XI</td><td rowspan="3">GPS and Background</td></tr>
<tr><td>Performance Wells</td><td rowspan="2">Quarterly for the 1st two years, then same as Compliance MWs thereafter.</td><td rowspan="2">GPS COCs and Adsorption Performance Parameters</td></tr>
<tr><td>Sentinel Wells</td></tr>
</table>

GPS Constituents of Concern (COC) are defined as any constituent on the Table 5.1 sampling list which has been identified at concentrations which exceed its respective GPS.

Adsorption Performance Parameters for this facility are listed below:

- Dissolved Arsenic
- Arsenic (III) and (V) speciation
- Total Iron (II and III)
- Dissolved Iron
- Sulfide

Other geochemical parameters listed below may be added to the Permittee's groundwater sampling plan voluntarily, as needed to provide site specific aquifer geochemistry information which may be used to substantiate the rate of success of the adsorption process:

- Specific Conductance
- Oxidation-Reduction Potential (ORP)
- Dissolved Oxygen
- pH
- Temperature
- Manganese
- Sulfate
- Turbidity (NTUs)

XIV.H.2 Frequency - The semi-annual sampling period shall meet the requirements of 9 VAC 20-80-10. "Annual," in the context of annual sampling, means an interval corresponding to approximately 360 days. For the purposes of scheduling monitoring activities, sampling within 30 days of the 360-day interval will be considered annual. If applicable, quarterly sampling shall be required as applied in the context of Section 10.1-1405 of Virginia Waste Management Act.

XIV.H.3 Constituent Detects - Detects refers to any constituent found above the laboratory limit of detection (LOD) during any sampling event.

XIV.H.4 Verification Samples are used to maintain an acceptable site-wide false positive rates while ensuring the statistical test used has adequate power to detect changes in groundwater quality. A verification sampling strategy involves collecting a pre-planned number of additional, independent samples, and if such methods are employed on site, they shall be fully described in the attached Corrective Action Monitoring Plan.

If the Permittee is to employ such a sampling strategy, the alpha value shall be modified as outlined in the Department's most recent technical memorandum for Data Analysis Guidelines for Solid Waste Facilities. 9 VAC 20-80-300.A.4.h.(2) restricts the timeframe under which a Permittee can submit the results of any independent samples undertaken during verification efforts. Verification sampling events conducted outside this timeframe, but within the compliance period, may be submitted in the form of an Alternate Source Demonstration meeting the requirements of 9 VAC 20-80-300.A.5.

XIV.I REMEDY PERFORMANCE DEMONSTRATIONS

XIV.I.1 Corrective Action System Evaluation (CASE) Submissions
A report titled Corrective Action Status Evaluation (CASE) shall be submitted to the Director, with a copy provided under separate cover to the Public Data Repository,

once every three years, due on the calendar date the Permit was amended to implement the chosen remedy. The Permittee shall utilize the Department's *Submission Instructions* for CASE reports (2009 as amended) when assembling the CASE report for submission.

The CASE reports, signed by a qualified groundwater professional, shall include the material requested within the *Submission Instructions*, including but not limited to:

XIV.I.1.a The concentrations of all sampled constituents identified above their respective detection limits in the corrective action plan well network [9 VAC 20-80-310.B.4.h.(2)] since remedy implementation.

XIV.I.1.b Plume maps showing the lateral and vertical extent of each constituent of concern found at levels above GPS and levels above background [9 VAC 20-80-310.A.2.a].

XIV.I.1.c Calculated rate of contaminant migration during the CASE period [9 VAC 20-80-300.A.4.c].

XIV.I.1.d Potentiometric surface map based on the most recent groundwater elevation data.

XIV.I.1.e A discussion of the progress during the CASE period toward reaching GPS including any revisions needed to the timelines initially provided in the attached Corrective Action Plan [9 VAC 20-80-310.A.4.a.(2).(a); (c); (d); a.(3), and 310.B.4.h.(3)].

XIV.I.1.f Copies of the field sampling records laboratory reports for all sampling events conducted during the CASE period [9 VAC 20-80-310.B.4.h.(7)].

XIV.J REMEDY COMPLETION DEMONSTRATION *[9 VAC 20-80-310.C.5, C.6]*

XIV.J.1 Certificate Submission

Within 14-days of completing the groundwater remedy, the Permittee shall submit a Certification, signed by the Permittee and a qualified groundwater scientist stating all requirements of 9 VAC 20-80-310.C.5 have been met, (a copy of the Certification shall also be placed at the Public Data repository).

XIV.J.2 CACR Submission

Within 30-days of submission of the Certification, the Permittee shall submit for approval by the Director, a Corrective Action Completion Report (CACR), signed by a qualified groundwater scientist, demonstrating that the remedial actions have been successful in meeting the requirements of 9 VAC 20-80-310.C.5 including:

XIV.J.2.a Documentation that groundwater protection standards have been achieved at all Performance and Sentinel monitoring points within the plume of contamination beyond the compliance well network established under Permit Module XI [9 VAC 20-80-310.C.5.a].

XIV.J.2.b Groundwater sampling data which proves there have been no statistical exceedances of groundwater protection standards for three consecutive years [9 VAC 20-80-310.C.5.b] in any part of the plume.

XIV.J.2.c Documentation that all technical actions and certifications required to complete the remedy have been satisfied [9 VAC 20-80-310.C.5.c].

XIV.J.3 If, after review of the Certification and the CACR, the Director agrees that Corrective Action requirements have been met, the Permittee shall be released from the requirements of 9 VAC 20-80-310 and 9 VAC 20-70-10 et seq. If the Director finds that the presented materials do not substantiate that Corrective Action goals have been achieved, the Permittee shall remain under the requirements of 9 VAC 20-80-310.C until such time as these requirements have been met.

XIV.K REMEDY ABANDONMENT [310.C.3]

The Permittee can submit to the Director a Technical Infeasibility Report (TIR) describing the technical reasons why the clean-up objectives can not be practically met on site using the chosen remedy. If submitted, the TIR shall include:

XIV.K.1 The certification of a qualified groundwater scientist [9 VAC 20-80-310.C.3.a].

XIV.K.2 A discussion of the reasons why the chosen remedy, and any applicable back-up remedy were not successful in meeting the Corrective Action requirements.

XIV.K.3 Within 180 days of the Director's approval of the TIR demonstration, but no later than 14 days prior to implementing any alternative measures [9 VAC 20-80-310.C.3.d], the Permittee shall submit an Alternate Measures Report (AMR). The report shall be signed by a qualified groundwater scientist and shall describe the Alternate Measures to meet the requirements of 9 VAC 20-80-310.C.3.b and c. A copy of the AMR shall also be placed at the Public Data Repository.

XIV.K.4 Upon the Director's approval of the TIR demonstration, if the Director agrees that the measures applied to the site meet the requirements of 9 VAC 20-80-310.C.3.b and c, the Permittee shall be released from the requirements of 9 VAC 20-80-310 and 9 VAC 20-70-10 et seq. Conversely, if the Director finds that the presented measures do not meet the regulatory requirements, the Permittee shall revise the AMR submission until such time as regulatory conformance is demonstrated.

XIV.K.5 If the Director denies the results of the TIR demonstration, then within 180 days, the Permittee shall submit a revised Corrective Action Plan, signed by a qualified groundwater scientist. The Plan shall describe a new remedy to be applied on site to meet the requirements of 9 VAC 20-80-310.C and shall remain in Corrective Action until these requirements are met.

XIV.L REMEDY RECORD-KEEPING REQUIREMENTS

XIV.L.1 The Permittee shall record in the facility operating record all actions related to the remedy installed on site, including but not limited to any manifests related to investigatively derived wastes, as well as any design plans, construction reports, as-built documentation, and waste manifests, where applicable.

XIV.L.2 Throughout the life of the Corrective Action Monitoring Program, the Permittee shall place on file, in a location accessible to the public, copies of any Corrective Action program materials submitted to the Department including copies of the final Nature and Extent and Assessment of Corrective Measures reports. Consistent with the US

EPA's RCRA Public Participation Policy, the location chosen by the Permittee shall serve as the public data repository for all monitoring reports generated during the Corrective Action process and shall in part satisfy the requirements for public participation established under RCRA. The location of the public data repository is listed below in XIV.I.

XIV.L.3 CORRECTIVE ACTION DATA REPOSITORY

Location Name: Major Hilliard Library Location Address: 824 Old George Washington Hwy North Location City: Chesapeake, Virginia

XIV.M CORRECTIVE ACTION NOTIFICATION REQUIREMENTS

XIV.M.1 System Preparation Update Notification

During any site preparation phase concerning implementation of a surface water mitigation system, or monitoring well installation phase, the Permittee shall provide written or electronic status updates to the Director every 30 days until such time as the construction of the components is considered complete [9 VAC 20-80-310.B.4.h.(1)].

XIV.M.2 System Component Failure
Emergency Modification Notification

Within 7 days of noting any component failure, the Permittee shall submit to the Director, a notification describing the issue [9 VAC 20-80-310.B.4.h.(5)].

XIV.M.3 System Modification

If modifications other than those described in the attached Corrective Action Plan are required to correct deficiencies or enhance monitoring system performance after implementation of the remedy [9 VAC 20-80-310.B.4.h.(5)], the Permittee shall submit a written request to the Director for approval of the proposed changes no later than 60 days prior to the date of the proposed modification. The notification shall include a description and drawings of the proposed modification; justification for the modification; and evaluation of the performance improvements.

XIV.M.4 System Design "As-builts"

Well installation diagrams, boring logs, and the requisite certification from a groundwater professional shall be submitted as required under 9 VAC 20-80-300. As-builts for any other remedy component installed after remedy implementation shall be submitted within 30-days of construction completion.

XIV.M.5 Miscellaneous Groundwater Notifications

The Permittee shall report new background determinations, GPS exceedances, background exceedances, off-site impacts, dry wells, well abandonment, well installation, etc., in a manner consistent with requirements of 9 VAC 20-80-300 unless otherwise defined in this Module.

XIV.N INVESTIGATIVELY DERIVED WASTES [9 VAC 20-80-310.C.4]

If applicable, based on the remedy implemented onsite, all investigatively derived solid waste shall be managed in a manner that is protective of human health and the environment, compliant with all applicable state and federal requirements, and is consistent with the methods outlined in the attached Corrective Action Plan.

XIV.O SURFACE WATER INVESTIGATION

XIV.O.1. Based on the potential for GPS COCs to discharge to surface water and potential benthic impairment to surface water on site, the permittee shall sample surface water in a manner consistent with the overall site remedy at the locations identified in **Attachment XIV-1.**

XIV.O.2. Locations & Parameters
Surface water samples shall be collected from SW-1, SW-2, SW-3, and SW-4, and analyzed for the constituent list identified in **Attachment XIV-2**, Section 3.0.

XIV.O.2.a. These locations shall be permanently marked or flagged at the nearest shore to allow easy identification.

XIV.O.2.b. The facility may add additional sampling locations as needed, based on the results of the surface water sampling.

XIV.O.2.c. If the location of the sampling points needs modification in the future, Director pre-approval shall be required.

XIV.O.2.d. Sampling locations which do not contain a sufficient water column within which to sample shall not be required to be re-sampled during the compliance period.

XIV.O.2.e. The surface water sampling actions shall be conducted in a manner equivalent to QA/QC procedures used by either the USEPA or US Geological Survey when conducting environmental sampling of surface waters. Because the primary COCs are inorganic constituents, samples should be obtained in a manner which avoids excess suspended solids introduced to the water column by disturbing the channel bottom during sampling.

XIV.O.2.f. If sampling locations will be accessed by foot, then to the extent practical, the sampling of surface waters should take place during 'high tide'. This shall minimize any physical disturbance to the estuarian substrate. If, instead, the access to the sampling locations will be by boat, the timing of the sampling need not be keyed to tidal cycles.

XIV.P MODULE ATTACHMENTS

Attachments to this Module include, at a minimum, the Corrective Action Plan and the Corrective Action Monitoring Plan.

It shall be the responsibility of the Permittee to update this Plan as needed, which may include Permit amendment as defined under 9 VAC 20-80-620.A – F, if changes to the monitoring program have taken place since Plan implementation.

XIV.Q LIMITATIONS

Should information contained in any Permittee-authored attachment to this Module conflict with any requirement or condition contained herein, or language found within 9 VAC 20-80-10 et seq., as amended; the Module condition and/or Regulatory requirement shall prevail over the language in the Permittee supplied attachment [see 9 VAC 20-80-60.D and 9 VAC 20-80-550.E] unless it can be demonstrated that a variance from that regulatory requirement has been granted by the Director under 9 VAC 20-80-730 et seq.

When the Permittee becomes aware that he failed to submit any relevant facts or submitted incorrect information in any groundwater monitoring report to the Director, he shall promptly submit such omitted facts or the correct information with an explanation [9 VAC 20-80-570.E].

XIV.R SCHEDULE OF COMPLIANCE

XIV.R.1. Implementation of Remedy

Existing wells shall be used and redesignated as performance and sentinel wells as shown in the table at permit condition **XIV.E.** Each phase of the remedy is detailed in Attachment **XIV-1 (9 VAC 20-80-310.B.4).** The remedy (CAMP monitoring) shall be initiated within 30 days of the approval of this amendment. Termination of the remedy shall be conducted in accordance with permit condition **XIV.N**. If any condition arises which causes a delay in the completion of scheduled activities, the permittee shall follow the requirements of Permit Condition **XIV.D.4**.

XIV.R.2. Supplemental Sediment Boring Assessment

Attachment **XIV-1**, pp. 20–22, describes how sediment coring shall be performed to provide direct evidence that the arsenic and sulfide adsorption process is capable of naturally attenuating arsenic and sulfide concentrations below GPS prior to discharge into adjacent surface water bodies. The work described shall be initiated, with the collection of at least thirty 1.5- foot sediment cores to produce at least three pore water and at least three sediment samples each analyzed for iron and arsenic as described in the CAP. The sampling, analysis, and reported results are to be initiated within 30 days of the approval of this amendment and completed within 180 days of initiation. If the study results are not successful, the permitted remedy shall either be modified or replaced to ensure successful arsenic and sulfide remediation at the facility.

PERMIT ATTACHMENT XIV – 1

CORRECTIVE ACTION PLAN & Related Figures

(Including Surface Water Monitoring)

Please note that Attachments A through I of the 2008 CAP may be found in the Department's file holdings at the Tidewater Regional Office

PERMIT ATTACHMENT XIV – 2

CORRECTIVE ACTION GROUNDWATER MONITORING PLAN

PERMIT MODULE
XIV
ADSORPTION BASED
GROUNDWATERCORRECTIVE ACTION [9 VAC 20-80-310]

XIV.A PURPOSE

This Permit Module describes the adsorption-based ground water remediation technology to be implemented on site as a result of the statistically significant exceedance of the arsenic and sulfide groundwater protection standards (GPS).

Attachments to this Module include:

- Corrective Action Plan
- Corrective Action Groundwater Monitoring Plan

XIV.B INTERIM MEASURES [9 VAC 20-80-310.C.1.c]

At any time during the Corrective Action process, the Permittee or Director may determine that interim measures are required. Nothing in this Permit shall preclude the Permittee from performing interim measures at any time if required to reduce or eliminate the risk to human health and the environment, provided the interim measures are consistent with the goals of the Corrective Action Plan.

If interim measures are required by the Director, the Permittee shall respond with a plan for interim measures within 60 days of the Director's notification of the need for the requirement.

XIV.C REMEDY REQUIREMENTS [9 VAC 20-80-310.B.2]

The remedy proposed for the impacted aquifer shall: 1] gain control of the source of the release, 2] comply with the standards for the management of waste, 3] be protective of human health and the environment, and 4] achieve all groundwater protection standards.

XIV.D REMEDY DESCRIPTION

The site-wide remedy consists of natural in-situ adsorption. Long term groundwater monitoring shall be implemented to measure the effectiveness of natural adsorption of arsenic and sulfide within the aquifer, a process catalyzed by iron, as further explained in Attachment **XIV-1**.

XIV.E REMEDY IMPLEMENTATION [9 VAC 20-80-310.C.1.b and 620.F.3]

XIV.E.1 Implementation of the attached Corrective Action Plan and its related monitoring program begins within 30 days after the date the Permit is amended to incorporate this Permit Module.

XIV.E.2 Any changes in the implementation of the remedy design or groundwater monitoring program shall require an amendment to the facility's Permit as noted under Table 7.2 to the VSWMR.

XIV.E.3 The Director has the authority to amend the Permit for any changes to Corrective Action if any conditions of 9 VAC 20-80-620.E.5 or E.8, & 9 VAC 20-80-310.C.2 are found to be applicable.

XIV.F ALTERNATE REMEDY ACTIONS [9 VAC 20-80-310.A.4.c; C.2]

Adsorption has been selected as the remedy of choice on site.

The Permittee or Director may determine, based on information obtained after Corrective Action has been implemented, that compliance with the requirements of 9 VAC 20-80-310.B.2 or C.5 are not being achieved by the remedy selected. In such cases, the Permittee shall within 90-days of the determination:

XIV.F.1 (unless the alternate remedy is already described in the Corrective Action Plan), submit a revised Corrective Action Plan describing the alternate remedy for Department review,

XIV.F.2 if the alternate remedy is already described in the existing Corrective Action Plan, submit any detailed design plans or monitoring component changes to the Department for review,

XIV.F.3 amend the facility's Permit to implement an alternate remedy, unless the Permittee submits the demonstration allowed under 9 VAC 20-80-310.C.3.

XIV.G REMEDY PERFORMANCE MONITORING [9 VAC 20-80-310.A.2; A.4.d; C.1.a]

The groundwater remediation effort shall be coupled with a monitoring system designed to demonstrate:

XIV.G.1 the areal extent (both vertical and horizontal) of the plume at concentrations which exceed background. Because both the horizontal and vertical aspects of the plume shall be monitored, the well network shall include wells installed to a depth appropriate to intersect all groundwater flow paths in the aquifer.

XIV.G.2 the effectiveness of the implemented Corrective Action Program.

XIV.G.3 compliance with the groundwater protection standard.

XIV.G.4 whether the plume remains on site.

XIV.G.5 successful arsenic adsorption catalyzed by iron.

The Permittee shall operate and maintain the groundwater monitoring wells on site as specified below, in a manner which is at a minimum consistent with 9 VAC 20-80-300.A.3.e and 310.A.2.a.

Upgradient Wells	Compliance Wells	Associated Performance Wells	Associated Sentinel Wells	Surface Water Sampling Point
MW-4R	CECW-1	CECW-1D		SW-4
MW-5	CECW-2	CECW-2D		SW-3
	CECW-3	CECW-3D	CECW-10	
			CECW-15	
	CECW-4			SW-2
	CECW-5			
	CECW-6I		CECW-6D	
	PO-8	PO-8D		SW-1

	PO-9			
	PO-10	PO-10D	CECW-8D	
			CECW-8	
	PO-11			

XIV.G.6 *Well Definitions*

XIV.G.6.a Upgradient wells are designed to provide site-specific background data and are monitored as part of the normal monitoring program identified and described in Permit Module XI.

XIV.G.6.b Compliance wells are monitored to determine whether the landfill has impacted groundwater quality at the waste management unit boundary as part of the normal groundwater monitoring program described in Permit Module XI.

XIV.G.6.c Sentinel wells are monitored to ensure there is no expansion of the plume or impact to sensitive receptors as a result of changes in plume migration post remedy implementation. These wells shall intercept groundwater which at a minimum shows no GPS exceedances, and preferably no (or only minimal) exceedances over background such that the data obtained from them can assist in delineating the full extent of the landfill-impacted groundwater.

XIV.G.6.d Performance wells are defined as wells monitored to help measure or quantify the success of in-situ arsenic adsorption. These wells, installed downgradient of each GPS exceeding well, shall intercept groundwater which displays GPS exceedances. Data obtained from these wells is used to measure the 'performance' of the adsorption remedy as well as to draw a line around that portion of the aquifer which continues to exceed GPS and thus requires remediation

XIV.G.6.e The Sentinel and Performance wells shall be positioned in a manner consistent with providing data required to measure the progress or effectiveness of adsorption in reducing the arsenic concentrations to GPS levels. The aquifer data required to demonstrate arsenic adsorption includes that which: (1) demonstrates the oxidation state of the aquifer within the plume of contamination and at the 'precipitation/oxidation' boundary, (2) can measure the relationship of other aquifer parameters in assisting or hindering chemical adsorption (i.e. total sulfide, total and dissolved iron, etc.), (3) identify the adsorbed forms of arsenic (4) verifies the plume is not expanding either vertically or horizontally, (5) verifies no unacceptable impact to on site or off site receptors, (6) can detect any new releases to the environment, and (7) verifies clean-up goals have been met.

XIV.G.6.f Sentinel and Performance wells shall be located along the same groundwater flow path as the corresponding impacted compliance well. Any inferences about adsorption based on decreases in contaminant concentrations in the downgradient direction may prove incorrect unless wells are located along the same downgradient groundwater flow path. Because both the horizontal and vertical aspects of the plume shall be monitored, the well network shall include wells installed to a depth appropriate to intersect all groundwater flow paths.

XIV.G.7 Well Certification

The adequacy (correct placement) of the Corrective Action performance and sentinel wells shall be certified by a qualified groundwater professional. A copy of this certification shall be supplied to the Director within 90-days of final installation of the wells listed in this Module.

XIV.G.8 Well Operations & Maintenance

XIV.G.8.a The Permittee shall operate and maintain the Corrective Action groundwater monitoring wells on site in a manner which is at a minimum, meets 9 VAC 20-80-300.A.3.e and allows the network to be operated as designed for the length of the Corrective Action Program.

XIV.G.8.b Any new wells installed on site shall be constructed to meet the requirements of EPA's RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD). All boring logs and well completion diagrams/reports shall be transmitted under signature of a qualified groundwater professional to the Department within 30-days of completion of installation activities [9 VAC 20-80-300.A.3.d].

XIV.G.8.c The Director shall be notified prior to the abandonment of any site wells utilized during Corrective Action. Wells shall be abandoned following the general requirements of EPA's RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD) and a well abandonment report shall be transmitted under signature of a qualified groundwater professional to the Department within 30-days of completion of field activities.

XIV.H MONITORING CONSTITUENTS

XIV.H.1 Requirements - The Permittee shall monitor all wells utilized during the Corrective Action Program for the constituents and frequencies defined below:

<table>
<tr><th>MONITOR WELL TYPE</th><th>MONITORING FREQUENCY</th><th>CONSTITUENT LIST</th><th>RESULTS COMPARED TO</th></tr>
<tr><td>Compliance & Background Wells</td><td colspan="2">As required under Permit Module XI</td><td rowspan="3">GPS and Background</td></tr>
<tr><td>Performance Wells</td><td rowspan="2">Quarterly for the 1st two years, then same as Compliance MWs thereafter.</td><td rowspan="2">GPS COCs and Adsorption Performance Parameters</td></tr>
<tr><td>Sentinel Wells</td></tr>
</table>

GPS Constituents of Concern (COC) are defined as any constituent on the Table 5.1 sampling list which has been identified at concentrations which exceed its respective GPS.

Adsorption Performance Parameters for this facility are listed below:

- Dissolved Arsenic
- Arsenic (III) and (V) speciation
- Total Iron (II and III)
- Dissolved Iron
- Sulfide

Other geochemical parameters listed below may be added to the Permittee's groundwater sampling plan voluntarily, as needed to provide site specific aquifer geochemistry information which may be used to substantiate the rate of success of the adsorption process:

- Specific Conductance
- Oxidation-Reduction Potential (ORP)
- Dissolved Oxygen
- pH
- Temperature
- Manganese
- Sulfate
- Turbidity (NTUs)

XIV.H.2 Frequency - The semi-annual sampling period shall meet the requirements of 9 VAC 20-80-10. "Annual," in the context of annual sampling, means an interval corresponding to approximately 360 days. For the purposes of scheduling monitoring activities, sampling within 30 days of the 360-day interval will be considered annual. If applicable, quarterly sampling shall be required as applied in the context of Section 10.1-1405 of Virginia Waste Management Act.

XIV.H.3 Constituent Detects - Detects refers to any constituent found above the laboratory limit of detection (LOD) during any sampling event.

XIV.H.4 Verification Samples are used to maintain an acceptable site-wide false positive rates while ensuring the statistical test used has adequate power to detect changes in groundwater quality. A verification sampling strategy involves collecting a pre-planned number of additional, independent samples, and if such methods are employed on site, they shall be fully described in the attached Corrective Action Monitoring Plan.

If the Permittee is to employ such a sampling strategy, the alpha value shall be modified as outlined in the Department's most recent technical memorandum for Data Analysis Guidelines for Solid Waste Facilities. 9 VAC 20-80-300.A.4.h.(2) restricts the timeframe under which a Permittee can submit the results of any independent samples undertaken during verification efforts. Verification sampling events conducted outside this timeframe, but within the compliance period, may be submitted in the form of an Alternate Source Demonstration meeting the requirements of 9 VAC 20-80-300.A.5.

XIV.I REMEDY PERFORMANCE DEMONSTRATIONS

XIV.I.1 Corrective Action System Evaluation (CASE) Submissions
A report titled Corrective Action Status Evaluation (CASE) shall be submitted to the Director, with a copy provided under separate cover to the Public Data Repository,

once every three years, due on the calendar date the Permit was amended to implement the chosen remedy. The Permittee shall utilize the Department's *Submission Instructions* for CASE reports (2009 as amended) when assembling the CASE report for submission.

The CASE reports, signed by a qualified groundwater professional, shall include the material requested within the *Submission Instructions*, including but not limited to:

XIV.I.1.a The concentrations of all sampled constituents identified above their respective detection limits in the corrective action plan well network [9 VAC 20-80-310.B.4.h.(2)] since remedy implementation.

XIV.I.1.b Plume maps showing the lateral and vertical extent of each constituent of concern found at levels above GPS and levels above background [9 VAC 20-80-310.A.2.a].

XIV.I.1.c Calculated rate of contaminant migration during the CASE period [9 VAC 20-80-300.A.4.c].

XIV.I.1.d Potentiometric surface map based on the most recent groundwater elevation data.

XIV.I.1.e A discussion of the progress during the CASE period toward reaching GPS including any revisions needed to the timelines initially provided in the attached Corrective Action Plan [9 VAC 20-80-310.A.4.a.(2).(a); (c); (d); a.(3), and 310.B.4.h.(3)].

XIV.I.1.f Copies of the field sampling records laboratory reports for all sampling events conducted during the CASE period [9 VAC 20-80-310.B.4.h.(7)].

XIV.J REMEDY COMPLETION DEMONSTRATION [9 VAC 20-80-310.C.5, C.6]

XIV.J.1 Certificate Submission

Within 14-days of completing the groundwater remedy, the Permittee shall submit a Certification, signed by the Permittee and a qualified groundwater scientist stating all requirements of 9 VAC 20-80-310.C.5 have been met, (a copy of the Certification shall also be placed at the Public Data repository).

XIV.J.2 CACR Submission

Within 30-days of submission of the Certification, the Permittee shall submit for approval by the Director, a Corrective Action Completion Report (CACR), signed by a qualified groundwater scientist, demonstrating that the remedial actions have been successful in meeting the requirements of 9 VAC 20-80-310.C.5 including:

XIV.J.2.a Documentation that groundwater protection standards have been achieved at all Performance and Sentinel monitoring points within the plume of contamination beyond the compliance well network established under Permit Module XI [9 VAC 20-80-310.C.5.a].

XIV.J.2.b Groundwater sampling data which proves there have been no statistical exceedances of groundwater protection standards for three consecutive years [9 VAC 20-80-310.C.5.b] in any part of the plume.

XIV.J.2.c Documentation that all technical actions and certifications required to complete the remedy have been satisfied [9 VAC 20-80-310.C.5.c].

XIV.J.3 If, after review of the Certification and the CACR, the Director agrees that Corrective Action requirements have been met, the Permittee shall be released from the requirements of 9 VAC 20-80-310 and 9 VAC 20-70-10 et seq. If the Director finds that the presented materials do not substantiate that Corrective Action goals have been achieved, the Permittee shall remain under the requirements of 9 VAC 20-80-310.C until such time as these requirements have been met.

XIV.K REMEDY ABANDONMENT [310.C.3]

The Permittee can submit to the Director a Technical Infeasibility Report (TIR) describing the technical reasons why the clean-up objectives can not be practically met on site using the chosen remedy. If submitted, the TIR shall include:

XIV.K.1 The certification of a qualified groundwater scientist [9 VAC 20-80-310.C.3.a].

XIV.K.2 A discussion of the reasons why the chosen remedy, and any applicable back-up remedy were not successful in meeting the Corrective Action requirements.

XIV.K.3 Within 180 days of the Director's approval of the TIR demonstration, but no later than 14 days prior to implementing any alternative measures [9 VAC 20-80-310.C.3.d], the Permittee shall submit an Alternate Measures Report (AMR). The report shall be signed by a qualified groundwater scientist and shall describe the Alternate Measures to meet the requirements of 9 VAC 20-80-310.C.3.b and c. A copy of the AMR shall also be placed at the Public Data Repository.

XIV.K.4 Upon the Director's approval of the TIR demonstration, if the Director agrees that the measures applied to the site meet the requirements of 9 VAC 20-80-310.C.3.b and c, the Permittee shall be released from the requirements of 9 VAC 20-80-310 and 9 VAC 20-70-10 et seq. Conversely, if the Director finds that the presented measures do not meet the regulatory requirements, the Permittee shall revise the AMR submission until such time as regulatory conformance is demonstrated.

XIV.K.5 If the Director denies the results of the TIR demonstration, then within 180 days, the Permittee shall submit a revised Corrective Action Plan, signed by a qualified groundwater scientist. The Plan shall describe a new remedy to be applied on site to meet the requirements of 9 VAC 20-80-310.C and shall remain in Corrective Action until these requirements are met.

XIV.L REMEDY RECORD-KEEPING REQUIREMENTS

XIV.L.1 The Permittee shall record in the facility operating record all actions related to the remedy installed on site, including but not limited to any manifests related to investigatively derived wastes, as well as any design plans, construction reports, as-built documentation, and waste manifests, where applicable.

XIV.L.2 Throughout the life of the Corrective Action Monitoring Program, the Permittee shall place on file, in a location accessible to the public, copies of any Corrective Action program materials submitted to the Department including copies of the final Nature and Extent and Assessment of Corrective Measures reports. Consistent with the US

EPA's RCRA Public Participation Policy, the location chosen by the Permittee shall serve as the public data repository for all monitoring reports generated during the Corrective Action process and shall in part satisfy the requirements for public participation established under RCRA. The location of the public data repository is listed below in XIV.I.

XIV.L.3 CORRECTIVE ACTION DATA REPOSITORY

Location Name: Major Hilliard Library Location Address: 824 Old George Washington Hwy North Location City: Chesapeake, Virginia

XIV.M CORRECTIVE ACTION NOTIFICATION REQUIREMENTS

XIV.M.1 System Preparation Update Notification
During any site preparation phase concerning implementation of a surface water mitigation system, or monitoring well installation phase, the Permittee shall provide written or electronic status updates to the Director every 30 days until such time as the construction of the components is considered complete [9 VAC 20-80-310.B.4.h.(1)].

XIV.M.2 System Component Failure
Emergency Modification Notification
Within 7 days of noting any component failure, the Permittee shall submit to the Director, a notification describing the issue [9 VAC 20-80-310.B.4.h.(5)].

XIV.M.3 System Modification
If modifications other than those described in the attached Corrective Action Plan are required to correct deficiencies or enhance monitoring system performance after implementation of the remedy [9 VAC 20-80-310.B.4.h.(5)], the Permittee shall submit a written request to the Director for approval of the proposed changes no later than 60 days prior to the date of the proposed modification. The notification shall include a description and drawings of the proposed modification; justification for the modification; and evaluation of the performance improvements.

XIV.M.4 System Design "As-builts"
Well installation diagrams, boring logs, and the requisite certification from a groundwater professional shall be submitted as required under 9 VAC 20-80-300. As-builts for any other remedy component installed after remedy implementation shall be submitted within 30-days of construction completion.

XIV.M.5 Miscellaneous Groundwater Notifications

The Permittee shall report new background determinations, GPS exceedances, background exceedances, off-site impacts, dry wells, well abandonment, well installation, etc., in a manner consistent with requirements of 9 VAC 20-80-300 unless otherwise defined in this Module.

XIV.N INVESTIGATIVELY DERIVED WASTES [9 VAC 20-80-310.C.4]

If applicable, based on the remedy implemented onsite, all investigatively derived solid waste shall be managed in a manner that is protective of human health and the environment, compliant with all applicable state and federal requirements, and is consistent with the methods outlined in the attached Corrective Action Plan.

XIV.O SURFACE WATER INVESTIGATION

XIV.O.1. Based on the potential for GPS COCs to discharge to surface water and potential benthic impairment to surface water on site, the permittee shall sample surface water in a manner consistent with the overall site remedy at the locations identified in **Attachment XIV-1.**

XIV.O.2. Locations & Parameters
Surface water samples shall be collected from SW-1, SW-2, SW-3, and SW-4, and analyzed for the constituent list identified in **Attachment XIV-2**, Section 3.0.

XIV.O.2.a. These locations shall be permanently marked or flagged at the nearest shore to allow easy identification.

XIV.O.2.b. The facility may add additional sampling locations as needed, based on the results of the surface water sampling.

XIV.O.2.c. If the location of the sampling points needs modification in the future, Director pre-approval shall be required.

XIV.O.2.d. Sampling locations which do not contain a sufficient water column within which to sample shall not be required to be re-sampled during the compliance period.

XIV.O.2.e. The surface water sampling actions shall be conducted in a manner equivalent to QA/QC procedures used by either the USEPA or US Geological Survey when conducting environmental sampling of surface waters. Because the primary COCs are inorganic constituents, samples should be obtained in a manner which avoids excess suspended solids introduced to the water column by disturbing the channel bottom during sampling.

XIV.O.2.f. If sampling locations will be accessed by foot, then to the extent practical, the sampling of surface waters should take place during 'high tide'. This shall minimize any physical disturbance to the estuarian substrate. If, instead, the access to the sampling locations will be by boat, the timing of the sampling need not be keyed to tidal cycles.

XIV.P MODULE ATTACHMENTS

Attachments to this Module include, at a minimum, the Corrective Action Plan and the Corrective Action Monitoring Plan.

It shall be the responsibility of the Permittee to update this Plan as needed, which may include Permit amendment as defined under 9 VAC 20-80-620.A – F, if changes to the monitoring program have taken place since Plan implementation.

XIV.Q LIMITATIONS

Should information contained in any Permittee-authored attachment to this Module conflict with any requirement or condition contained herein, or language found within 9 VAC 20-80-10 et seq., as amended; the Module condition and/or Regulatory requirement shall prevail over the language in the Permittee supplied attachment [see 9 VAC 20-80-60.D and 9 VAC 20-80-550.E] unless it can be demonstrated that a variance from that regulatory requirement has been granted by the Director under 9 VAC 20-80-730 et seq.

When the Permittee becomes aware that he failed to submit any relevant facts or submitted incorrect information in any groundwater monitoring report to the Director, he shall promptly submit such omitted facts or the correct information with an explanation, [9 VAC 20-80-570.E].

XIV.R SCHEDULE OF COMPLIANCE

XIV.R.1. Implementation of Remedy

Existing wells shall be used and redesignated as performance and sentinel wells as shown in the table at permit condition **XIV.E.** Each phase of the remedy is detailed in Attachment **XIV-1 (9 VAC 20-80-310.B.4)**. The remedy (CAMP monitoring) shall be initiated within 30 days of the approval of this amendment. Termination of the remedy shall be conducted in accordance with permit condition **XIV.N.** If any condition arises which causes a delay in the completion of scheduled activities, the permittee shall follow the requirements of Permit Condition **XIV.D.4.**

XIV.R.2. Supplemental Sediment Boring Assessment

Attachment **XIV-1**, pp. 20–22, describes how sediment coring shall be performed to provide direct evidence that the arsenic and sulfide adsorption process is capable of naturally attenuating arsenic and sulfide concentrations below GPS prior to discharge into adjacent surface water bodies. The work described shall be initiated, with the collection of at least thirty 1.5- foot sediment cores to produce at least three pore water and at least three sediment samples each analyzed for iron and arsenic as described in the CAP. The sampling, analysis, and reported results are to be initiated within 30 days of the approval of this amendment and completed within 180 days of initiation. If the study results are not successful, the permitted remedy shall either be modified or replaced to ensure successful arsenic and sulfide remediation at the facility.

PERMIT ATTACHMENT XIV- 1

CORRECTIVE ACTION PLAN (Including Surface Water Monitoring)

Groundwater
& Environmental Services, Inc.

Corrective Action Plan

Dominion Generation

Chesapeake Energy Center Ash Landfill
Solid Waste Permit No. 440
Tidewater Regional Office
Chesapeake, VA

RECEIVED – DEQ
MAR - 9 2009
Tidewater Regional Office

Prepared for:

Dominion Generation
Innsbrook Technical Center
5000 Dominion Boulevard
Glen Allen, VA 23060

Prepared by:

Groundwater & Environmental Services of NC, Inc.
23 South 13th Street, Suite 201
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February 2008

42019

Corrective Action Plan
Dominion Generation
Chesapeake Energy Center Ash Landfill
Chesapeake, VA,
Solid Waste Permit No. 440

February 2008

Prepared for:	Dominion Generation Innsbrook Technical Center 500 Dominion Boulevard Glen Allen VA 23060
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42020

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B. Geochemical Testing and Analysis of Arsenic Occurrence and Mobility at the CEC Ash Landfill
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D. Laboratory Certificates of Analyses – Soil Samples
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H. Compliance Well Arsenic Trend Evaluation Data
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EXECUTIVE SUMMARY

Arsenic has been detected in groundwater monitoring wells surrounding the Chesapeake Energy Center (CEC) Ash Landfill. Dissolved arsenic concentrations in water samples from the approved monitoring network near the periphery of the landfill have exhibited concentrations as high as 396 µg/L. The groundwater protection standard (GPS) for arsenic is 10 µg/L. Dominion entered the DEQ corrective action program in 2002 as a result of the arsenic GPS exceedence. Groundwater is not used for drinking water at the site, and a human health and ecological risk assessment indicated that there was no unacceptable risk to receptors. The primary source of the arsenic entering the groundwater is believed to be wet ash from former ash settling basins. The current dry ash landfill was constructed with a geomembrane liner in 1985, above the former settling basins.

Arsenic mobility in the subsurface can be affected by formation of precipitates and adsorption onto aquifer minerals. Both of these processes can remove dissolved arsenic from groundwater, resulting in natural attenuation that could potentially lower arsenic concentrations below the GPS. In order to evaluate the significance of arsenic natural attenuation at the CEC, geochemical testing and analysis was conducted on a series of groundwater and sediment samples.

The results of the recent geochemical investigation indicate that arsenic adsorption onto minerals is the primary natural attenuation process in the aquifer beneath the CEC Ash Landfill. The amount of arsenic that has adsorbed to aquifer sediments near the periphery of the landfill correlates with the amount of iron adsorbent in the sediments. Although significant adsorption of arsenic has taken place, the amount of iron oxide adsorbent associated with these sediments is not sufficient to maintain dissolved arsenic concentrations below the GPS within the monitored area. There is a potential for the elevated arsenic in groundwater to be further attenuated by adsorption onto iron minerals in the subsurface mixing zone between groundwater and surface water prior to groundwater discharge to the Southern Branch Elizabeth River (SBER).

Geochemical modeling simulations demonstrated that attenuation via adsorption will reduce dissolved arsenic concentrations in the groundwater and surface water mixing zone. The supplemental geochemical assessment proposed as part of this Corrective Action Plan (CAP) is intended to verify the presence of this mixing zone and the adsorption of arsenic. The Corrective Action Monitoring Program (CAMP) is designed to demonstrate that attenuation by adsorption is an active process at this site through which the mobility of arsenic is controlled beyond the site boundary.

1.0 INTRODUCTION

This Corrective Action Plan (CAP) has been prepared for the Chesapeake Energy Center (CEC) Ash Landfill located in Chesapeake, Virginia. A site location map is included as **Figure 1**. The purpose of this CAP is to present a remedy that is protective of human health and the environment and complies with applicable state and federal standards pertaining to the management of solid waste. The CAP has been prepared based on data included in the Nature and Extent Study (NES)/Assessment of Corrective Measures (ACM) report (URS, 2003) the Risk Assessment (MACTEC, 2003) and the recent geochemical investigation data presented herein. In addition, this CAP reflects the revisions submitted and approved by the Virginia Department of Environmental Quality (DEQ) as required by the following:

- 10/25/2006 1st Technical Review – CAP;
- 3/22/2007 2nd Technical Review – CAP;
- 4/30/2007 3rd Technical Review – CAP; and
- 1/30/2008 Final Technical Review

The Technical Review letters provided by the DEQ are included in **Attachment A**.

This document was prepared in general accordance with the Virginia Department of Environmental Quality's Submission Instructions No. 17 – Corrective Action Plan, Submission Instructions No. 21 – MNA-based CAMPs, and the Virginia Administrative Code 9 VAC 20-80-310.

2.0 GEOCHEMICAL INVESTIGATION

Pursuant to NES/ACM technical review comments received from DEQ in 2005, Dominion collected additional hydrogeological and geochemical data to further support a monitored natural attenuation CAP. This section of the CAP outlines the scope of the recent geochemical investigation. Groundwater and Environmental Services, Inc. (GES) collected groundwater samples at 17 wells located in the vicinity of the CEC Ash Landfill and 15 sediment samples collected at various depths from four wells located near the perimeter of the landfill. The sediment samples were evaluated by Battelle using water extractions and sequential selective extractions. Data from these extractions and the groundwater samples were combined with geochemical modeling to evaluate phase associations and the mobility of arsenic in the aquifer surrounding the CEC Ash Landfill (see Battelle Report, **Attachment B**). Results from the geochemical investigation indicate that arsenic adsorption onto minerals is the primary natural attenuation process in the aquifer beneath the CEC landfill.

In November 2005, GES personnel contracted Boart Longyear Co. to install six new monitoring wells, (MW-5D, CECW-2D, CECW-3D, CECW-8D, PO-8D, PO-10D). The new wells were installed adjacent to existing shallow wells to provide water quality and hydraulic head data across the uppermost aquifer. Construction details for the new wells are provided in **Table 1**. All new wells were installed with five foot PVC screen at a depth such that the screen was emplaced just above the Yorktown confining unit. Each well was completed with a PVC riser to two feet above ground surface and finished with a protective steel casing. Filter sand was dispensed around the screen to two feet above the screen. Wells were sealed with two feet of bentonite above the sand, and completed with grout to ground surface. Each new well is co-located adjacent to a shallow well for the purpose of providing groundwater data for both the shallow and the deep portion of the aquifer across the site. Locations of new wells are depicted on **Figure 2**. Boring Logs for these wells are included as **Attachment C**. Soil samples were taken from four of the six wells, (MW-5D, CECW-8D, PO-8D, PO-10D); sampling results are provided as **Table 2**. Laboratory certificates of analysis are provided in **Attachment D**. Soil was analyzed for multiple parameters by the following laboratories:

- Battelle, Richland Washington, analyzed samples for concentrations of adsorbed species by Battelle;
- Applied Speciation and Consulting Inc., Tukwila Washington, analyzed samples for total metals
- E-Lab Analytical Inc., Houston Texas, analyzed samples for total sulfur and total organic carbon.

After installation of new monitoring wells, GES personnel developed both the new and existing monitoring wells that would be included in the sampling regimen. Monitoring wells were gauged and then surged using a two inch surge block to remove fine sediment from the well screen. After surging, groundwater was purged from the well using a two inch Grundfos pump with control box.

Wells were purged until turbidity stabilized, at which point general water quality parameters (dissolved oxygen, turbidity, oxidation-reduction potential, pH, specific conductance, and temperature) were measured in a flow cell using a YSI Sonde 6820.

GES also installed four groups of nested piezometers, (PW-1, PW-2, PW-3, and PW-4). The piezometers were installed downgradient of the existing monitoring wells, near the adjoining surface water bodies to monitor the water quality at multiple depths along the groundwater/surface water interface. Locations of piezometers are provided on **Figure 2**. Piezometers are composed of a six inch metal well screen, approximately a half an inch in diameter, attached to a length of poly tubing running from the screen to ground surface. They were installed by driving steel rods, encasing the screens, into the ground using an air hammer. The space surrounding the screen and tubing was filled with number two filter sand to six inches below ground surface, and completed with bentonite to ground surface. Each location has a piezometer installed at the following depths below ground surface:

- PW-1 (4.5', 6.5', 10.5', 15')
- PW-2 (2.5', 6.5', 10.5', 15')
- PW-3 (2.5', 6.5', 10.5', 15')
- PW-4 (2', 10')

Monitoring wells sampled as part of this geochemical investigation included MW-5, MW-5D, PO-8, PO-8D, CECW-6I, CECW-6D, CECW-10, CECW-15, CECW-8, CECW-8D, PO-10, PO-10D, CECW-3, CECW-3D, CECW-2, CECW-2D, CECW-1, and CECW- 1D. Because wells CECW-8 and PO-8 could not be properly purged they were not sampled.

Sampling at each well began by gauging and recording the water level. Prior to gauging, the interface probe was decontaminated with an Alconox solution and rinsed using distilled water. A Grundfos pump with dedicated tubing was then used to purge the well. Prior to placing the pump into the well, the pump was decontaminated by pumping an Alconox solution followed by a distilled water rinse through the pump. Using a Lamotte turbidity meter, turbidity was measured periodically during the purging process. Turbidity is considered to be the primary bias factor regarding metals analyses, so wells were purged until the turbity was under ten NTU's. Grundfos pump flow was then reduced to a rate appropriate for low-flow sampling (100 to 200 ml/min). Using a YSI Sonde 6820 and flow cell, field parameters (dissolved oxygen, turbidity, oxidation-reduction potential, pH, specific conductance, and temperature) were logged every three minutes until all parameters stabilized. A summary of field parameters are presented in **Table 3**. The YSI was disconnected and the following samples were collected from each well in the sampling regimen:

- Total metals/ in-organics by EPA method 200.8 modified (ICP-DRC-MS)
- Acenaphthalene and Dibenzofuran by SW-846, method 8270C
- Sulfide by SW-846, method 9034

- Alkalinity
- Major anions – HCO_3/CO_3, SO_4, Cl, NO_3, NO_2
- Major cations – Ca, Mg, Na, K, NH_4
- Total Inorganic Carbon as $CaCO_3$
- TOC by EPA 300 Series and SW-846 Method 6010B

To ensure quality control, the following samples were taken:

- 2 MS/MD, an equipment blank, and a field duplicate

All samples were packed in a cooler with ice and a field blank, and shipped on a daily basis. Total metals/in-organics were shipped to Applied Speciation and Consulting Inc. in Tukwila Washington. All other samples were shipped to E-lab Analytical Inc. in Houston Texas. The laboratory analytical results for the groundwater sampling are summarized in **Table 4**; the Laboratory Certificates of Analysis are provided in **Attachment E**.

Several attempts were made to collect field measurements from the piezometers using a battery operated peristaltic pump and the Sonde YSI 6820. Due to lack of flow from the piezometers as a result of the presence of a layer of organic-rich material encountered along the bank of the peninsula, water quality samples could not be collected as proposed.

3.0 SITE DESCRIPTION

3.1 Physical Setting

CEC occupies approximately 145 acres of property, approximately 8 miles west of Virginia Beach and 7 miles south of the city of Norfolk. The existing coal ash landfill is located on a peninsula in the southern portion of the CEC property. The landfill is bordered by the SBER to the East, Deep Creek to the South, and a non-contact cooling water channel to the West.

Adjoining land is marsh and grass lands with various industrial facilities across the SBER from the landfill. The surrounding area is highly developed for commercial, industrial, and residential use. A Risk Assessment for CEC was prepared by MACTEC in December of 2003 and is included as **Attachment F.** The assessment found that the nearest residences were 2,000 feet to the West and up-gradient of the landfill. There are no potable wells within 1,000 feet of the landfill; CEC and structures in the city obtain water from public water supply lines. The shallow aquifer is not expected to ever be used as a drinking water source due to the salinity of the water.

Possible onsite receptors were identified as non-Dominion employees, Dominion employees, adjoining surface waters, and terrestrial biota living on the landfill peninsula. The Landfill, by and large, is surrounded by a chain link fence and non-employees are instructed not to enter the landfill area; therefore, they are not likely receptors. Since Dominion employees have no contact with the groundwater, and minimal contact with the landfill soil, the exposure pathway is incomplete for said employees as well.

Adjoining surface waters were sampled during the Risk Assessment conducted in 2003. Surface waters did not exhibit arsenic concentrations above the Ambient Water Quality Criteria (AWQC) or an increase of arsenic that would be expected from a groundwater contribution. The Elizabeth River project (2003) listed the SBER as a severe problem for all measurement factors, except metals. In fact, the SBER rates metals as "no problem".

The terrestrial biota on the landfill is considered to be limited by the large amount of human activity (i.e., heavy machinery use) and the minimal area that can provide an ecological niche. The individual song birds that do make their home on the peninsula marsh have foraging habits that preclude significant contact with the landfill slope substrate, and therefore are at minimal risk.

3.2 Aquifer Recognition

The hydrologic framework of the shallow aquifer system is composed of the Colombia Aquifer which resided mostly in the Norfolk Formation. The Norfolk Formation is underlain by the Yorktown Confining Unit. The Norfolk Formation is composed of sands and silts with an average hydraulic conductivity of 287 to 323 feet/ year with conductivities decreasing with depth (URS, 2003).

Above the Norfolk Formation resides various fill materials, which may contain ash from the ash sluicing activities that predate the current landfill. Average hydraulic conductivity in the fill material is 1.5 to 5 feet/year (URS, 2003). Due to the mounding in this area, it is believed that there is an Anthropogenic Water Bearing Unit (AWBU) within this fill material (URS, 2003). Impacted groundwater is thought to flow radially outward and downward from the landfill area into the AWBU, then locally to the shallow Colombia Aquifer, draining into the cooling water channel, Deep Creek, and the SBER. Potentiometric maps for both the deep wells and the shallow wells are included as **Figures 3** and **4**.

Currently there are structural controls in place to limit the migration of contamination. The remnant ash from the pre-landfill sluicing activities is currently capped by a 20 mil high density polyethylene (HDPE) flexible geomembrane layer. This HDPE layer also functions as a liner underneath the functioning landfill area.

3.3 Monitoring Well Network

A series of shallow and deep nested wells are located along the perimeter of the CEC landfill. Groundwater monitoring has been conducted at the site since 1984, primarily from the upper portion of the aquifer. Data collected from the recent installation of six deep monitoring wells (MW-5D, CECW-2D, CECW-3D, CECW-8D, PO-8D, PO-10D) provided an increased understanding of the geochemical conditions of the lower portion of the aquifer.

MW-5 and MW-5D function as background wells. Compliance wells are located around the dry ash landfill, as well as south of the sedimentation basin, and include all wells in the recent sampling regimen. They are intended to serve as regulatory points of compliance with regard to the uppermost aquifer underlying the facility. Based on accepted arsenic transportation theory, the existing well network will be able to measure the performance of the natural attenuation remedy both directly and indirectly. They will directly measure water quality to ensure that geochemical conditions remain conducive to natural attenuation.

4.0 SITE REMEDY

The following section summarizes the geochemical conditions observed at the CEC Ash Landfill and presents factors which support the proposed remedy.

4.1 Overview of Process

In groundwater environments, the presence of dissolved arsenic is controlled by interaction with the aquifer solids (geomedia). The interactions are physical and chemical in nature. Arsenic species move slower than the groundwater flows. Dilution is observed because of physical mixing along the flow path, a process not unique to arsenic. Additionally, arsenic concentration and mobility are strongly affected by specific chemical reactions with other dissolved species and geomedia. These chemical reactions can slow down and stop, or accelerate, arsenic migration and concentration. Unlike organic compounds that can be mineralized (turned to CO_2 and H_2O) by reactions, arsenic cannot be destroyed by chemical processes, chemical processes cause arsenic to have a lesser or greater affinity for immobilization on geomedia. The degree and direction of arsenic attenuation depends on the geochemical environment(s) along the flow path. The balance and interaction between dissolved arsenic, the geomedia, and the other chemical constituents present in the groundwater at CEC will control the on-site and off-site groundwater arsenic concentrations.

Arsenic contaminated groundwater has been monitored at the CEC landfill for several years. In support of the geochemical evaluation/modeling, the arsenic in five groundwater samples (CECW-1I/1D, MW-5, PO-10 and CECW-6I) was speciated by two separate laboratories (Applied Speciation and New Mexico Tech). The majority of the dissolved arsenic found in the groundwater is in the As(III) state (See **Attachment G**). Others (Gibbons, 2001) have reported analysis of trends in arsenic concentration that indicate that some attenuation is taking place at the landfill (i.e., arsenic concentrations appear to be decreasing with time). This suggests that it would be useful to examine the CEC landfill hydrogeologic and geochemical setting for probable arsenic attenuation processes and pathways.

4.2 Aqueous Geochemistry of Arsenic

Arsenic has a rich geochemistry. It is generally found in groundwater in two oxidation states, As(III) and As(V). As(V) [also known as As^{+5} or arsenate] is the more oxidized of the two species; it has lost more electrons to chemical reactions than As(III) [also known as As^{+3} or arsenite]. Many elements have more than one oxidation state, forming one or more redox pairs, the As(III)/As(V) redox couple being an example. Redox reactions involve the transfer of electrons, changing the oxidation states of the participating elements.

The two redox states of dissolved arsenic each form several ionic species in groundwater, the most common are, H_3AsO_4 for As(V), and H_3AsO_3 for As(III). The compounds H_3AsO_4 and H_3AsO_3 will lose H^+ to become negatively charged as pH increases. H_3AsO_3 remains uncharged

until about pH 9 where one H^+ disassociates to form the charged oxyanion $H_2AsO_3^{1-}$. At most groundwater pH ranges As(III) species will be uncharged. In comparison, H_3AsO_4 will begin losing H^+ at about pH 2. In most groundwater, As(V) species will be negatively charged, present again as an oxyanion. The pH controlled loss and gain of H^+ ions does not affect the oxidation state of the arsenic, only the electrostatic charge on the ion.

The charge characteristics of arsenic species are very important with respect to transport rates. The electrostatic charges on the dissolved species interact with the charged surfaces of the geomedia, capturing and concentrating the dissolved species in a thin film on the surface. At this point, captured arsenic oxyanions can covalently bond to oxide mineral surfaces, removing them from solution. The amount of arsenic that will stick to the surface is controlled by:

- The amount and type of mineral oxide forming the surface;
- The oxide surface's pH-dependent charge behavior;
- The pH of the solution as it controls arsenic speciation;
- The affinity of an arsenic species for the specific surface;
- The concentration and redox state of the arsenic species ($^+3$ or $^+5$); and,
- The presence and concentration of other dissolved ions that compete with arsenic oxyanions for a finite number of bonding sites.

These relationships have been measured for numerous individual minerals, and arsenic oxidation states, over a range of pH values with varying concentrations of competing ions.

There is complex interplay and feedback between the factors listed above that suggests that they be evaluated simultaneously in order to make predictions. As an example, from pH alone we might assume that because the As(III) compound H_3AsO_3 is an uncharged oxyanion below pH 9, it has no affinity for mineral oxides at a lower pH. However, in natural systems and laboratory studies we find that As(III) oxyanions can have an affinity for mineral oxides near equal to that observed for As(V) oxyanions (Dixit and Hering, 2003) at pH 7-8. Using this measured pH dependent As(III) affinity for iron oxides, and the average pH at the CEC Landfill of ~6.4 from the December 2005 sampling results (when outliers are removed), we expect to see sorption of As(V) over As(III), but not an absence of As(III) sorption. In bulk, the As(III) transport is faster at the CEC Landfill than the As(V) transport.

In groundwater systems where As(V) is bonded to oxides at a greater proportion than As(III), As(III) may constitute the majority arsenic species in the leading edge of the plume. This is one factor that contributes to the apparent redox disequilibrium between As(III) and As(V). The As(III)/As(V) redox couple can transform slowly (Wilkie and Hering, 1998; Miller, 2000), allowing As(III) to be transported preferentially. Once relative transport rates are considered, the disequilibrium is predictable. Finally, consideration should be given to the problems associated with accurate measurement of redox potential in general, and the particular bias towards higher measured potentials in iron rich waters (Appelo and Postma, 1996). The preferred transport of

As(III) is caused by the factors listed here.

Iron and manganese oxides in soils and aquifers have been studied for over 100 years because of their ability to control the movement of nutrients. It is generally agreed that iron and/or manganese oxides in aquifers are the dominant solid phases interacting with arsenic oxyanions. It has been observed and demonstrated by several research groups, at many scales, using state of the art techniques, that:

- Iron oxides, hydroxides, and oxyhydroxides in aquifers are efficient at adsorbing arsenic, if present in sufficient quantities;
- Reductive dissolution of iron oxides, hydroxides, and oxyhydroxides releases bound arsenic and creates dissolved iron and arsenic plumes in groundwater;
- Manganese oxides are efficient at oxidizing As(III) to As(V), even in the absence of dissolved oxygen;
- As(III) cannot be oxidized efficiently by only increasing dissolved oxygen concentration, however, there is some evidence for co-oxidation of As(III) and Fe(II) by dissolved oxygen;
- When commingled dissolved arsenic and iron plumes encounter increasing dissolved oxygen levels, iron precipitates as a metal oxide and produces continuous arsenic removal at the interface; and,
- The effect of species that compete with arsenic for bonding/adsorption to iron/manganese oxides cannot be neglected if accurate predictions are needed.

The development and use of computerized methods has been essential to developing quantitative predictive models for arsenic transport. Recently, it has been demonstrated that manganese oxides can bring about oxidation, and natural attenuation of As(III) plumes, allowing their efficient sorption to iron oxides (Amirbahman et al., 2006). The levels of manganese oxides are higher in the CEC sediments than in the geomedia used for the experiments of Amirbahman et al. This group showed that the natural attenuation of As(III) and As(V) can be modeled in a predictive fashion, in a setting not unlike CEC. These models are being successfully applied when all major processes are accounted for in the calculations, and are being used with increasing frequency at the field-site scale.

4.3 CEC Landfill Conditions

The groundwater monitoring network is physically constrained by the landfill boundary; a peninsula in a tidally influenced estuary. Currently, the monitoring network has not been extended to define the limits of contaminated groundwater. Similarly, monitoring wells have not been constructed in the dry ash landfill, or through the landfill liner. However, a reasonable conceptual model for groundwater flow has been developed from the available data.

Wells proximal to the landfill-estuary boundary exceed the GPS for arsenic. Groundwater flow in

the northern and extreme southern ends of the peninsula generally flows outward from the center towards the surface water bodies to the east, west and south. However, at the southern end of the dry ash landfill, an artificial groundwater mound has been created because of recharge from the unlined ponds situated in this area of the site (see **Figures 3** and **4**). Based on the site-specific and local hydrogeologic setting it is a reasonable expectation that precipitation and capillarity-induced mounding in the landfill cause semi-vertical groundwater flow, downward through the landfill contents into the underlying Norfolk Formation. The Norfolk Formation is underlain by the Yorktown confining unit. The combination of the lower Yorktown confining barrier, and the upper lower hydraulic conductivity alluvium, berms, and ash overlying the Norfolk sand, forces the groundwater to flow horizontally from the landfill area. Outside the confining influence of the landfill and berms, groundwater in the Norfolk Formation probably responds to semi-vertical upward gradients and discharges to the cooling water channel and the SBER. The quantity and timing of the expected discharge to the surface water system will be influenced by the tidal, flow reversal, and salt wedge effects common to estuaries and may be complex. In general, groundwater flow is down through the landfill, out under the berms, and up into the surface water system.

The sampling of groundwater at the landfill has demonstrated significant and measurable geochemical changes in groundwater quality along known flow paths. In the well clusters MW-5 and -5D; and CECW- 1, -1I, and 1D, similarities in the major iron chemistry are noted with depth in contaminated and uncontaminated areas. Analysis of a few aquifer sediment samples suggests that the Norfolk Formation has chemically participated in water quality changes along some of these same paths. For example, the soil sampling and analysis of MW-5D, CECW-8D, and PO-10D show a zone of mid-depth iron depletion as compared to shallower and deeper sediments (see **Table 2**). Patterns in the chemical concentrations of redox sensitive species suggest that there are dynamic changes in groundwater geochemistry between the well cluster closest to the landfill (CECE-3 and 3D) and edge of the landfill; comparison of Eh, sulfate, and dissolved oxygen points to active redox processes.

Surface water sampling conducted as part of a risk assessment, did not detect the increase in arsenic concentration expected from a groundwater contribution. The conceptual flow model will explain much of the observed groundwater chemical variation, but not if we consider the flow paths to be non-reactive. Groundwater at the CEC landfill falls on the redox and pH controlled phase boundary between dissolved Fe(II) and $Fe(OH)_3$. Only a very small change in pH or dissolved oxygen is needed to shift the boundary towards iron precipitation, and associated arsenic removal.

The concentrations of iron and manganese in both sediments and groundwater are very high, too high to expect no natural chemical evolution of arsenic concentrations along flow paths. Additionally, sediment-bound manganese concentrations are similar to a site where As(III) oxidation has been observed (Amirbahman et al., 2005). Iron seeps are not noted locally, suggesting that iron is removed from groundwater before discharge and mixing with surface water. Conditions are suitable for oxidation of As(III) to As(V) on manganese oxides along flow paths,

enhancing arsenic removal at pH < 7. As(V) is generally less mobile than As(III); oxidation of arsenic enhances the efficiency of arsenic attenuation. On discharge through the estuary sediments, the groundwater will be subjected to increasingly oxidizing conditions and a rich biogeochemical environment that enhances iron and manganese precipitation. It is a reasonable expectation that the arsenic contaminated groundwater undergoes attenuation before discharge to the estuary.

Based on available data and the current understanding of arsenic species transport, it is *reasonable to assume that iron oxidation and precipitation is taking place before* CEC groundwater discharges to the estuary and the arsenic is attenuated by sorption on the iron oxides. A supplemental geochemical study of site conditions from the standpoint of arsenic occurrence and mobility was conducted to evaluate natural attenuation of arsenic at CEC. The results of that study support these conclusions on natural attenuation of arsenic at the CEC landfill. The Battelle report is included as **Attachment B.** This adsorption process has been modeled and will reduce the arsenic concentrations prior to discharge to the adjacent surface water bodies.

Under this conceptual model, as the reduced ground water passes across the redox boundary (see **Figure 5**) below the adjacent estuary, the arsenic is (currently) being adsorbed onto iron oxides and removed from the groundwater to levels below the GPS (MACTEC, 2003). While the redox process is well documented in the scientific literature, the exact location (vertically and horizontally) of the redox boundary is unknown and maybe mobile, depending on actual groundwater discharge and tidal conditions. The supplemental assessment is designed to sample locations off the peninsula, validating the adsorption process.

Given the mass of iron minerals in the Norfolk Formation, coupled with the significant volume of oxygenated water in the SBER compared to the volume of impacted (reduced) water discharging from below the CEC landfill, this adsorption process will continue for the foreseeable future. In practical terms, the site data and current geochemical processes in the vicinity of the CEC landfill are actively reducing the arsenic concentrations to below the GPS. In absence of major changes to site hydrology, or geochemistry, the processes currently attenuating arsenic and iron are continuous. To document the effectiveness of the MNA remedy, Dominion will monitor the site conditions periodically as described in the CAMP until the source of the groundwater impacts has been reduced to the point where the monitoring wells around the landfill do not exceed the GPS.

Given that the proposed remedy does not require the installation of any water or vapor processing and/or treatment equipment, pumping wells, pumps, piping, tanks and associated infrastructure typically associated with more traditional corrective measures, no other permitting requirements exist for the proposed MNA remedy.

The dissolved arsenic data set for the CEC Landfill compliance wells was evaluated to calculate a time range for GPS achievement. The data were checked for distributional normality and the Mann-Kendall non-seasonal, non-parametric, method was selected for trend evaluation. Each

well's period of record (1999 -2006) was evaluated in its entirety; no adjustments were made for seasonality or yearly averages taken. The trend analysis (Tables and figures in **Attachment H**) reveals that the majority of compliance wells have negative slope regressions (arsenic concentrations trend downward) and negative Mann-Kendall S statistics (the trend is constant over time).

CECW 2 does not follow the trend. The general trend at the landfill is for lower concentrations. The minimum period to achieve the GPS calculated to be 4.1 years (PO 9), the maximum 17.4 years (PO 10), and a median value of 6.3 years to achieve the GPS, with no action, was determined.

4.4 Remedy Design & Specifications

The proposed remedy for the CEC Ash Landfill is monitored natural attenuation. To measure the effectiveness of monitored natural attenuation, the following well network will be monitored on a semi-annual basis:

- MW-5, MW-5D, PO-8, PO-8D, CECW-6I, CECW-6D, CECW-10, CECW-15, CECW-8, CECW-8D, PO-10, PO-10D, CECW-3, CECW-3D, CECW-2, CECW-2D, CECW-1, and CECW-1D

All wells will be sampled for filtered and unfiltered iron and arsenic. Water quality parameters (dissolved oxygen, oxidation-reduction potential, pH, turbidity, specific conductance and temperature) will be measured during purging. Using the sampling data described above, the geochemical groundwater model will be updated periodically to ensure that conditions are appropriate for continued monitored natural attenuation.

As discussed above, the fate and transport of arsenic in groundwater is controlled by adsorption processes at the site. Quantifying this geochemical process is important in evaluating the viability of natural attenuation. To document that this geochemical process decreases arsenic concentrations along the groundwater flow path Dominion intends to collect groundwater samples along the flow path of several existing monitoring wells. These sampling points will be used to test the practicality and possible locations for performance and sentinel monitoring wells. This data will augment the Corrective Action Monitoring Plan.

4.5 Project Schedule

Based on the groundwater data collected as part of the facility's compliance monitoring program, coupled with the most recent data presented, the only constituent of concern for the CEC landfill is arsenic. Pursuant to the solid waste regulations, the proposed remedy will begin after approval of the CAP by the DEQ and the amendment of the facility's Permit. However, as described in Section 4.3 above, the hydrologic setting, sediment/water quality data and geochemical modeling suggest that the oxidation/adsorption process is currently reducing the arsenic concentrations to below the GPS. The supplemental investigation (see Section 6.0) will validate the MNA concept.

Within six months of approval, the monitoring proposed in the CAMP will be implemented to document the long-term efficacy of the monitored natural attenuation remedy. As noted in Section 4.7.1 (page 16) and the risk assessment included (**Attachment F**), the risks to community, workers or receptors are currently minimal. The site is an active power generation facility and access to the site and landfill area is controlled by Dominion.

The only risk pathway identified in the risk assessment was to aquatic life from groundwater discharge of arsenic to surface water. The groundwater arsenic concentrations, at the point of discharge to surface water, would have to exceed 1,780 mg/L before sensitive aquatic receptors would be impacted. The highest observed groundwater arsenic concentration is an order of magnitude below the surface water risk-based screening level.

The Norfolk formation aquifer in the vicinity of the site is unsuitable for potable use due to salinity, has not been used for potable use in the recent past, and has a very low probability of being used for potable use in the reasonable future (MACTEC, 2003).

Attachment I includes a 24 March 2006 letter from Dominion demonstrating financial assurance for their various solid waste facilities in Virginia. The CEC landfill is listed under permit No. 440.

4.5.1 Long-Term Reliability of Remedy

The conceptual site model and site geochemical conditions suggest that the long-term reliability of the proposed MNA remedy is high. Data to be collected as part of the supplemental assessment activities proposed herein will confirm the effectiveness of the adsorption process. Given the lack of environmental risk to potential receptors, the fact that groundwater is not used (and has a very low probability of being used for potable use in the reasonable future) as a potable resource in the area and because access to the landfill area is restricted by Dominion, the proposed MNA remedy is considered to be protective of both human health and ecological receptors. Future use of the site and adjacent landfill area will remain heavy industrial, which is consistent with the surrounding land use.

A general description of the landfill construction and containment was provided in Section 3.2 (pages 6 and 7) and depicted on **Figure 5**. A more detailed description of the historical and current landfill construction and containment was provided in the Nature and Extent/Assessment of Corrective Measures report prepared by URS in 2003. Given the fact that the dry ash fill is underlain by a synthetic liner, the bottom and fly ash material below the current dry ash fill liner (see **Figure 5**) is likely the source of the groundwater impacts measured in the facility's well network. This material is essentially "capped" by the overlying liner for the dry ash fill, which will eliminate the possibility of infiltration from rainfall into the underlying bottom and fly ash fill. The proposed monitored natural attenuation remedy does not involve disturbing the liner or adjusting chemical or physical conditions of soil or groundwater at or near the liner. Therefore, the remedy will not interfere with the ability of the synthetic liner to prevent future releases from the dry ash mass.

As noted in Section 4.1 (page 8), a statistical evaluation of the historical groundwater data (Gibbons, 2001) reported that trends in arsenic concentrations appear to be decreasing with time. This trend would seem to suggest that the "source" strength or mass in the bottom and fly ash is starting to diminish and, given that no new source material is being added below the dry ash liner, the dissolved arsenic concentrations emanating from the fill should continue to drop over time.

In accordance with 9 VAC 20-80-310.C.6, upon completion of the remedy (i.e., groundwater concentrations are below the GPS), Dominion will notify the Director within 14 days via the submission of a certification of completion. The certification will document that the remedy was completed in compliance with the requirements of 9 VAC 20-80-310.C.5. The certification will be signed by Dominion and a qualified groundwater scientist.

The current risk to potential receptors is acceptable (MACTEC, 2003). Residual risks associated with the landfill are not expected to change as a result of the proposed remedy. Land use restrictions and engineering controls (guards and fencing) associated with the operation of the power generation facility will limit access to the landfill area, controlling potential exposures.

Arsenic attenuation is caused by the formation of relatively insoluble iron oxides that adsorb the arsenic. Because the arsenic is immobilized, rather than destroyed, the reliability of the adsorption process and the stability of the resultant solids are important to the ultimate success of the MNA. We believe that under foreseeable conditions that the iron precipitation portion of the attenuation mechanism will continue to operate long after the arsenic source is depleted. Our confidence is derived from the ubiquitous nature of these redox boundaries in sub-aqueous sediments, the relatively high iron concentrations being transported to the redox boundary, and the stability of iron oxides in oxidizing conditions.

The principles of biologically mediated iron cycling in sediments are well described in the literature (Stumm and Morgan, 1996; Charette et al., 2005, Charette and Sholkovitz, 2006). With respect to the longevity of the MNA, the critical observation is that there will always be an oxidizing boundary to upward flow somewhere below the sediment water interface. It is expected that the shallow tidal reaches of SBER will always be well aerated, and will always supply sufficient oxygen to the sediments to oxidize the abundantly available dissolved iron; maintaining the barrier to arsenic. While the redox boundary may move, it will always have an oxidized side, where any redissolved /resolubilized iron/arsenic will be reprecipitated/resorbed during upward flow. Iron oxides and resistant to dissolution over a wide Eh and pH range (Garrels and Christ, 1965). The arsenic attenuation process is expected to be continuous with the resultant solids remaining stable in the sediments.

4.6 Operations & Maintenance Plan

Due to the passive nature of the remedy, operations and maintenance will consist solely of maintaining the integrity of the monitoring network.

4.7 Replacement Remedy

4.7.1 Risk Potential

The risk assessment (MACTEC, 2003), which is included in **Attachment F**, concluded that the risks to community, workers or receptors were currently minimal. The single significant closed risk pathway was to aquatic life from groundwater discharge of arsenic to surface water. Modeling results indicate that arsenic concentrations would have to exceed 1,780 mg/L in groundwater underlying the landfill before arsenic concentrations would increase in the surrounding surface water bodies to a point that sensitive aquatic receptors would be at risk.

The Norfolk formation aquifer in the vicinity of the site is unsuitable for potable use due to salinity, has not been used for potable use in the recent past, and has a very low probability of being used for potable use in the reasonable future (MACTEC, 2003).

Given the very limited risk potential and open pathways for workers and the community, the highest observed groundwater arsenic concentration on the closed pathway an order of magnitude below the risk-significant level, and the probability of long-lived institutional controls at the site the CEC Landfill poses only de minimus risk to stakeholders.

4.7.2 Replacement Remedy

We do not believe that it is likely that a replacement remedy will be needed. Our confidence is generally supported by the principles of iron redox cycling in sediments (Cornell and Schwertmann, 2003; Appelo and Postma, 1996; Stumm and Morgan, 1996). One common observation is that as oxygenated water passes downward into sediments, oxygen is lost and iron oxides are dissolved (VanCappellen and Wang, 1996). Alternately, when anoxic iron groundwater passes upward through sediments towards oxygenated surface water, redox reversal is rapid, causing precipitation of iron oxides and associated resorption of dissolved metals on the iron oxides (Moore, 1999; Nicolas et al., 2003; Langmuir, 1997). Additionally, the site-specific investigations conducted to date (URS, 2003, MACTEC, 2003) and the similarity of the hydrogeologic setting to other sites where metal attenuation by dissolved iron precipitation occurs (Caetano and Vale, 2002; Kostka et al., 2002; Liang, 1993), bolsters the probability that the general iron-cycle observations are indeed applicable to the CEC Landfill-SBER groundwater-sediment system.

In the event that MNA performance in mitigating the dissolved arsenic plume is limited in effectiveness, a replacement remedy will be required. As previously discussed, the remedy will be required if surface water monitoring indicates that groundwater arsenic is not being attenuated below the sediment-water interface.

The replacement remedy is designed to enhance, supplement, or replace the natural oxidation of dissolved iron (with associated arsenic attenuation) with induced oxidation. The planned

supplemental investigation (see Section 6.0) will validate the MNA concept. During the course of the MNA the groundwater and surface water sampling programs may indicate the need for enhanced oxidation of the groundwater in the Norfolk Formation to bring about the desired result. Conceptually, the replacement remedy augments the iron oxidation and sorption on the down gradient side (sediment-water interface) by adding oxygen to the formation on the up gradient side (proximal to the landfill berm).

In situ oxidation of aquifers has been proven successful in similar geochemical systems (Appelo et at. 1999; Rott and Freidle, 2000). Aquifer oxidation has been used in European countries for over 50 years to remove iron and manganese. Opportunistic observation of water quality for process control revealed that these systems also treat arsenic to below European drinking water standards as they remove iron. Air sparging and other oxidation techniques, of organic chemical plumes has been observed to attenuate iron and arsenic migration at numerous sites (ITRC, 2005, and references therein). Air, pure oxygen, proprietary oxygen release compounds, and chemical oxidants of various formulations have a broad history of introduction to aquifers with successful oxidation of the inorganic, and organic, contaminants of concern. The technical feasibility of the approach is well established.

High performance injection wells would be used to introduce oxidants into the aquifer. Injection permits and Department approval of the injection strategy will be obtained prior to construction implementation. The wells would be located at the points and frequency necessary to bring about oxidation. The locations and frequency will be variable dependant on: the level of oxidation required, the groundwater flow rates and directions proximal to the well, the type and quantity of oxidant to be introduced. Tidal influences and timing will have to be considered. It is probable that the wells would be located on, or outside of the berms. Depending on the scope of the required remedy it may be necessary to conduct supplementary investigations to narrow the source areas of arsenic seepage to maximize efficiency and reduce costs of implementation. Satisfactory performance of the Replacement Remedy will be verified through the surface water sampling program.

4.7.3 Notification of Additional Corrective Measures

Should the need arise for implementation of the Replacement Remedy, Dominion will submit a report to the Director justifying the plan at least 14 days prior to implementation. At this time, Dominion elects not to include any additional remedies as part of the CAP. If natural or induced oxidation is determined to be an ineffective remedy for arsenic attenuation, we will conduct additional assessment and submit an alternative strategy, expecting to undergo full permit amendment and public notice requirements.

5.0 REMEDY SURFACE WATER ISSUES

5.1 Introduction

The CEC is located within the heavily urbanized Elizabeth River watershed. The landfill site itself is bordered by surface water on the east, west, and south. Dissolved arsenic concentrations in the surface water taken upstream, landfill-side, and downstream do not exceed established water quality criteria. Using conservative exposure assumptions, the estimated risk for the maxiumum total arsenic concentration in surface water is minimal.

Risk assessment modeling indicated that arsenic concentrations in groundwater were being attenuated along the flow path to surface water and that surface water impact could be expected if the arsenic in groundwater were not reduced prior to seepage to the estuary. To demonstrate the attenuation of arsenic a surface water sampling program has been proposed.

Under slack tide conditions flow-related disturbance of sediments and aqueous chemistry is minimized. Low tide conditions provide for the highest up flow gradient between the Norfolk Formation and the estuary sediment. Mixing of groundwater with surface water should be minimal during low slack tide. Sampling of near bottom surface water under these conditions should provide a direct measure of arsenic flux from the landfill, thus a direct measurement of the MNA processes taking place. Using this conceptual model, samples of surface water are suited to monitor the natural attenuation of arsenic at the CEC Landfill.

5.2 Sampling Locations

As described in Section 6.0, sediment coring and analysis has been proposed to identify natural attenuation zones in the estuary sediments. A bathymetric survey will be used to guide the coring investigation. Areas of lesser and greater arsenic attenuation will be identified and observations of the condition of the sediment-water interface proximal to the landfill will be made. Sediment suspension and dispersion during tidal flows will be evaluated as necessary to select a sampling elevation in the water column that will minimize the influence of sediment remobilization. These observations will be used to guide location of surface water monitoring stations. A total of four (4) surface water sample stations are proposed (SW-1, SW-2, SW-3 and SW-4). The concept is detailed in Section 6.0 and depicted schematically on **Figure 6.**

5.3 Sampling Technique

Aqueous sampling will be accomplished using weighted tubing and a peristaltic pump. Tubing will be of a type approved for the analytical parameter list. New tubing will be used for each sampling event at each sampling site. Tubing weights will be non-reactive and decontaminated between uses. At each sampling site a sampling elevation in the water column (measured from the sediment-water interface) will have been predetermined using the rational previously described. The sample will be representative of a larger area of groundwater outflow if a relatively large

sample aliquot (4 L) is collected. This large sample is then agitated and subsampled for unfiltered water quality, followed by subsampling and filtering (0.45 micron) for dissolved water quality parameters.

5.4 Analytical Parameters

The four (4) surface water samples will be analyzed for following constituents:

- Total and dissolved arsenic;
- Arsenic speciation (As(III) and As(V);
- Total and dissolved iron;
- Total suspended solids; and
- General water quality parameters (dissolved oxygen, oxidation-reduction potential, pH, temperature, turbidity and specific conductance)

5.5 Sampling Interval

Samples will be collected quarterly during the first year, then semiannually thereafter.

6.0 SUPPLEMENTAL ASSESSMENT WORK PLAN

6.1 Introduction

Site-specific data and modeling provides strong indications that natural attenuation is reducing groundwater arsenic concentrations in the Norfolk Formation. The proposed long term MNA monitoring described in the CAMP is designed to document the reliability of the remedy and to determine when the remedy is complete. However, direct evidence is needed to document that natural attenuation of arsenic by oxidation of ferrous iron and concurrent adsorption of arsenic onto the produced iron oxides, hydroxides, and oxyhydroxides. This plan presents a sampling approach to identify natural attenuation zones in support of the MNA alternative. Certain elements of this plan may be modified based upon preliminary field results, unanticipated field conditions, and/or developments of the conceptual model.

6.2 Site Specific Conditions

The natural attenuation verification sampling proposed herein builds on the conceptual model presented herein. In a groundwater focus, the MNA demonstration would be based on the spatial relationships of arsenic and iron concentrations in the Norfolk Formation (e.g. at equal hydrostratigraphic elevations at ever increasing distances from the site). Because of the unstated difficulty collecting groundwater samples in a submerged, shipping channel, environment, and/or limited understanding of flow and transport past the banks of the river, we need to consider methods other than sampling the ***groundwater*** in the Norfolk Formation away from the banks of the peninsula.

Under our current understanding and conceptual model, groundwater in the Norfolk Formation is reducing and contains high dissolved iron (and arsenic in specific locations) once it leaves the peninsula. What will change that condition is terminal electron acceptor processes (TEAPs). TEAPs are both abiotic and biologically mediated, the dominant TEAP in this case being reaction with oxygen. Flow in the Norfolk Formation is dominantly horizontal, with some component discharging vertically upward to SBER. We assume that all Norfolk Formation groundwater eventually discharges to surface water. To evaluate natural attenuation, we need to determine the distribution of the TEAPs that are going to remove the arsenic and iron. This will be accomplished by sampling and testing to determine the following:

- The location of the redox boundary between reducing (Norfolk) and oxidizing (estuary) condition in the sediment;
- The concentrations of iron and arsenic in the pore water above and below the redox boundary; and,
- The concentrations of iron and arsenic in the solid phase above, within, and below the redox boundary.

We believe that redox boundary will be located where the discharging groundwater interfaces with oxygen (prior to discharging into the adjacent surface water), in the bottom sediments of SBER and the cooling water channel. A transient interface is also created if oxygen is tidally pumped into the Norfolk; the prevalence and affect of this latter condition is unknown at this time.

6.3 Proposed Approach

Attenuation (via adsorption) in vertically upward flowing Norfolk groundwater is required for the MNA demonstration. While the mass and concentration of arsenic and iron in the Norfolk is expected to decrease if we simply sample at increasing distance from the landfill, the decrease will be due primarily to dispersion. MNA demonstrations generally require separation of attenuation from dispersion. Ideally, we would demonstrate a sub-benthic interface in the sediments with high arsenic and iron below, and low arsenic and iron above. Sampling in the Norfolk Formation moving upward from the shallow sediment and into the benthic surface water should show decreases in arsenic and iron, and an increase in Eh. A sediment core should show a deposition zone of iron 'oxides' and associated arsenic. Pore waters should show the same trend. The collection and analysis of sediment cores and groundwater samples taken at selected transects and point locations near the landfill boundary is expected to provide the basis of our demonstration.

The vertical location of the postulated interface is currently unknown. It is known that tidal conditions cause groundwater pumping, but we do not know tidal influence with respect to the location of transitions from reducing to oxidizing in the SBER bottom sediments. In addition, these redox interfaces are not uniformly distributed and are known to move, so we may select points rather than transects. Success from a groundwater perspective will be to focus on the vertical rather than the horizontal.

Given the lack of understanding of actual groundwater flow characteristics below the landfill and the associated attenuation distances away from the peninsula, we recommend that a phased, line-of-evidence approach be undertaken as described below:

6.3.1 Phase I

A bathymetric survey of the shoreline extending 0-100' normal to the shoreline will be conducted using a boat, recording depth finder (sonar) and GPS location determination. The purpose of the survey is to identify the general bottom contours to place the location of the sediment cores in a 3 dimensional context with respect to bottom conditions. The survey will identify bottom conditions deleterious to sampling, such as submerged objects/utilities, and conditions that may require more critical evaluation, such as scarps or slumps that may indicate groundwater discharge points. During this observational activity we will also identify bottom parameters that will guide location of surface water sampling activities. A Secci disk will be used to evaluate sediment remobilization during tidal flows.

General coring activities will proceed in the following manner:

- Collect shallow (0-1.5 feet below the bottom of the SBER) sediment cores using a box-corer or large-bore sediment sampler (or similar sampling device) along transects perpendicular to the berm;
- Visually observe/photograph the sediment core for a deposition zone (redox boundary) of iron 'oxides' or rusty surfaces where discharge may be occurring. Then;
- Sub-sample the sediment core at closely spaced intervals (below, within and above oxidized zone if observed or every 10-20 cm if not observed), mix with deioninzed water to form a slurry and measure the pH, Eh (ORP) and conductivity. Care will be taken to maintain sediments in an anoxic condition during sub-sampling. Review data, then;
- Sub-sample the core and submit to off-site laboratory for total iron and arsenic in solids and pore-water.

We currently conceptualize three areas for transects (**Figure 6**) that are roughly equidistant from each other. Additional spot cores will be taken in the cooling water channel, making a transect of the channel length. Core and transect locations will be guided by the bathymetry and recorded using GPS.

6.3.2 Phase II

Determine what specific intervals to submit to off-site laboratory once field screening data have been critically reviewed. Submit the selected samples and use the resultant data to document adsorption process is capable of reducing the arsenic concentration to below the GPS prior to discharging to the adjacent surface water bodies.

7.0 PUBLIC PARTICIPATION PLAN

7.1 Reports Available for Public Review

The following reports are/will be included in the local repository and available for review by the general public:

- Solid Waste Permit No. 440;
- NES/ACM Report;
- Risk Assessment;
- The approved CAP;
- Copies of each CASE report;
- Copies of any public notices; and
- Transcripts of any public meetings

7.2 Location of Public Repository

Major Hillard Public Library
824 Old George Washington Hwy. N.
Chesapeake, Virginia

7.3 Site Contact Information

For information regarding the site, or if the general public has any questions, the following person should be contacted:

Donald Hintz, P.G.
Dominion Resource Services, Inc.
Innsbrook Technical Center
500 Dominion Boulevard
Glen Allen VA 23060
(804) 273-3552

8.0 COMPLETION OF CORRECTIVE ACTION

In accordance with 9 VAC 20-80-310.C6, should the corrective action monitoring program indicate that the groundwater protection standards have not been exceeded for a period of three consecutive years, Dominion will notify the Director within 14 days by submitting a certification that the remedy has been completed in compliance with the requirements of the 9 VAC 20-80-310.C5. The certification will be signed by the owner/operator and by a qualified groundwater scientist.

9.0 REFERENCES

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Figures

SOURCE: USGS 7.5 MINUTE SERIES
TOPOGRAPHIC QUADRANGLE 1986
NORFOLK SOUTH, VIRGINIA
CONTOUR INTERVAL = 5'

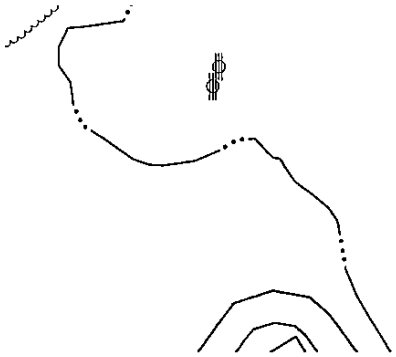
QUADRANGLE LOCATION

LAT. 036° 45' 58.96" N
LONG. 076° 18' 7.84" W
(APPROXIMATE SITE COORDINATES)

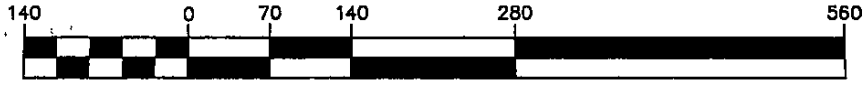
DRAFTED BY: W.A.W. (N.J.)	SITE LOCATION MAP
CHECKED BY: A.T.	DOMINION VIRGINIA POWER 1701 VEPCO STREET CHESAPEAKE, VIRGINIA
REVIEWED BY: M.B.	
NORTH	Groundwater & Environmental Services, Inc. 23 SOUTH 13TH STREET, SUITE 201, RICHMOND, VA 23219

SCALE IN FEET	DATE	FIGURE
0 — 2000	3-28-06	1

42049



GRAPHIC SCALE



(IN FEET)
1 inch = 140 ft.

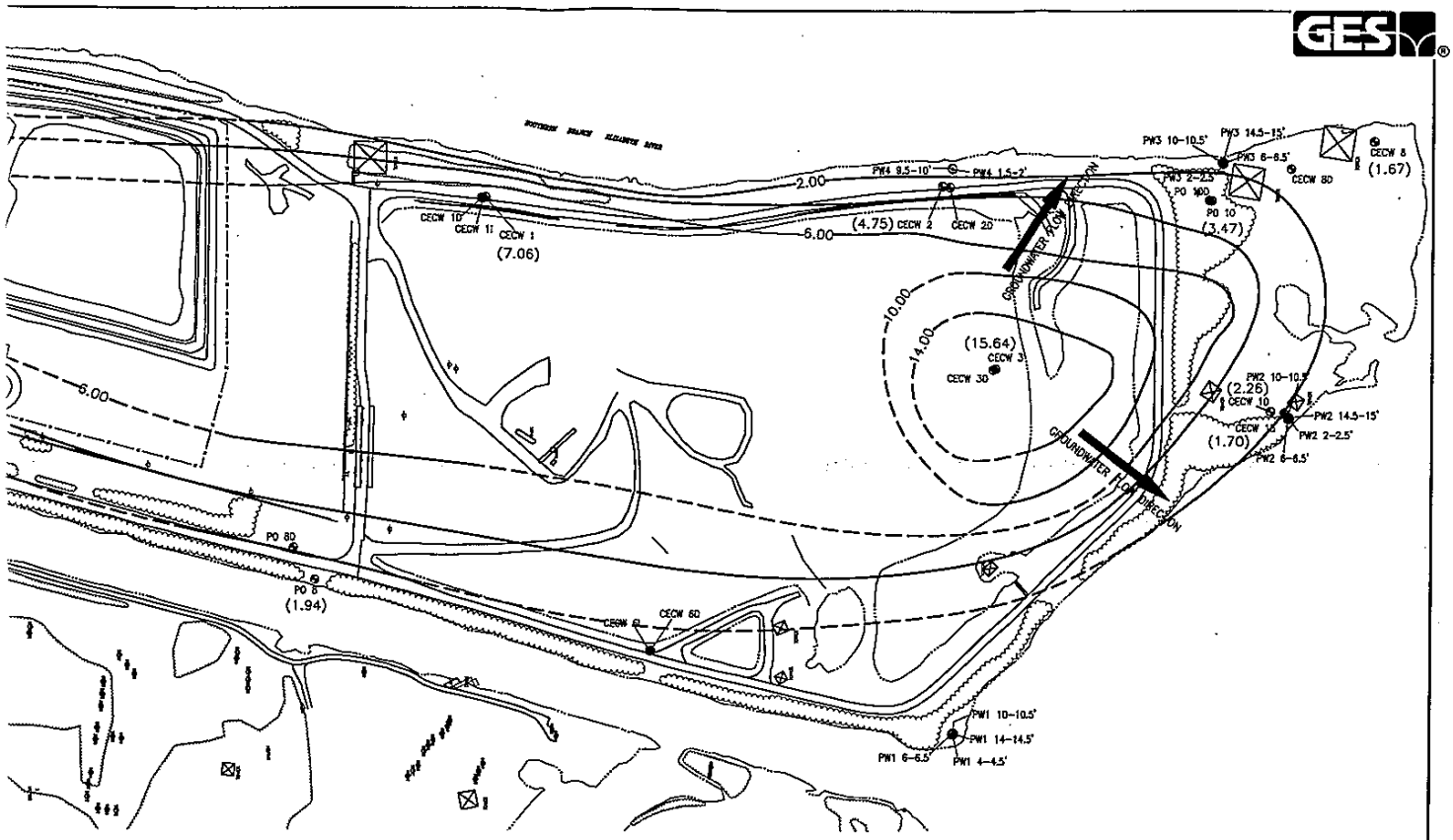
NOTE:

THIS MAP BASED ON THE SURVEY PREPARED BY PRECISION MEASUREMENTS, INC., DATED 9 JANUARY 2006.

DRAFTED BY: W.A.W. (N.J.)	SITE MAP
CHECKED BY:	DOMINION VIRGINIA POWER 1701 VEPCO STREET CHESAPEAKE, VIRGINIA
REVIEWED BY:	
NORTH	Groundwater & Environmental Services, Inc. 23 SOUTH 13TH STREET, SUITE 201, RICHMOND, VA 23219

	DATE	FIGURE
	5-10-07	2

42050



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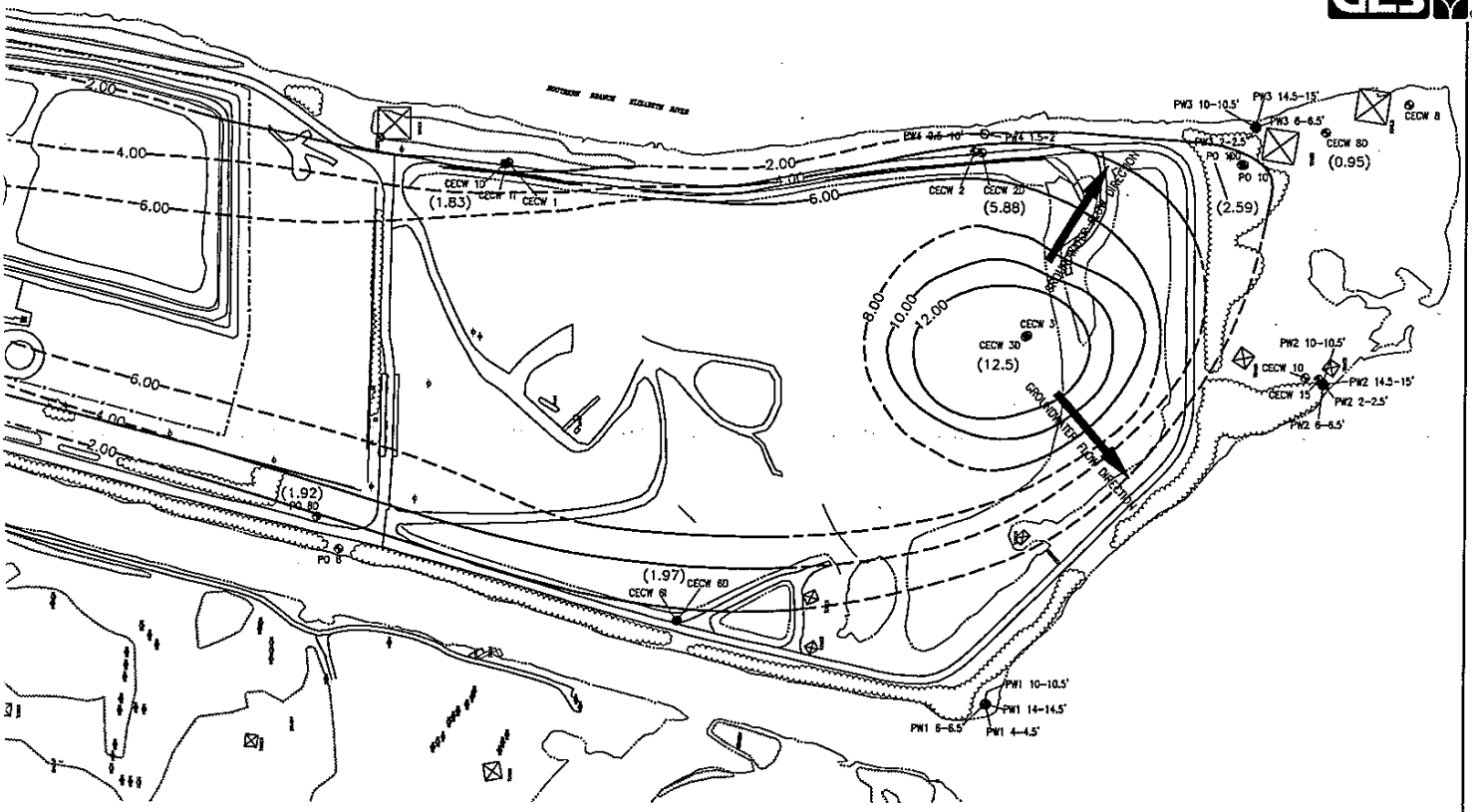
NOTE:

THIS MAP BASED ON THE SURVEY PREPARED BY PRECISION MEASUREMENTS, INC., DATED 9 JANUARY 2006.

DRAFTED BY: W.A.W. (N.J.)	GROUNDWATER CONTOUR MAP (SHALLOW WELLS) DECEMBER 6, 2005		
CHECKED BY: J.T.T.	DOMINION VIRGINIA POWER 1701 VEPCO STREET CHESAPEAKE, VIRGINIA		
REVIEWED BY: R.F.S.	Groundwater & Environmental Services, Inc. 23 SOUTH 13TH STREET, SUITE 201, RICHMOND, VA 23219		
NORTH	SCALE IN FEET 0 250	DATE 3-29-06	FIGURE 3

42051



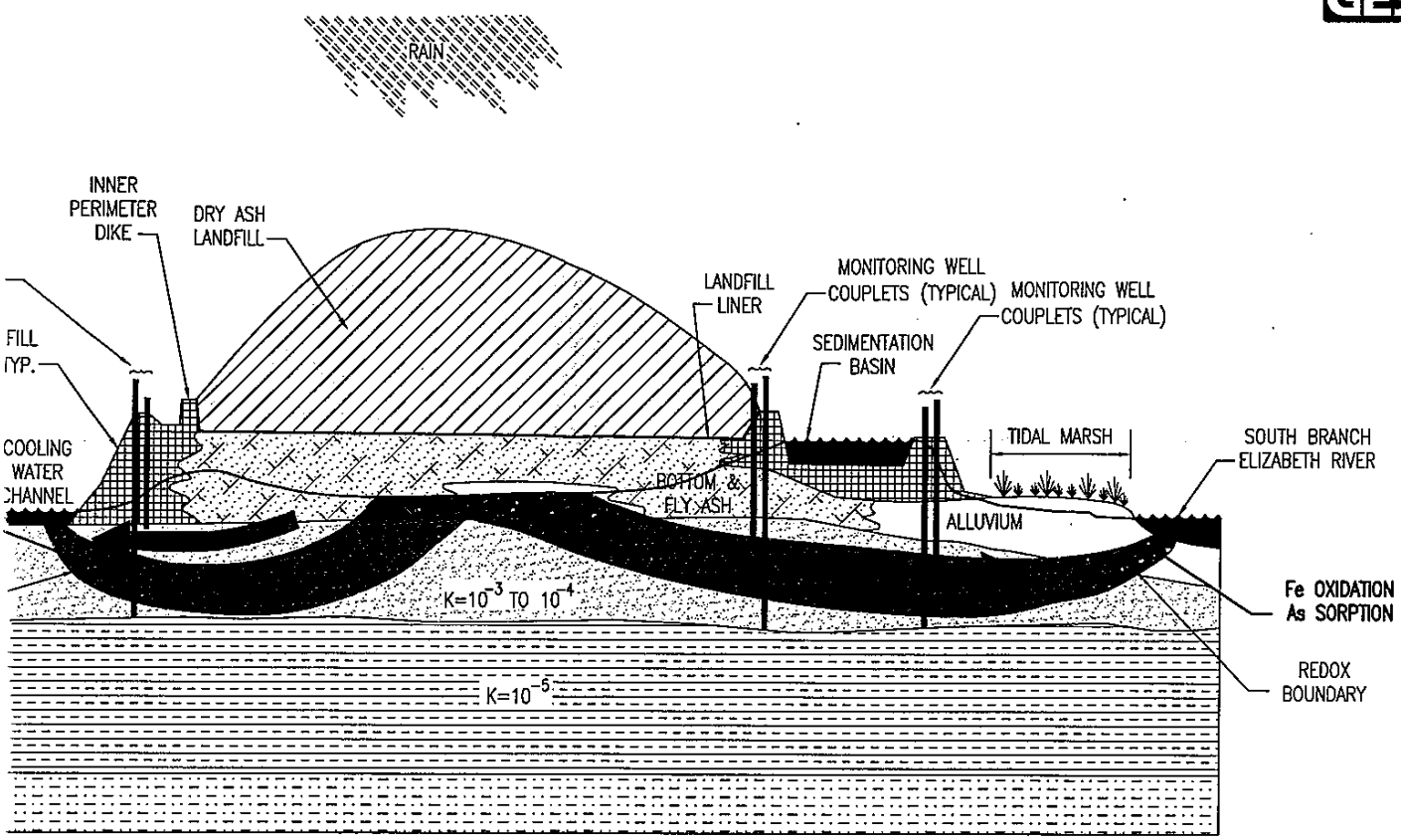
(feet)
N (feet)
R (feet)
ED

NOTE:

THIS MAP BASED ON THE SURVEY PREPARED BY PRECISION MEASUREMENTS, INC., DATED 9 JANUARY 2006.

DRAFTED BY: W.A.W. (N.J.)	GROUNDWATER CONTOUR MAP (DEEP WELLS) DECEMBER 6, 2005		
CHECKED BY: J.T.T.	DOMINION VIRGINIA POWER 1701 VEPCO STREET CHESAPEAKE, VIRGINIA		
REVIEWED BY: R.F.S.	Groundwater & Environmental Services, Inc. 23 SOUTH 13TH STREET, SUITE 201, RICHMOND, VA 23219		
NORTH	SCALE IN FEET 0 250	DATE 3-29-06	FIGURE 4

42052

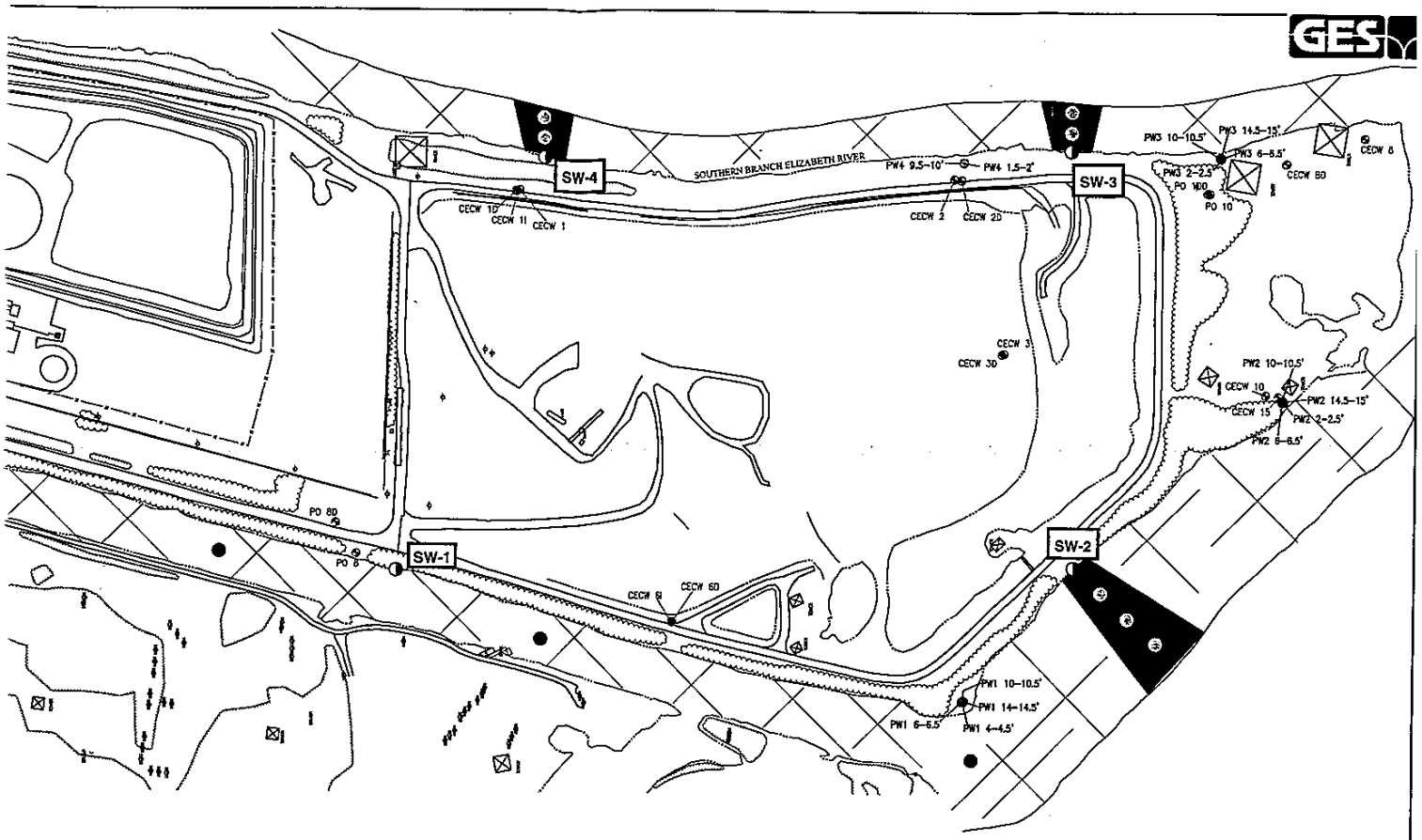


RONMENT

PTION

DRAFTED BY: W.A.W. (N.J.)	CONCEPTUAL ARSENIC SORPTION MODEL FIGURE		
CHECKED BY: A.T.	DOMINION VIRGINIA POWER 1701 VEPCO STREET CHESAPEAKE, VIRGINIA		
REVIEWED BY: M.B.	Groundwater & Environmental Services, Inc. 23 SOUTH 13TH STREET, SUITE 201, RICHMOND, VA 23219		
	NOT TO SCALEE	DATE 3-28-06	FIGURE 5

42053



L
ATION (FEET)
TATION (4)
)
G "POINT"
T" AREA (3)
A (1)

NOTE:

THIS MAP BASED ON THE SURVEY PREPARED BY PRECISION MEASUREMENTS, INC., DATED 9 JANUARY 2006.

DRAFTED BY: W.A.W. (N.J.)	Supplemental Assessment Sample Locations
CHECKED BY: J.T.T.	DOMINION VIRGINIA POWER 1701 VEPCO STREET CHESAPEAKE, VIRGINIA
REVIEWED BY: R.F.S.	Groundwater & Environmental Services, Inc. 23 SOUTH 13TH STREET, SUITE 201, RICHMOND, VA 23219
NORTH	SCALE IN FEET 0 250 / DATE 3-28-06 / FIGURE 6

42054

Tables

Table 1
Well Contruction Information
Dominion Energy Center
Chesapeake, Virginia

Well ID	Date Installed	Northings	Eastings	Well Diameter - inches	TOC Elevation - msl	GW Level - bTOC (12/05)	Water Elevation - msl (12/05)	TOS - bTOC	TOS Elevation - msl	Depth to Bottom - bTOC	Elevation of Bottom - msl
CECW-1	Aug-98	3445582.29	12127066.67	2	21.58	14.52	7.06	17.2	4.38	27.20	-5.62
CECW-1D	May-00	3445589.12	12127064.65	2	21.85	20.02	1.83	46.65	-24.8	51.65	-29.8
CECW-1I	May-00	3445587.14	12127064.48	2	21.77	18.6	3.17	35.35	-13.58	40.35	-18.58
CECW-2	Aug-98	3444571.56	12127094.71	2	22.02	17.27	4.75	10	12.02	25.00	-2.98
CECW-2D	Nov-05	3444555.48	12127092.99	2	21.79	15.91	5.88	40.8	-19.01	45.80	-24.01
CECW-3	Aug-98	3444453.15	12126692.13	2	27.49	11.85	15.64	10.4	17.09	25.40	2.09
CECW-3D	Nov-05	3444457.93	12126690.03	2	27.42	14.92	12.50	40.9	-13.48	45.90	-18.48
CECW-6D	May-00	3445210.40	12126068.26	2	22.14	20.17	1.97	39.4	-17.26	44.40	-22.26
CECW-6I	May-00	3445212.62	12126067.90	2	22.12	19.67	2.45	29.15	-7.03	34.15	-12.03
CECW-8	May-00	3443621.09	12127195.28	2	3.87	2.80	1.07	2.57	1.3	7.57	-3.7
CECW-8D	Nov-05	3443803.24	12127135.06	2	4.58	3.63	0.95	27.35	-22.77	32.35	-27.77
CECW-10	May-00	3443845.86	12126599.81	2	6.53	4.27	2.26	2.75	3.78	12.75	-6.22
CECW-15	Aug-00	3443816.65	12126597.02	2	6.45	4.75	1.70	22.25	-15.8	32.25	-25.8
MW-5	Dec-92	3447218.33	12126784.44	4	12.84	9.31	3.53	6.88	5.96	16.88	-4.04
MW-5D	Nov-05	3447221.85	12126786.63	2	12.41	8.90	3.51	27	-14.59	32.00	-19.59
PO-8	Dec-83	3445951.48	12126223.08	2	13.26	11.32	1.94	13.7	-0.44	18.7	-5.44
PO-8D	Nov-05	3445999.26	12126293.92	2	23.23	21.31	1.92	42.9	-19.67	47.90	-24.67
PO-10	Dec-83	3443979.52	12127064.10	2	5.94	2.47	3.47	7.35	-1.41	12.35	-6.41
PO-10D	Nov-05	3443985.02	12127065.05	2	6.04	3.45	2.59	23.85	-17.81	28.85	-22.81
PW1 (10-10.5)*	Nov-05	3444541.10	12125888.76	0.25	1.8	"	"	10	-8.2	10.5	-8.7
PW1 (14.5-15)*	Nov-05	3444539.36	12125887.17	0.25	1.8	"	"	14.5	-12.7	15	-13.2
PW1 (4-4.5)*	Nov-05	3444541.46	12125885.12	0.25	1.7	"	"	4	-2.3	4.5	-2.8
PW1 (6-6.5)*	Nov-05	3444543.59	12125886.29	0.25	1.8	"	"	6	-4.2	6.5	-4.7
PW2 (10-10.5)*	Nov-05	3443808.66	12126586.55	0.25	3.9	"	"	10	-6.1	10.5	-6.6
PW2 (14.5-15)*	Nov-05	3443805.46	12126586.92	0.25	3.5	"	"	14.5	-11	15	-11.5
PW2 (2-2.5)*	Nov-05	3443804.32	12126583.70	0.25	3.5	"	"	2	1.5	2.5	1
PW2 (6-6.5)*	Nov-05	3443807.46	12126583.28	0.25	3.5	"	"	6	-2.5	6.5	-3
PW3 (10-10.5)*	Nov-05	3443956.22	12127147.81	0.25	2.3	"	"	10	-7.7	10.5	-8.2
PW3 (14.5-15)*	Nov-05	3443953.32	12127149.19	0.25	2.2	"	"	14.5	-12.3	15	-12.8
PW3 (2-2.5)*	Nov-05	3443953.57	12127145.00	0.25	2.6	"	"	2	0.6	2.5	0.1
PW3 (6-6.5)*	Nov-05	3443952.17	12127147.32	0.25	2.2	"	"	6	-3.8	6.5	-4.3
PW4 (1.5-2)*	Nov-05	3444549.47	12127133.17	0.25	3.7	"	"	1.5	2.2	2	1.7
PW4 (9.5-10)*	Nov-05	3444550.11	12127134.50	0.25	3.4	"	"	9.5	-6.1	10	-6.6

Notes:
All measurements are in Feet (ft) unless noted otherwise
TOC = TOP OF CASING
TOS = TOP OF SCREEN
BOS = BOTTOM OF SCREEN
bTOC = Below Top of Casing
msl = mean sea level
* = depths measured from ground surface (bgs)
~ = No Data

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Table 2
Soil Analytical Data Summary Table
CEC Ash Landfill
Chesapeake, Virginia

W-5D	MW-5D	MW-5D	MW-5D	CECW-8D	CECW-8D	CECW-8D	PO-8D	PO-8D	PO-8D	PO-8D	PO-10D	PO-10D	PO-10D	PO-10D
'-5')	(9'-10')	(23'-24')	(29'-30')	(4'-5')	(16'-17')	(25'-26')	(9'-10')	(21'-22')	(30'-31')	(39'-40')	(3'-4')	(7'-8')	(16'-17')	(23'-24')
.468	0.206	0.299	0.294	0.152	0.121	0.207	0.341	0.255	0.113	0.201	0.299	0.268	0.113	0.156
000*	16100	13700	46300	4920	12100	35800	28300	17400	12400	37600	34000	14500	19600	16200
.53	3.75	4.44	3.44	0.409	1.12	1.10	14.5	2.77	1.91	1.87	1.08	1.45	0.566	7.89
81*	76.6	267	356	86.3	117	236	283	131	82.3	424	220	97.1	502	194
553	0.325	0.431	1.01	0.036	0.198	0.253	4.57	0.380	0.175	0.388	0.244	0.047	0.074	0.310
095	0.033	0.034	0.552	(<0.012)	0.020	0.026	0.255	0.024	0.043	0.038	0.021	(<0.012)	0.013	0.056
.09	1.56	1.63	12.5	0.305	0.814	1.63	12.5	1.49	1.02	0.958	1.59	0.802	0.260	0.975
2.8	24.4	21.7	44.0	3.2	11.2	18.7	51.3	17.3	11.6	27.3	18.8	9.1	3.4	23.8
0.4	5.60	6.47	13.45	1.80	2.73	5.31	86.4	5.30	3.25	4.50	5.27	3.69	1.55	3.69
100	9020	6890	16200	1880	2830	7860	21100	5950	3700	6650	7840	4740	2160	13100
.0*	70.5	119	72.9	43.0	21.5	64.6	113	132	32.0	79.8	135	136	54.0	53.2
3.6	5.89	5.68	24.6	0.960	2.29	3.61	55.6	5.10	3.60	3.37	4.86	2.32	0.799	2.98
1.0	8.72	7.46	14.9	3.00	7.30	7.79	24.4	9.00	5.96	8.76	8.36	5.31	2.64	6.24
29	0.19	0.34	0.23	(<0.16)	0.32	(<0.16)	1.53	0.20	(<0.16)	0.20	(<0.16)	(<0.16)	(<0.16)	0.19
512	0.275	0.221	0.553	0.185	0.204	0.308	10.9	0.206	0.184	0.197	0.248	0.203	0.160	0.272
000	321000	356000	294000	320000	301000	350000	264000	343000	290000	285000	352000	333000	291000	277000
25	0.89	0.60	1.24	1.08	0.51	0.88	2.37	0.75	0.45	0.77	0.85	1.03	0.39	0.69
17	0.171	0.104	0.045	0.055	0.161	0.220	0.708	0.191	0.120	0.255	0.188	0.093	0.072	0.213
77	32.7	28.9	50.6	7.27	18.7	27.5	164	27.9	28.2	27.6	27.6	16.1	8.34	27.7
7.7	13.4	16.0	62.2	5.84	7.43	18.1	63.3	14.2	7.94	16.1	17.4	11.5	3.48	13.5
3.2	4.1	1.6	33.4	0.42	4.16	4.0	309.7	7.0	8.20	2.3	15.9	4.6	1.57	4.9
2.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)
2.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)
2.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)	(<22.1)
57	(<0.06)	(<0.06)	1.85	(<0.06)	(<0.06)	(<0.06)	4.66	0.23	(<0.06)	(<0.06)	0.21	0.14	(<0.06)	0.06
3	0.22	0.25	0.14	0.28	0.27	0.23	0.17	0.23	0.13	0.17	0.22	(<0.10)	0.21	0.21

rwise specified
e narrative.
e reporting limit of 22.1

Dominion Chesapeake VA

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Table 3
Water Quality Parameter Summary Table
CEC Ash Landfill
Chesapeake, Virginia

Well ID	Date	Well Depth	pH	Conductivity	Turbidity	Dissolved Oxygen	Temperature	Oxidation Reduction Potential	Eh
		Feet btoc	Standard Units	mS/cm	NTU	mg/L	deg C	mV	mV
CECW-1	12/1/05	27.20	6.50	8.63	3.0	0.49	19.80	-32.0	168
	12/2/05 *	27.20	6.51	8.56	1.18	0.49	19.71	-29.5	170.5
CECW-1D	12/1/05	51.65	6.55	12.57	1.8	0.23	14.58	14.8	214.8
	12/2/05 *	51.65	6.56	12.58	3.19	0.25	15.96	15.2	215.2
	2/14/06	52.00	6.39	11.29	1.6	0.34	18.52	11.0	211
CECW-11	12/1/05	40.35	6.75	10.60	5.6	0.33	18.75	-115.3	84.7
	12/2/05 *	40.35	6.76	10.58	2.87	0.35	19.21	-98.7	101.3
	2/14/06	40.55	6.58	11.31	0.0	0.21	18.47	-51.0	149
CECW-2	11/30/05	25.00	6.57	20.00	0.0	0.36	19.88	-194.0	6
	12/07/05 *	35.00	6.73	17.64	0.0	0.93	19.52	-125.2	74.8
CECW-2D	11/30/05	45.80	6.46	21.12	0.0	0.38	19.81	-66.2	133.8
	12/07/05 *	45.80	6.38	20.37	0.0	0.32	18.25	-124.3	75.7
CECW-3	12/2/05	23.40	6.67	15.40	4.37	3.52	22.72	47.5	247.5
	12/2/05	45.90	7.43	24.89	0.0	0.39	19.86	-154.2	45.8
CECW-6D	12/5/05	44.40	5.87	15.91	0.0	0.48	18.39	73.9	273.9
CECW-6I	12/5/05	34.15	6.56	10.66	2.89	0.17	18.26	-117.6	82.4
	2/14/06	34.14	6.68	9.099	1.2	0.33	18.85	-104.1	95.9
CECW-8	12/6/05 **	7.57							
CECW-8D	12/6/05	32.35	6.24	24.45	0.0	0.78	19.17	-17.7	182.3
CECW-10	12/1/05	12.75	6.33	20.21	1.79	0.12	17.33	-134.6	65.4
	12/7/05 *	12.75	6.39	17.30	0.0	0.38	16.90	-34.2	165.8
CECW-15	12/1/05	32.25	4.89	28.31	0.85	0.18	17.60	109.7	309.7
	12/7/05 *	32.25	4.60	23.40	2.9	0.37	17.54	178.7	378.7
MW-5	12/2/05	16.88	5.57	0.480	1.8	0.52	20.34	42.8	242.8
	12/7/05 *	16.88	5.76	0.471	3.2	1.31	20.82	79.4	279.4
	2/14/06	16.88	5.76	0.962	4.2	0.99	17.73	111.0	311
MW-5D	12/2/05	32.00	6.43	4.09	4.7	0.40	20.28	-43.2	156.8
	12/7/05 *	32.00	6.54	4.07	0.0	0.70	20.52	-28.5	171.5
PO-8	12/6/05 ***	18.7							
PO-8D	12/6/05	47.90	6.08	6.78	4.2	0.38	20.60	5.5	205.5
PO-10	12/1/05	12.35	6.97	20.77	1.67	0.24	18.12	-49.9	150.1
	12/7/05*	12.35	7.17	20.98	1.6	0.36	17.35	-69.4	130.6
	2/14/06	12.75	6.90	17.45	0.8	0.27	13.75	-43.5	156.5
PO-10D	12/1/05	28.85	6.70	23.30	3.01	0.24	19.39	-83.9	116.1
	12/7/05 *	28.85	6.52	22.77	4.81	0.49	19.69	-81.7	118.3

Notes
* Anoxic speciation, and / or filtered and un-filtered metals were collected during this event
**CECW-8 could not be sampled because this wells slow recharge rate did not allow sampling to occur before the tide made sampling impossible.
***PO-8 could not be sampled because the flow was to low to collect a sample in enough time to complete the sampling event
Eh is calculated by adding 200 mV to the ORP value
ORP is calibrated with a redox solution made by Hanna instruments (HI7021) with a value of 240 mV. The YSI meter used to measure ORP has a range of -999 mV to 999 mV.

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December 2005 Sampling Results
Dominion Chesapeake Energy Center
1701 Vepco St.
Chesapeake VA 23323

PO-10 D	CECW-1 I	CECW-1 D	CECW-1	CECW-3 D	CECW-3	MW-5	MW-5 D	CECW-6 I	CECW-6 D	PO-8 D	CECW-8 D	Field Duplicate (CECW-8D)	CECW-2 D*	CECW-2*	CECW-10*	CECW-15*	Equip Blank	Field Blank
28.85	40.35	51.65	27.20	45.90	25.40	16.88	32.00	34.15	44.40	47.90	32.35	32.35	45.80	25.00	12.75	32.25		
6.70	6.76	6.56	6.51	7.43	6.67	5.57	6.43	6.56	5.87	6.08	6.24	6.24	6.38	6.73	6.39	4.60		
23.30	10.59	12.58	8.56	24.89	15.40	0.480	4.09	10.66	15.91	6.78	24.45	24.45	20.37	17.64	17.30	23.40		
3.01	2.87	3.19	1.18	0.0	4.37	1.8	4.7	2.89	0.0	4.2	0.0	0.0	0.0	0.0	0.0	2.9		
0.24	0.35	0.25	0.49	0.39	3.52	0.52	0.40	0.17	0.48	0.38	0.78	0.78	0.32	0.93	0.38	0.37		
19.39	19.21	15.96	19.71	19.86	22.72	20.34	20.28	18.25	18.39	20.60	19.17	19.17	18.25	19.52	16.90	17.54		
-83.9	-96.7	15.2	-29.5	-154.2	47.5	42.8	-43.2	-117.6	73.9	5.5	-17.7	-17.7	-124.3	-125.2	-34.2	178.7		
(<0.068)	(<0.068)	0.090	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	0.097	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)
(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	(<0.068)	NR	NR
380	841	1060	674	98	2170	314	190	332	1440	460	487	512	163	299	551	4650	60	57
108	81	82	130	109	103	171	104	108	933	197	83	83	93	124	311	4260	NR	NR
71.6	154	24.5	81.3	78.8	9.05	5.55	2.41	370	43.9	4.81	7.06	6.10	60.8	56.7	37.7	0.720	(<0.046)	(<0.046)
54.7	143	23.3	90.8	78.5	8.09	5.30	2.24	396	43.8	4.00	6.43	6.28	44.1	55.2	37.5	0.673	NR	NR
75.4	68.4	58.0	578	108	234	20.4	48.1	178	64.9	51.4	109	107	83.5	150	103	57.8	(<0.061)	(<0.061)
79.2	64.3	55.1	533	107	230	20.3	46.4	179	63.8	48.8	107	106	78.9	151	106	55.9	NR	NR
0.022	(<0.021)	0.071	0.068	0.023	0.105	0.065	0.067	0.130	0.398	0.415	(<0.021)	0.022	0.021	0.060	0.021	0.481	0.009	0.000
0.047	0.064	(<0.021)	0.049	0.023	(<0.021)	0.057	0.078	0.040	0.554	0.205	(<0.021)	(<0.021)	0.056	(<0.021)	(<0.021)	0.348	NR	NR
0.292	5.05	3.19	0.073	0.109	1.03	0.066	0.152	4.46	2.69	0.168	(<0.032)	(<0.032)	(<0.032)	(<0.032)	(<0.032)	0.690	(<0.032)	(<0.032)
0.184	4.98	3.06	0.058	0.145	0.856	0.069	0.217	4.59	2.89	0.268	(<0.032)	(<0.032)	(<0.032)	(<0.032)	0.035	0.720	NR	NR
2.73	0.771	3.56	0.859	1.91	6.76	1.51	44.7	3.85	8.00	11.7	1.22	1.29	2.13	0.808	0.944	3.17	(<0.017)	(<0.017)
9.91	0.695	2.95	0.731	1.54	6.60	1.52	49.3	2.94	7.91	12.7	1.24	1.16	2.42	0.839	0.929	3.47	NR	NR
8.09	8.05	8.67	14.2	7.57	9.73	10.4	4.75	5.78	7.30	5.53	9.12	8.58	8.01	7.75	6.98	8.56	3.69	3.83
8.14	5.76	5.68	6.07	7.80	6.78	10.4	4.56	5.38	6.02	4.80	7.33	6.82	7.33	8.26	6.82	8.83	NR	NR
4.90	7.54	7.60	16.6	1.30	9.61	2.56	2.54	1.71	21.0	0.94	2.71	7.26	1.01	0.76	1.09	13.6	0.91	0.65
1.33	2.45	7.12	1.99	4.48	19.8	2.15	0.63	0.74	18.5	0.66	0.94	0.83	0.61	0.72	0.71	15.1	NR	NR
4610	6700	6770	10800	4350	2000	2250	33300	19400	13800	14300	33400	32500	17900	2370	5950	31000	8	17
5410	6000	6260	11100	4510	1320	2220	35200	20500	14300	13600	30100	30400	18500	2270	5410	29900	NR	NR
138	178	460	516	171	101	80.5	934	665	261	300	307	311	194	499	132	382	0.38	0.44
177	174	456	502	174	101	82.8	997	717	262	285	297	297	179	537	133	384	NR	NR
3.40	3.83	7.17	7.39	3.35	7.54	24.0	64.4	9.33	11.5	15.4	4.58	4.86	6.32	4.32	2.47	7.95	0.16	0.20
5.10	3.31	6.23	3.22	3.29	7.25	24.2	72.0	8.16	11.1	15.8	4.36	4.27	6.81	4.15	2.46	7.99	NR	NR
0.302	0.232	0.980	0.462	(<0.015)	0.562	0.160	0.320	0.074	2.13	0.404	0.424	0.293	(<0.015)	0.080	0.104	13.7	0.030	(<0.015)
0.016	(<0.015)	0.427	0.037	0.060	(<0.015)	0.110	0.112	(<0.015)	2.23	0.288	0.025	0.035	(<0.015)	(<0.015)	0.019	13.7	NR	NR
0.074	(<0.050)	(<0.050)	0.277	(<0.050)	1.22	0.167	0.086	0.078	(<0.050)	(<0.050)	(<0.050)	(<0.050)	(<0.050)	(<0.050)	(<0.050)	(<0.050)	(<0.050)	(<0.050)
(<0.050)	(<0.050)	0.056	0.200	(<0.050)	1.27	0.156	0.095	(<0.050)	(<0.050)	(<0.050)	(<0.050)	(<0.050)	(<0.050)	(<0.050)	(<0.050)	(<0.050)	NR	NR
0.269	(<0.061)	0.296	0.144	0.147	47.9	1.05	5.51	0.260	2.79	9.29	0.295	0.341	0.225	0.132	0.287	4.38	0.133	(<0.061)
0.437	(<0.061)	0.277	0.231	0.137	47.8	0.931	6.24	0.127	2.52	7.77	0.258	0.320	0.084	0.196	0.265	4.35	NR	NR
385000	382000	593000	330000	404000	358000	43600	196000	481000	342000	151000	399000	428000	396000	408000	255000	361000	19200	(<21000)
342000	363000	650000	364000	370000	336000	50800	197000	491000	319000	181000	358000	354000	378000	391000	281000	368000	NR	NR
(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)
(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	(<0.23)	NR	NR
0.020	(<0.013)	0.053	(<0.013)	(<0.013)	2.59	0.060	0.050	(<0.013)	0.149	0.049	(<0.013)	(<0.013)	(<0.013)	(<0.013)	(<0.013)	0.184	0.013	(<0.013)
0.015	(<0.013)	0.047	(<0.013)	(<0.013)	2.72	0.057	0.068	(<0.013)	0.164	0.059	(<0.013)	(<0.013)	(<0.013)	(<0.013)	(<0.013)	0.176	NR	NR
71.3	47.7	48.3	39.6	65.3	56.8	837	28.8	49.3	52.9	37.8	66.6	65.4	63.6	55.6	55.3	87.5	25.5	25.5
71.6	44.2	44.2	39.4	68.2	55.6	808	27.1	47.6	51.0	38.7	65.3	61.0	64.1	59.1	55.4	85.8	NR	NR
2.53	8.35	8.52	31.8	0.85	8.27	11.0	84.8	3.23	50.1	180	22.4	17.9	3.22	1.29	81.9	74.4	(<0.28)	(<0.28)
4.51	6.68	7.46	19.0	1.37	14.0	10.3	110	1.81	49.3	198	12.9	13.4	4.32	(<0.28)	85.7	71.4	NR	NR
28000	9200	19900	6600	25400	16800	(<1000)	2900	13900	20500	5000	31200	31000	26500	19300	19800	31900	(<100)	(<100)
28600	10500	19900	6800	25900	17100	(<1000)	3100	13600	20600	6600	31400	31100	25300	20900	22300	31700	NR	NR
(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<100)	(<100)
(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	NR	NR
(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	100	100
(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	(<1000)	NR	NR
0.99	0.41	3.31	0.35	0.76	4.79	4.7	2.47	0.35	1.11	1.64	1.99	2.24	1.17	0.86	1.08	1.36	0.23	0.26
0.61	(<0.16)	2.72	(<0.16)	0.58	2.83	3.76	1.46	0.28	0.67	1.3	1.92	1.75	1.07	0.85	0.59	0.96	NR	NR
(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)
(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)
8,830	3,110	4,000	2,520	8,890	5,340	44.9	939	3,450	5,070	2,150	10,200	10,100	6,980	8,800	7,490	10,700	1.43	1.45
0.177	0.180	0.172	0.281	0.165	0.498	0.236	0.184	0.173	0.166	0.169	0.161	(<0.100)	0.171	0.170	0.166	0.171	0.188	0.240
<0.100)	(<0.100)	(<0.100)	(<0.100)	(<0.100)	(<0.100)	(<0.100)	(<0.100)	(<0.100)	(<0.100)	(<0.100)	(<0.100)	(<0.100)	(<0.100)	(<0.100)	(<0.100)	(<0.100)	(<0.100)	(<0.100)
1,110	1,050	2,460	417	1,130	1,030	102	358	1,440	1,050	481	1,390	1,370	792	1,110	941	1,500	1.08	1.09
220	170	270	350	220	120	60.0	370	415	85.0	275	80.0	85.0	330	120	80.0	10.0	(<5.00)	(<5.00)
(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)
(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)	(<5.00)
220	170	270	350	220	120	60.0	370	415	85.0	275	80.0	85.0	330	120	80.0	10.0	(<5.00)	(<5.00)
210	241	503	282	258	244	17.8	127	317	237	80.4	245	241	242	282	195	281	(<5.00)	0.539
607	204	375	145	607	410	29.3	87.2	297	442	68.9	621	604	509	392	505	740	(<0.200)	1.46
164	103	240	74.2	190	159	5.27	35.7	149	139	26.8	171	164	143	120	154	177	(<0.200)	0.828
3,420	1,570	2,210	1,330	4,290	3,310	44.3	613	1,890	3,730	1,200	5,270	5,200	3,990	3,270	3,270	4,660	0.499	12.9
205	255	504	293	237	240	17.9	139	371	216	103	244	268	303	258	171	245	(<5.00)	(<5.00)
579	221	368	146	544	404	26.8	94.1	336	400	84.2	586	658	435	540	442	645	(<0.200)	(<0.200)
166	112	242	78.4	174	162	4.72	38.8	175	131	32.7	163	183	131	154	136	154	0.321	0.332
4,760	1,720	2,160	1,370	4,860	3,280	33.0	658	2,120	3,420	1,380	5,050	5,660	3,530	4,340	3,870	5,480	0.429	0.680
0.550	2.51	1.05	3.63	0.389	0.117	0.304	0.552	0.371	1.12	0.453	1.12	1.14	2.30	2.63	0.288	1.66	(<0.0250)	(<0.0250)
<1.00)	(<1.00)	1.31	(<1.00)	(<1.00)	(<1.00)	1.95	(<1.00)	(<1.00)	(<1.00)	(<1.00)	(<1.00)	(<1.00)	(<1.00)	(<1.00)	(<1.00)	(<1.00)	(<1.00)	(<1.00)
2.20	1.01	3.03	4.18	1.24	1.60	10.5	2.84	2.22	1.06	3.28	1.57	1.52	1.68	2.70	2.21	0.790	(<0.500)	1.21
2.30	1.60	3.11	5.54	1.34	1.66	11.2	3.21	2.48	1.46	4.58	2.00	2.05	4.12	2.09	2.71	0.982	(<0.500)	(<0.500)

·d dilution.
:se wells were sampled for other analytes separately. See Table of Parameters.

PERMIT ATTACHMENT XIV - 2

CORRECTIVE ACTION GROUNDWATER MONITORING PLAN

Groundwater
& Environmental Services, Inc.

Corrective Action Monitoring Plan

Dominion Generation

Chesapeake Energy Center Ash Landfill
Solid Waste Permit No. 440
Tidewater Regional Office
Chesapeake, VA

Prepared for:

Dominion Generation
Innsbrook Technical Center
5000 Dominion Boulevard
Glen Allen, VA 23060

Prepared by:

Groundwater & Environmental Services, Inc.
23 South 13th Street, Suite 201
Richmond VA 23219

February 2008

42061

Corrective Action Monitoring Program
Dominion Generation
Chesapeake Energy Center
Chesapeake, Virginia
Solid Waste Permit No. 440

February 2008

Property Information	
Land Use:	Industrial
Responsible Party:	Dominion Generation Innsbrook Technical Center 500 Dominion Boulevard Glen Allen VA 23060
Contact:	Mr. Don Hintz (804)-273-3552

Groundwater & Environmental Services, Inc.

Montgomery S. Bennett, P.G.
Senior Project Manager

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APPENDICES

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B. Sample Chain of Custody

1.0 INTRODUCTION

This Corrective Action Monitoring Plan (CAMP) has been prepared in general accordance with and designed to meet the requirements of 9 VAC 20-80-300.A.2 and 310.C.1.a. This MNA-based Groundwater Monitoring Plan (GMP) is being submitted for inclusion with the facility's Permit as a CAMP. The CAMP was developed based on the guidance provided in the Virginia Department of Environmental Quality's (VDEQ) Submission Instructions No. 21 (v.04/14/04). Where appropriate, this CAMP report format follows the outlined provided in Table C of the Submission Instructions. Sampling of the compliance wells shall continue under the respective monitoring program during the Corrective Action process.

2.0 MONITORING PLAN

2.1 Site Location Description

CEC occupies approximately 145 acres of property, approximately 8 miles west of Virginia Beach and 7 miles south of the city of Norfolk. A site location map is included as **Figure 1**. The existing coal ash landfill is located on a peninsula in the southern portion of the CEC property (**Figure 2**). The landfill is bordered by the Southern Branch of the Elizabeth River (SBER) to the East, Deep Creek to the South, and a non-contact cooling water channel to the West.

2.2 Description of Aquifer

The hydrologic framework of the shallow aquifer system is composed of the Colombia Aquifer which resided mostly in the Norfolk Formation and is semi-contained from below by the Yorktown Confining Unit. The Norfolk Formation is composed of sands and silts with an average hydrologic conductivity of 287 to 323 feet/ year with velocities decreasing with depth (MACTEC, 2003).

Above the Norfolk Formation resides various fill materials, which may contain ash from the ash sluicing activities that predate the current landfill. Average hydraulic conductivity in the fill material is 1.5 to 5 feet/year (URS, 2003). Due to the mounding in this area, it is believed that there is an Anthropogenic Water Bearing Unit (AWBU) within this fill material (URS, 2003). The mounding in the area may also be responsible for the downward gradient observed between the shallow and deep wells across the site. Impacted groundwater is thought to flow radially outward and downward from the landfill area into the AWBU, then locally to the shallow Colombia Aquifer, draining into the cooling water channel, Deep Creek and the SBER. Potentiometric maps (December 2005) for both the deep wells and the shallow wells are included as **Figures 3 and 4**.

2.3 Monitoring System (well type definitions)

The existing monitoring well locations are depicted on **Figure 2**. As shown on Figure 2, significant geographic constraints exist with respect to siting compliance, performance and sentinel wells that are typically associated with MNA-based CAPs. The proposed MNA-based GMP incorporates both

groundwater monitoring wells and surface water samples. The existing well network includes a background well and a series of wells that are situated as close to the edge of the peninsula as possible. The wells around the landfill are considered to be "performance wells" as they will be used to track trends in arsenic concentrations in groundwater emanating from the landfill. Each proposed well location consists of a shallow and deep well couplet designed to provide data on both the horizontal and vertical groundwater impacts.

Given the geographic constraints at the Dominion site, surface water samples will also be collected at various points around the peninsula. The surface water points will serve as "sentinel" points to confirm the reliability of the remedy at the receptor. Section 3.0 details the proposed groundwater and surface water sampling procedures. Sampling of near bottom surface water will provide a direct measure of arsenic flux from the landfill, thus a direct measurement of the MNA processes taking place. Based upon the site conceptual model, samples of surface water are well suited to monitoring the natural attenuation of arsenic at the CEC Landfill. A total of four (4) surface water sampling locations (SW-1, SW-2, SW-3 and SW-4) are proposed (see **Figure 2**).

The CEC landfill is ringed by a series of shallow and deep nested wells which provide data on both horizontal and vertical extent of plume migration. MW-5 and MW-5D are located far enough away from the landfill to function as background wells. To measure the effectiveness of monitored natural attenuation, the following well network will be monitored on a quarterly basis for the first year:

- MW-5, MW-5D, PO-8, PO-8D, CECW-6I, CECW-6D, CECW-10, CECW-15, CECW-8, CECW-8D, PO-10, PO-10D, CECW-3, CECW-3D, CECW-2, CECW-2D, CECW-1, and CECW-1D

Note - Sampling of the compliance wells (MW-4, MW-5, CECW-1, CECW-2, CECW-3, CECW-5, PO8, PO9, PO10 and PO11) shall continue under the respective monitoring program during the Corrective Action process.

As shown on **Figure 2**, these wells are intended to serve as "points of compliance" with regard to the uppermost aquifer underlying the facility. All wells, except PO-8D, CECW-8D, CECW-3, and CECW-15 which currently exhibit arsenic concentrations below the GPS of 10 ug/L, should also be considered performance wells. Based on accepted arsenic transportation theory, the facility wells will be able to measure the performance of the natural attenuation remedy both directly and indirectly. They will directly measure the arsenic concentrations to ensure that arsenic levels are not increasing, implying that no more arsenic is being added to the aquifer system. By measuring iron levels as well as groundwater chemistry, these performance wells will be integral in creating arsenic transport models, if needed, as an indirect measurement of the success of monitored natural attenuation.

2.4 Well Installation Procedures

No new well installations are planned. Boring Logs/as-built diagrams for the wells to be sampled as part of the MNA-based GMP are included as **Appendix A**.

3.0 SAMPLING PROGRAM

3.1 Constituent(s) Listing (well specific)

3.1.1 Groundwater

All groundwater monitoring wells listed in Section 2.3 will be monitored for the constituents listed below. The MNA performance list included in Submission Instructions No. 21 are not all applicable to document the viability of the arsenic adsorption process. The following constituents will be monitored in order to monitor site geochemical conditions and concentrations over time:

- Total and dissolved arsenic by EPA method 200.8 modified (ICP-DRC-MS);
  - LOD – 0.004 mg/L; LOQ – 0.010 mg/L
- Arsenic Speciation (As^{+3} and As^{+5}) samples using anion resin column followed by analysis by EPA method 200.8 modified (ICP-DRC-MS)
  - LOD – 0.004 mg/L; LOQ – 0.010 mg/L
- Total and dissolved iron by EPA method 200.8 modified (ICP-DRC-MS);
  - LOD – 0.007 mg/L; LOQ – 0.010 mg/L
- General water quality parameters (dissolved oxygen, oxidation-reduction potential, pH, temperature, turbidity and specific conductance)

The proposed analytical methods meet or exceed the limits of detection (LOD) and quantitation (LOQ) listed in SW-846 as updated.

3.1.2 Surface Water

The surface water samples (4 total) will be analyzed for following constituents:

- Total and dissolved arsenic by EPA method 200.8 modified (ICP-DRC-MS);
- Arsenic Speciation (As^{+3} and As^{+5}) samples using anion resin column followed by analysis by EPA method 200.8 modified (ICP-DRC-MS)
- Total and dissolved iron by EPA method 200.8 modified (ICP-DRC-MS);
- Total (unfiltered) suspended solids by EPA Method 160.2; and
- General water quality parameters (dissolved oxygen, oxidation-reduction potential, pH,

temperature, turbidity and specific conductance) will be measured in a flow cell using a YSI Sonde 6820.

The proposed analytical methods meet or exceed the limits of detection (LOD) and quantitation (LOQ) listed in SW-846 as updated.

3.2 Sample Collection Frequency

Samples (groundwater and surface water) will be collected on a quarterly basis for the first year. The first year of monitoring data will be evaluated and compared to the latest statistical evaluation of the monitoring data collected under the requirements of the Virginia Solid Waste Management Regulations (VSWMR). Given the magnitude of the historical data collected under the VSWMR monitoring program, it is anticipated that the sampling frequency can be reduced to semi-annual following one year of quarterly sampling. Recommendations for future monitoring will be presented in the initial Corrective Action Site Evaluation (CASE) report, which will be prepared within 60 days following the conduct of the 4th quarterly sampling event.

3.3 Sample Preservation / Handling

3.3.1 Groundwater

Sampling at each well begins by gauging and recording the water level and total depth of each well. Prior to gauging, the interface probe will be decontaminated with an Alconox solution and rinsing using distilled water. A Grundfos pump (or equivalent) with dedicated tubing will then be used to purge the well. Prior to placing the pump into the well, the pump will be decontaminated by pumping an Alconox solution followed by a distilled water rinse through the pump.

The pump will be paced at the midpoint of the screened interval. Grundfos pump flow will adjusted to minimize drawdown (0.2 ft or less) and adjusted to a rate appropriate for low-flow sampling (100 to 200 ml/min). All purge water will be directed to ground adjacent to each well. Using a YSI Sonde 6820 (or equivalent) and flow cell, field parameters (dissolved oxygen, turbidity, oxidation-reduction potential, pH, specific conductance, and temperature) will be logged every three minutes until all parameters stabilize. Stabilization is achieved when all parameters have met the following criteria for three successive readings:

- pH agreement within 0.1+/- S.U.s:
- conductivity agreement within 3%+/-; and
- oxidation-reduction potential and dissolved oxygen within 10%+/-

Using a Lamotte turbidity meter (or equivalaent), turbidity will be measured periodically during the purging process. Turbidity is considered to be the primary bias factor regarding metals analyses, so wells were purged until the turbidity is under ten (10) NTU's.

Upon parameter stabilization, the flow-through cell will be removed and ground water samples will

be directed into laboratory supplied containers under proper chain of custody and placed into a cooler containing ice. Samples will be shipped to the appropriate laboratory at a temperature between two and negative two degrees Celsius.

3.3.2 Surface Water

Sampling will be accomplished using weighted tubing and a peristaltic pump. Tubing will be of a type approved for the analytical parameter list. New tubing will be used for each sampling event at each sampling site. Tubing weights will be non-reactive and decontaminated between uses. At each sampling site a sampling elevation in the water column (measured from the sediment-water interface) will have been predetermined using the rational previously described. The sample will be representative of a larger area of groundwater outflow if a relatively large sample aliquot (4 L) is collected. This large sample is then agitated and subsampled for unfiltered (total) water quality, followed by subsampling and filtering (0.45 micron) for dissolved water quality parameters.

3.4 Chain of Custody Procedure

A chain of custody form will be completed by sampling personal and placed in each cooler to be shipped. A copy will be kept by field personnel. After receiving the shipment, the laboratory project manager signs the Chain of Custody that arrived in the coolers, and returns the copy to personnel along with the sampling results. An example Chain of Custody is included as **Appendix B.**

3.5 Field Book Records

Detailed field notes of the sampling efforts will be kept during sampling events. Following the sampling event, field notes will be copied and filed with the laboratory analytical results.

3.6 Laboratory Procedures

The laboratory will ensure that the samples were received at the appropriate temperature and under a signed chain of custody form. All groundwater and surface water samples will be analyzed for total/dissolved metals by EPA method 200.8 modified (ICP-DRC-MS). Surface water will also be analyzed for total (unfiltered) suspended solids by EPA Method 160.2.

3.7 QA/QC Program

To ensure the integrity of the data, the following quality control samples will be collected during each sampling event:

- an equipment blank will be taken by sampling de-ionized water that has been poured over sampling equipment; and
- one field duplicate for groundwater and surface water

Equipment used shall be calibrated routinely as recommended by the manufacturer.

3.8 Statistical Trend Evaluations

Using data from the pre-corrective action sampling performed under the facility's compliance monitoring program and the data obtained as part of the corrective action program, the Permittee will perform a statistical evaluation to document the overall reduction of the mass flux from the source material to groundwater around the landfill. The proposed groundwater and surface water constituents are designed to demonstrate the viability and long-term reliability of the adsorption process.

3.9 Interpretation of GW Elevation Data

Dominion will determine the elevation of the groundwater surface for both the shallow and deeper potions of the upper aquifer each time the groundwater is sampled to the nearest 0.01 foot. Potentiometric surface maps will be prepared for the shallow and deeper portion of the aquifer for each sampling event. The rate and direction of groundwater flow will also be determined. The groundwater flow maps will be submitted as part of the Corrective Action Site Evaluation reports submitted periodically.

3.10 Record Keeping

The Permitee shall retain all field sampling, monitoring, testing and analytical data obtained throughout the corrective action monitoring period.

4.0 REPORTING SCHEDULE

4.1 GPS Exceedance Notifications

GPS exceedances have been documented for arsenic at various locations at the site. However, a recent statistical evaluation (Gibbons, 2001) indicates that the arsenic concentrations appear to be decreasing with time. The proposed corrective action (MNA) will use surface water samples in the adjacent estuaries to document the long term effectiveness of the adsorption process. In the event that any of the downgradient surface water samples exceed the GPS for arsenic, the Permittee will notify the VDEQ of this finding within 14 days.

Within 90 days, the Permittee will submit the following:

- an evaluation of the concentrations measured in the groundwater and surface water at each monitoring point;
- any proposed changes to the monitoring program necessary to meet the requirements of the corrective action program; and
- any proposed changes to the monitoring frequency or sampling procedures

Should the need arise for implementation of a replacement remedy, the Permittee will submit a report to the Director justifying the plan at least 14 days prior to implementation.

4.2 CASE Reports

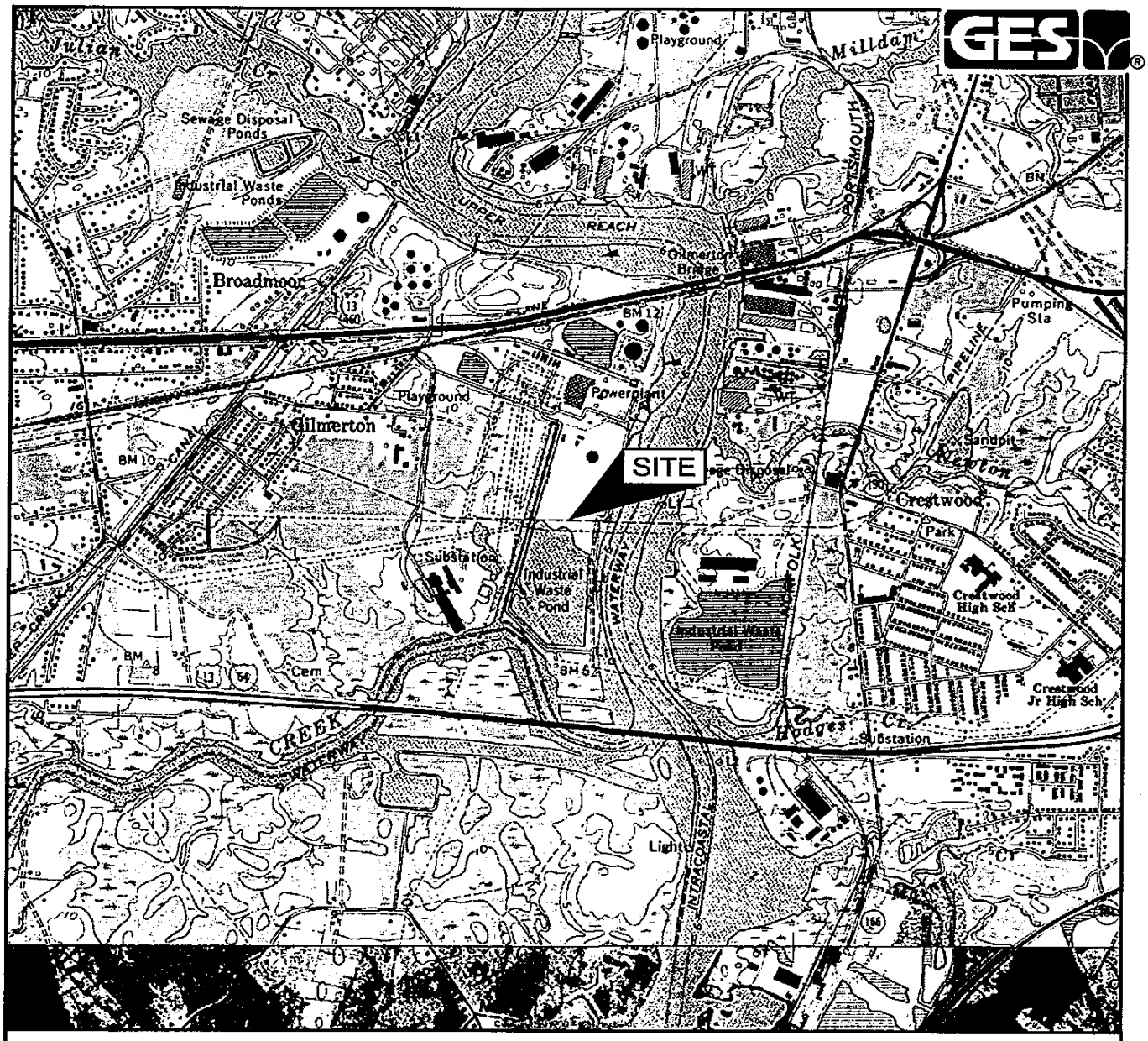
Dominion will prepare and submit Corrective Action Site Evaluation (CASE) reports on a periodic basis to address the evaluation and criteria topics outlined in 9 VAC 20-80-310.B. The CASE reports shall be signed by a qualified groundwater professional. As currently envisioned, the initial CASE report will be submitted within 60 days following the 4th quarterly sampling event of the first year of monitoring. Given the volume of historical groundwater data for the CEC landfill, there are enough data to perform a CASE study after the first year of corrective action monitoring. However, the CASE report submission timeframe will be set in the Permit (typically on a 3-year timeframe).

As currently envisioned, each CASE report shall include the following information, at a minimum:

- Summary of most recent groundwater and surface water quality data, including a discussion of arsenic concentrations along flow paths and a demonstration that the adsorption process is capable of reducing the arsenic concentrations to below the GPS before discharging to the adjacent estuary;
- Summary of most recent groundwater elevation data;
- Plume maps and potentiometric surface maps; and
- Summary of investigation-derived waste and disposition of those residuals

5.0 WELL O&M PROGRAM

Monitoring wells will be inspected during each sampling event. If it is found that a well is no longer capable of providing representative samples, it will be redeveloped or abandoned and replaced before the next sampling event.



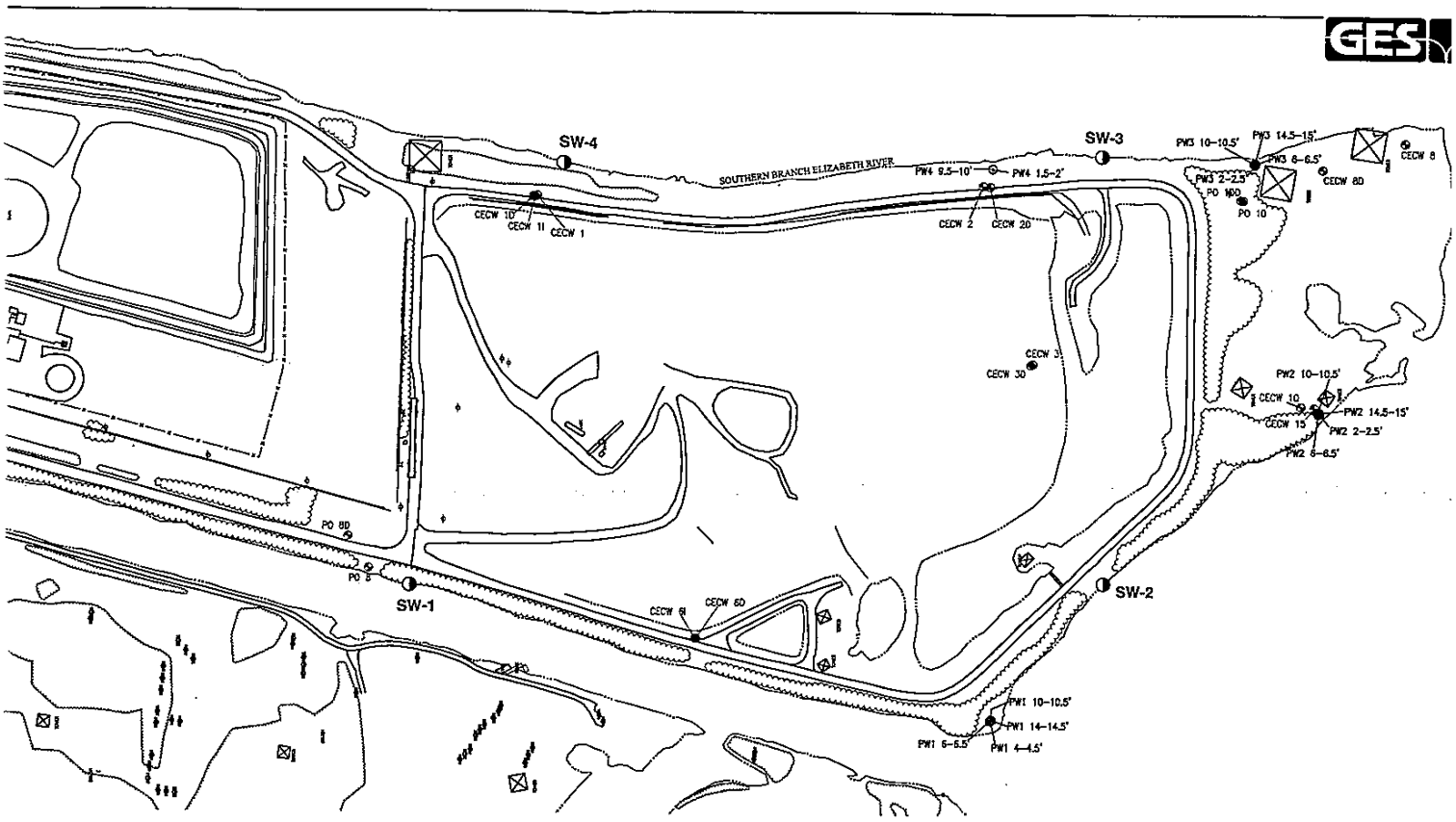
SOURCE: USGS 7.5 MINUTE SERIES
TOPOGRAPHIC QUADRANGLE 1986
NORFOLK SOUTH, VIRGINIA
CONTOUR INTERVAL = 5'

QUADRANGLE LOCATION

LAT. 036° 45' 58.96" N
LONG. 076° 18' 7.84" W
(APPROXIMATE SITE COORDINATES)

DRAFTED BY: W.A.W. (N.J.)	SITE LOCATION MAP		
CHECKED BY: A.T.	DOMINION VIRGINIA POWER 1701 VEPCO STREET CHESAPEAKE, VIRGINIA		
REVIEWED BY: M.B.	Groundwater & Environmental Services, Inc. 23 SOUTH 13TH STREET, SUITE 201, RICHMOND, VA 23219		
NORTH	SCALE IN FEET 0 2000	DATE 3-28-06	FIGURE 1

42072



LL
ATION (FEET)
STATION (4)

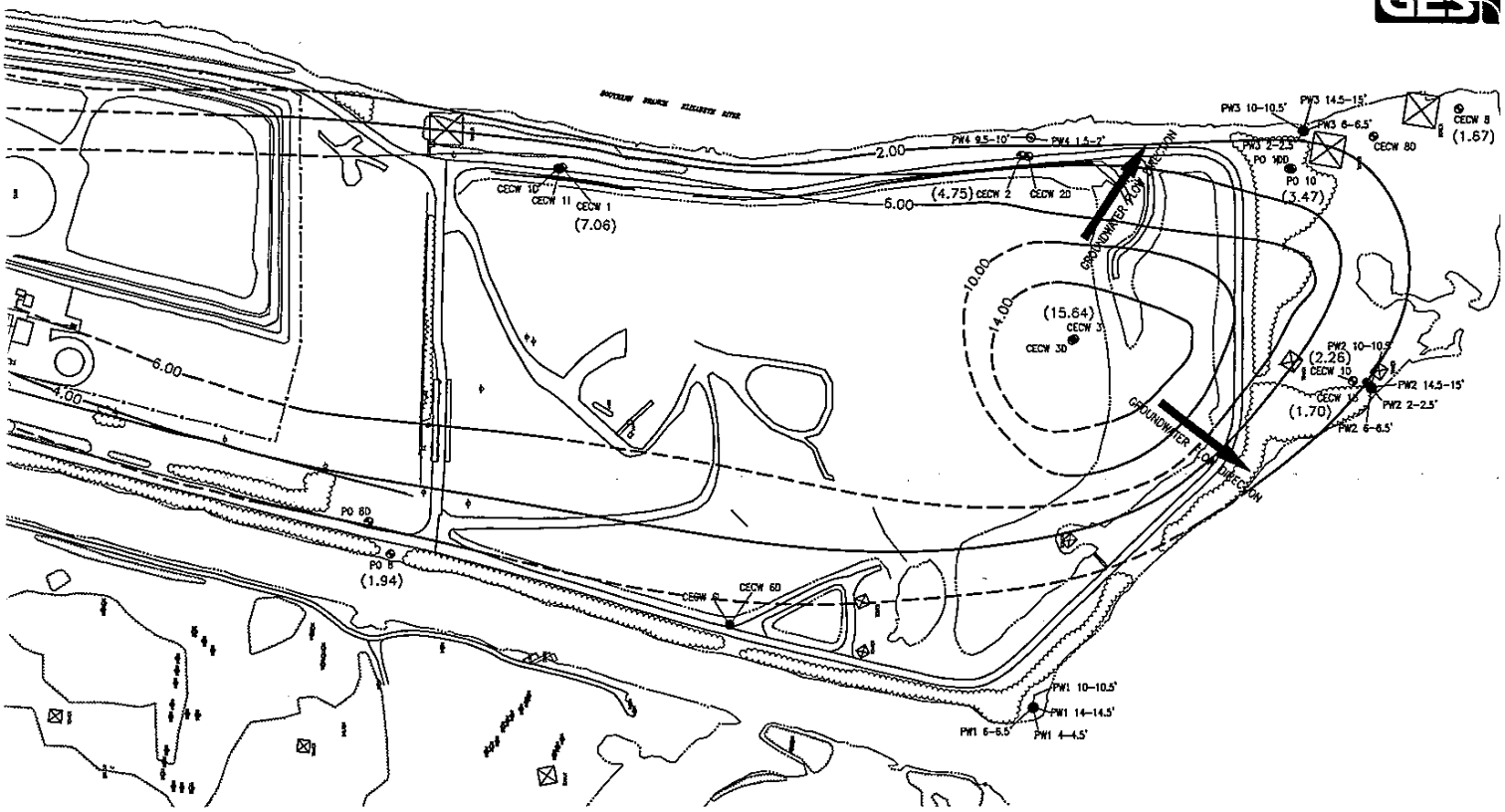
NOTE:

THIS MAP BASED ON THE SURVEY PREPARED BY PRECISION MEASUREMENTS, INC., DATED 9 JANUARY 2006.

DRAFTED BY: W.A.W. (N.J.)	SITE MAP
CHECKED BY: J.T.T.	DOMINION VIRGINIA POWER 1701 VEFCO STREET CHESAPEAKE, VIRGINIA
REVIEWED BY: R.F.S.	
NORTH	Groundwater & Environmental Services, Inc. 23 SOUTH 13TH STREET, SUITE 201, RICHMOND, VA 23219

SCALE IN FEET	DATE	FIGURE
0 250	3-28-06	2

42073



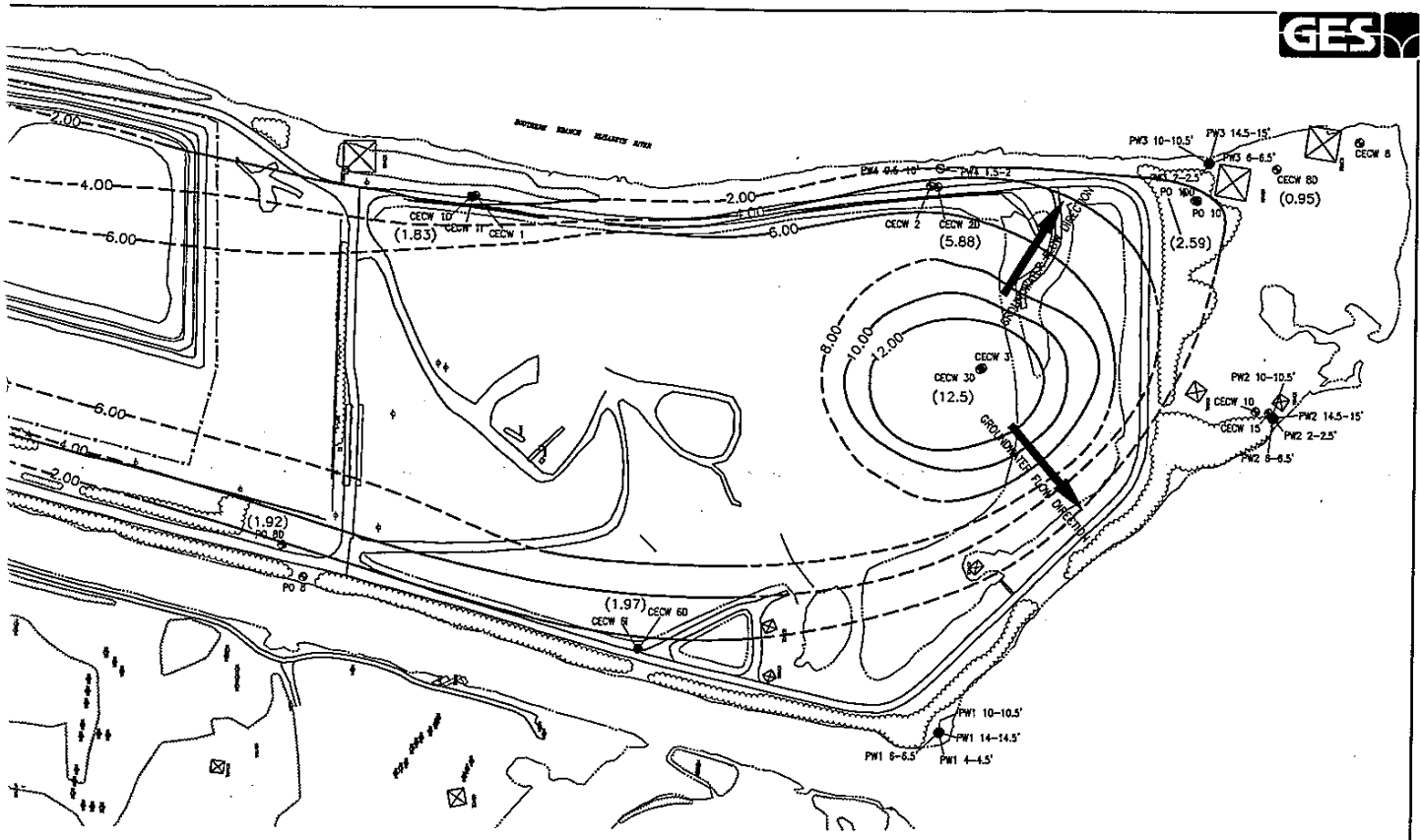
L
ATION (feet)
LEVATION (feet)
ONTOUR (feet)
NFERRED

NOTE:

THIS MAP BASED ON THE SURVEY PREPARED BY PRECISION MEASUREMENTS, INC., DATED 9 JANUARY 2006.

DRAFTED BY: W.A.W. (N.J.)	GROUNDWATER CONTOUR MAP (SHALLOW WELLS) DECEMBER 6, 2005
CHECKED BY: J.T.T.	DOMINION VIRGINIA POWER 1701 VEPCO STREET CHESAPEAKE, VIRGINIA
REVIEWED BY: R.F.S.	
NORTH	Groundwater & Environmental Services, Inc. 23 SOUTH 13TH STREET, SUITE 201, RICHMOND, VA 23219
	SCALE IN FEET 0 250 — DATE 3-29-06 — FIGURE 3

42074



DRAFTED BY: W.A.W. (N.J.)	GROUNDWATER CONTOUR MAP (DEEP WELLS) DECEMBER 6, 2005
CHECKED BY: J.T.T.	DOMINION VIRGINIA POWER 1701 VEPCO STREET CHESAPEAKE, VIRGINIA
REVIEWED BY: R.F.S.	
NORTH	Groundwater & Environmental Services, Inc. 23 SOUTH 13TH STREET, SUITE 201, RICHMOND, VA 23219
	SCALE IN FEET 0 250 / DATE 3-29-06 / FIGURE 4

NOTE:

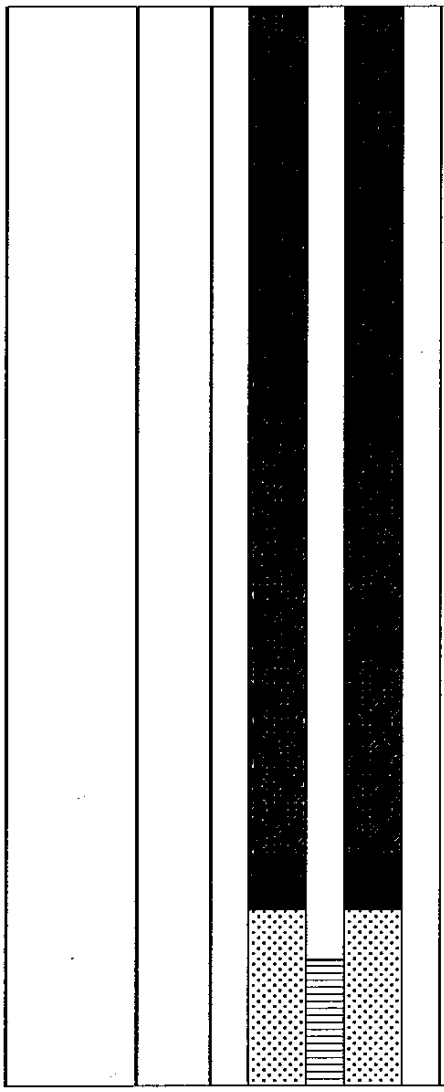
THIS MAP BASED ON THE SURVEY PREPARED BY PRECISION MEASUREMENTS, INC., DATED 9 JANUARY 2006.

Soil Boring Log

Borehole Number: CECW-2D

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Dominion Chesapeake	DRILLING CO.:	Boart Longyear
SITE LOCATION:	Chesapeake, Virginia	DRILLER:	Matt White, and Travis Wisenbeck
JOB NAME:	1200686	RIG TYPE:	Track Mounted Mini Sonic
LOGGED BY:	Eli Holland	METHOD OF DRILLING:	Roto - Sonic
PROJECT MANAGER:	Eli Holland		
DATES DRILLED:	11/2/05	HAMMER	NA
BOREHOLE NO.:	CECW-2D	TOTAL DEPTH:	43
WEATHER:		▼ Observed Water Level	NA = Not Applicable

DEPTH	SOIL/ROCK SYMBOLS	SOIL DESCRIPTION	BLOW COUNT	PID (ppm)	WELL CONSTRUCTION	NOTES
0		Black/Brown Silty Dry Sand				Completed with 3' stick-up with protective steel casing and concrete well pad. Hand cleared to 4'
-5		Tan Fine Moist Sand				
-10		Lite Tan Fine Well Sorted Moist Sand With Cobbles and Possible Sandstone Lens at 13 feet				
▼						
-15		Brown Fine Moist Sand Grading Down to a Dark Grey Clay and Sand at 18 feet				
-20		Brown Fine Wet Sand With Soft Grey Clay				
-25		Tan Medium to Fine Wet Sand Grading Down to a Dark Brown Fine Wet Clayey Sand				
-30		Tan Fine Wet Sand and Clay. Shells and Organic Material Encountered at 37-39' bgs				
-35						
-40		Lite Tan Fine Wet Sand to Brown Clay Grading Down to a Grey green Clay at 43' bgs				



Soil Boring Log

Borehole Number: CECW-3D

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Dominion Chesapeake	DRILLING CO.:	Boart Longyear
SITE LOCATION:	Chesapeake, Virginia	DRILLER:	Matt White, and Travis Wisenbeck
JOB NAME:	1200686	RIG TYPE:	Track Mounted Mini Sonic
LOGGED BY:	Eli Holland	METHOD OF DRILLING:	Roto - Sonic
PROJECT MANAGER:	Eli Holland		
DATES DRILLED:	11/3/05	HAMMER	NA
BOREHOLE NO.:	CECW-3D	TOTAL DEPTH:	43
WEATHER:		▼ Observed Water Level	NA = Not Applicable

Page 1 of 1

DEPTH	SOIL/ROCK SYMBOLS	SOIL DESCRIPTION	BLOW COUNT	PID (ppm)	WELL CONSTRUCTION	NOTES
0		Grey Black Fine Silty Sand				Completed with 3' stick-up with protective steel casing and concrete well pad.
-5		Grey Black Fine to Medium Wet Silty Sand Grading Down to a Tan Medium Sand				Hand cleared to 4'
-10 ▼		Tan Brown Medium Moist Sand				
-15		Grey Black Fine Wet Sand and Silt or Ash				
-20		Grey Black Fine Wet Silt or Ash With Some Sand				
-25		Tan Brown Medium Sand Fining Downward				
-30		Grey Fine Wet Sand				
-35						
-40		Grey With Some Orange Medium to Course Sand Fining Downward				

42078

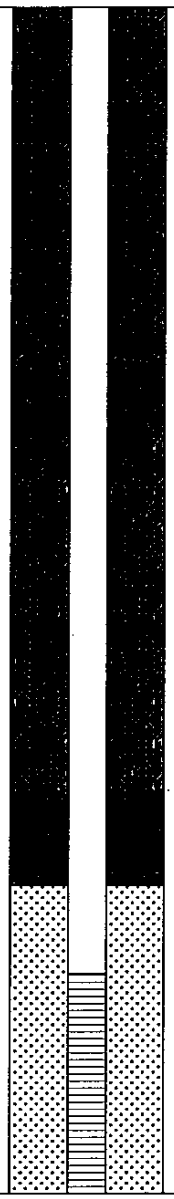
Soil Boring Log

Borehole Number: CECW-8D

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Dominion Chesapeake	DRILLING CO.:	Boart Longyear
SITE LOCATION:	Chesapeake, Virginia	DRILLER:	Matt White, and Travis Wisenbeck
JOB NAME:	1200686	RIG TYPE:	Track Mounted Mini Sonic
LOGGED BY:	Eli Holland	METHOD OF DRILLING:	Roto - Sonic
PROJECT MANAGER:	Eli Holland		
DATES DRILLED:	11/4/05	HAMMER	NA
BOREHOLE NO.:	CECW-8D	TOTAL DEPTH:	27
WEATHER:		⧗ Observed Water Level	NA = Not Applicable

Page 1 of 1

DEPTH	SOIL/ROCK SYMBOLS	SOIL DESCRIPTION	BLOW COUNT	PID (ppm)	WELL CONSTRUCTION	NOTES
0 ⧗		Lite Tan Fine Wet Sand				Completed with 3' stick-up with protective steel casing and concrete well pad.
						Hand cleared to 4'
-5		Lite Tan Medium Wet Sand				
-10		Lite Tan Medium Wet Sand				
-15		Lite Tan Wet Sand Grading Down to Lite Tan Fine Silty Wet Sand				
-20		Tan Medium Wet Sand Grading Down to Tan Orange Fine Silty Sand				
-25		Tan/ Orangish Brown Fine Silty Sand Into a Dark Grey Clay With Some Sand at 28' bgs				



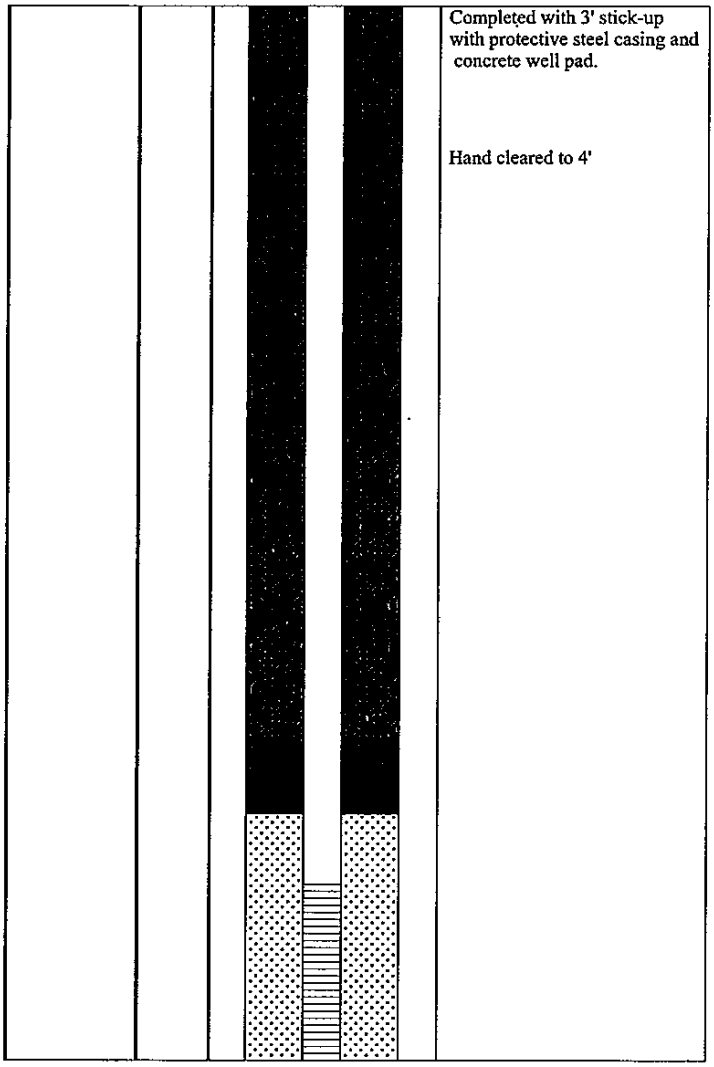
Soil Boring Log

Borehole Number: MW-5D

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Dominion Chesapeake	DRILLING CO.:	Boart Longyear
SITE LOCATION:	Chesapeake, Virginia	DRILLER:	Matt White, and Travis Wisenbeck
JOB NAME:	1200686	RIG TYPE:	Track Mounted Mini Sonic
LOGGED BY:	Eli Holland	METHOD OF DRILLING:	Roto - Sonic
PROJECT MANAGER:	Eli Holland		
DATES DRILLED:	11/4/05	HAMMER	NA
BOREHOLE NO.:	MW-5D	TOTAL DEPTH:	30
WEATHER:		⧗ Observed Water Level	NA = Not Applicable

Page 1 of 1

DEPTH	SOIL/ROCK SYMBOLS	SOIL DESCRIPTION	BLOW COUNT	PID (ppm)	WELL CONSTRUCTION	NOTES
0		Brown Moist Silty Sand				Completed with 3' stick-up with protective steel casing and concrete well pad.
						Hand cleared to 4'
-5 ⧗		Lite Tan Fine Grained Wet Sand				
		Lite Tan Fine Grained Wet Sand				
-15		Lite Tan and Orange Fine Wet Sand Grading Down to a Fine to Medium Sand				
-20		Lite Tan Fine to Medium Wet Sand				
-25		Lite Tan Fine to Medium Wet Sand Grading Down to a Brownish Orange Fine Wet Sand				
-30						



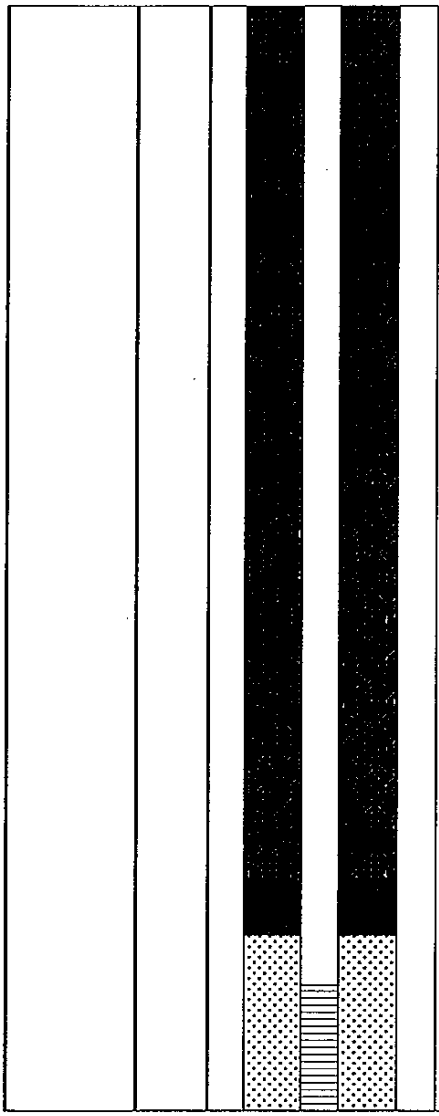
Soil Boring Log

Borehole Number: PO-8D

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	Dominion Chesapeake	DRILLING CO.:	Boart Longyear
SITE LOCATION:	Chesapeake, Virginia	DRILLER:	Matt White, and Travis Wisenbeck
JOB NAME:	1200686	RIG TYPE:	Track Mounted Mini Sonic
LOGGED BY:	Eli Holland	METHOD OF DRILLING:	Roto - Sonic
PROJECT MANAGER:	Eli Holland		
DATES DRILLED:	11/5/05	HAMMER	NA
BOREHOLE NO.:	PO-8D	TOTAL DEPTH:	44
WEATHER:		▼ Observed Water Level	NA = Not Applicable

Page 1 of 1

DEPTH	SOIL/ROCK SYMBOLS	SOIL DESCRIPTION	BLOW COUNT	PID (ppm)	WELL CONSTRUCTION	NOTES
0		Black Loose Sand and Fill Gravel				Completed with 3' stick-up with protective steel casing and concrete well pad.
-5		Lite Tan Loose Sand into Dark Grey/ Black Fine Silty Sand and Gravel at 8' bgs				Hand cleared to 4'
-10		Black Fine Loose Wet Sand				
-15		Dark Grey Medium Stiff wet Clay Grading Down to a Black Course Sand and Gravel at 18' bgs				
▼ -20		Dark Grey Medium Stiff Clay Grading Down to a Black Fine Sand at 27' bgs				
-25		Grey With Orange Mottling Soft Wet Clay Grading Down to a Tan Fine to Medium Wet Sand				
-30		Lite Tan / Orangish Brown Fine Wet Silty Sand				
-35		Lite Tan / Orangish Brown Fine Wet Silty Sand				
-40		Dark Grey Silty Wet Sand and Dark Grey Medium Stiff Wet Clay				



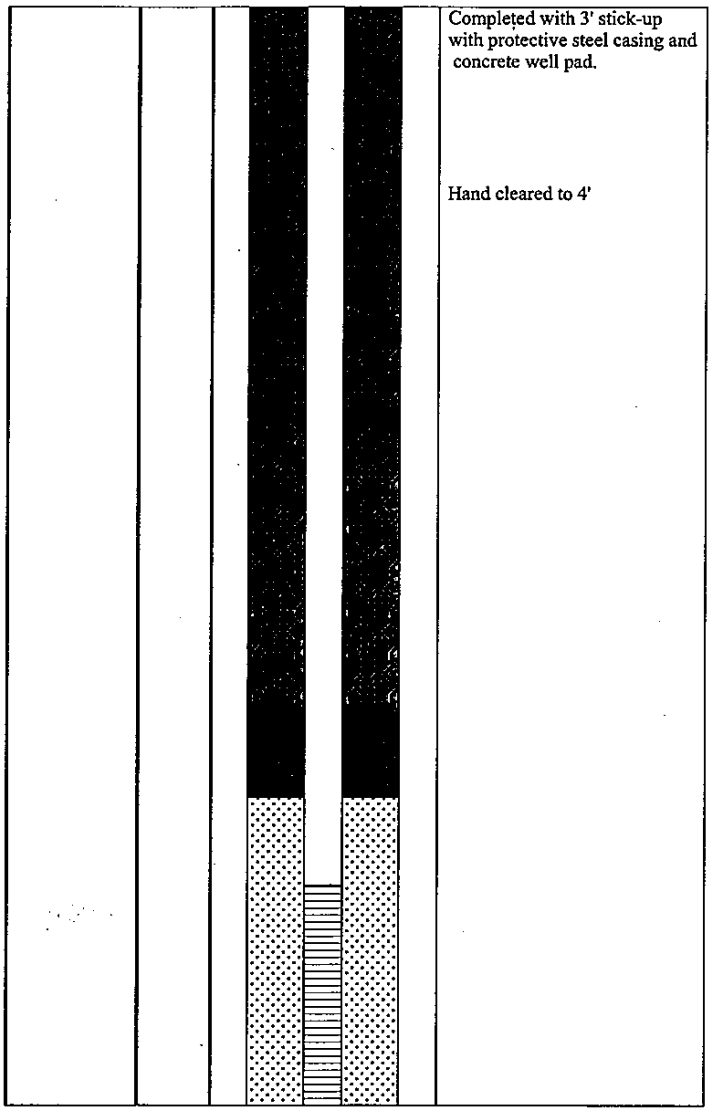
Soil Boring Log

Borehole Number: PO-10D

PROJECT INFORMATION		DRILLING INFORMATION	
P CT:	Dominion Chesapeake	DRILLING CO.:	Boart Longyear
SITE LOCATION:	Chesapeake, Virginia	DRILLER:	Matt White, and Travis Wisenbeck
JOB NAME:	1200686	RIG TYPE:	Track Mounted Mini Sonic
LOGGED BY:	Eli Holland	METHOD OF DRILLING:	Roto - Sonic
PROJECT MANAGER:	Eli Holland		
DATES DRILLED:	11/5/05	HAMMER	NA
BOREHOLE NO.:	PO-10D	TOTAL DEPTH:	25
WEATHER:		▼ Observed Water Level	NA = Not Applicable

Page 1 of 1

DEPTH	SOIL/ROCK SYMBOLS	SOIL DESCRIPTION	BLOW COUNT	PID (ppm)	WELL CONSTRUCTION	NOTES
▼ 0		Lite Grey Fine Sand and Clay				Completed with 3' stick-up with protective steel casing and concrete well pad.
						Hand cleared to 4'
-5		Brown Fine Wet Sand				
-10		Brown Fine Wet Sand Grading Down to Medium Sand				
-15		Brown Course Wet Sand Grading Down to Fine Sand				
-20		Lite Grey/Orange Fine Wet Silty Sand Grading Down to Grey Green Clay at 25' bgs				
-25						



42082

STL Mob"-
900 Lakeside
Mobile, AL 36693
phone 251-666-6633 fax 251-666-6696

Chain of Custody Record

SEVERN TRENT STL

Severn Trent Laboratories, Inc.

42084

Client Contact	Project Manager:	Site Contact:	Date:	COC No:
Your Company Name here	Tel/Fax:	Lab Contact:	Carrier:	_____ of _____ COCs
Address	Analysis Turnaround Time			Job No.
City/State/Zip	Calendar (C) or Work Days (W) _____			
(xxx) xxx-xxxx Phone	TAT if different from Below _____			
(xxx) xxx-xxxx FAX	☐ 2 weeks			SDG No.
Project Name:	☐ 1 week			
Site:	☐ 2 days			
P O #	☐ 1 day			

Sample Identification	Sample Date	Sample Time	Sample Type	Matrix	# of Cont.	Filtered Samples																			Sample Specific Notes:

Preservation Used: 1= Ice, 2= HCl; 3= H2SO4; 4=HNO3; 5=NaOH; 6= Other _____

Possible Hazard Identification
☐ *Non-Hazard* ☐ *Flammable* ☐ *Skin Irritant* ☐ *Poison B* ☐ *Unknown*

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)
☐ *Return To Client* ☐ *Disposal By Lab* ☐ *Archive For* _____ *Months*

Special Instructions/QC Requirements & Comments:

Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time: