BATTLEFIELD GOLF CLUB WATER PROJECT

Water Supply Feasibility Study

Prepared For

City of Chesapeake

April 10, 2009

URS

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1.0 EXECUTIVE SUMMARY

The potential introduction of contaminants from the Battlefield Golf Course fly ash into the Surficial groundwater has created a situation requiring immediate action. The City of Chesapeake has initiated a comprehensive water supply feasibility study to evaluate existing conditions and assess viable alternatives capable of delivering potable water to City residents located within the study area.

Existing local hydrogeologic data, water well information, and recent well water quality data were collected and evaluated to determine suitable water sources, well yield limits, and potential constituents requiring treatment to comply with drinking water standards. URS developed and assessed the following four alternatives:

Alternative 1: Extend the City of Chesapeake's central water distribution system via a water main extension.

Alternative 2: Install a "stand alone" community groundwater supply, treatment, storage and distribution system capable of providing potable water service to 100 equivalent residential connections (ERC).

Alternative 3: Install point-of-entry (POE) treatment systems on existing private wells currently used to provide water to these homes/businesses.

Alternative 4: Install and develop new individual residential and commercial water supply wells into aquifer(s) offering potentially less susceptibility to reduced water quality conditions and potential contaminants from the fly ash.

The four alternatives were evaluated using the following criterion: regulatory compliance, property owner impact, operational requirements, technical feasibility, permitting / administrative concerns, and present worth cost (capital and operations and maintenance (O&M) costs).

Alternatives 2 and 3 present significant regulatory issues. Even if these alternatives are able to overcome the regulatory obstacles, their ultimate costs from both capital and O&M perspectives are so substantial that a path forward make these alternatives unfavorable.

Alternative 4 costs are attractive and new wells can be implemented in a relatively expeditious manner, but this option suffers from the lack of certainty to completely protect the residents' future water quality without first obtaining more information from the concurrent City study focused on the fate and transport of any potential contaminants. Therefore, avoidance of future risk is not assured with this option. The complete present exercise of evaluating options and actions may only be temporarily delayed with this option.

URS recommends that the City proceed with the construction of Alternative 1 and extend the City distribution system to serve these areas. The provision of City water would allow for a safe, reliable, monitored water supply that would be most protective against any potential future impacts to the existing aquifer supply.

2.0 BACKGROUND

Due to concerns regarding potential impacts to groundwater quality from the use of fly ash as fill at the Battlefield Golf Club, the City of Chesapeake is undertaking efforts to supply water to homes on Murray Drive, from Centerville Turnpike to Whittamore Road; Whittamore Road, from Centerville Turnpike to Murray Drive; and, Centerville Turnpike, from Murray Drive to Whittamore Road. (With the installation of a City Water System Extension, other homes and businesses along Centerville Turnpike could also connect to the water system between the southern terminus of Albemarle Acres and Etheridge Manor Boulevard). This Water Supply Feasibility Study assesses four alternatives for providing potable water to these homes based on regulatory compliance, property owner impact, operational requirements, technical feasibility, administrative/permitting concerns, and present worth cost (capital and operations and maintenance (O & M) costs).

2.1 Project Area Background

The Murray-Whittamore-Centerville project area is located in the City of Chesapeake, VA. See Figure 1 for a Site Location Map. The area is represented on the Fentress, Virginia USGS topographic quadrangle at an approximate elevation of 10 to 15 feet (ft) above mean sea level (MSL), and it slopes eastwards.

The 216-acre Battlefield Golf Course is located on Centerville Turnpike between Murray Drive and Whittamore Road. It is understood based on information provided to URS that the site was constructed by using 1.5 million tons of fly ash originating from the Chesapeake Energy Facility operated by Dominion Power. Under Virginia's administrative code, fly ash, a coal combustion byproduct, can be used as a fill material as long as there are two feet of separation between the groundwater and an 18-inch cap of soil covering the fly ash at all times. Construction of the golf course took approximately 5 years and was completed in the summer of 2007.

In 2008, residents living in the immediate vicinity of the Golf Course voiced concerns to the City regarding the potential impacts to groundwater quality from the use of the fly ash. According to City documents, there are approximately 93 dwelling units adjacent to the golf course using wells as the primary source of drinking water.

In response to resident concerns, the City began to test drinking water wells of the surrounding residents for constituents of concern, including arsenic, barium, boron, chromium, cadmium, lead, selenium, silver, vanadium and mercury. On July 16, 2008, the City sent a letter to the U.S. Environmental Protection Agency (EPA) regional office requesting the Agency to respond to the detection of various analytes in the groundwater in support of the surrounding residents. The City then commissioned URS to investigate water supply alternatives described in Section 2.2 to bring reliable, potable water to the community.

2.2 Water Supply Feasibility Study Objectives

The purpose of this study is to provide stakeholders with information on existing conditions and to assess viable alternatives that assures potable water supply to city residents. Existing local hydrogeology data, water well information, and recent well water quality data have been collected and evaluated to determine suitable water sources, well yield limits, and potential constituents requiring treatment to comply with drinking water standards. Based on this information URS has generated the following four alternatives to provide potable water to 100 equivalent residential connections (ERC):

Alternative 1: Extend the City of Chesapeake's central water distribution system via a water main extension.

Alternative 2: Install a "stand alone" community groundwater supply, treatment, storage and distribution system capable of providing potable water service to 100 ERC.

Alternative 3: Install point-of-entry (POE) treatment systems on existing private wells currently used to provide water to these homes/businesses.

Alternative 4: Install and develop new individual residential and commercial water supply wells into aquifer(s) offering potentially less susceptibility to reduced water quality conditions and potential contaminants from the fly ash.

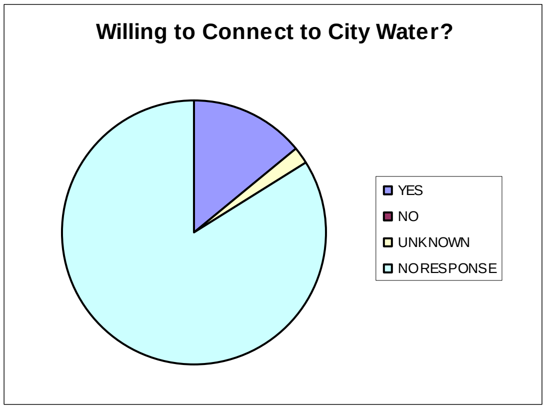
The alternatives have been compared to identify the relative suitability of each alternative, and to provide a recommended alternative based on the analysis performed.

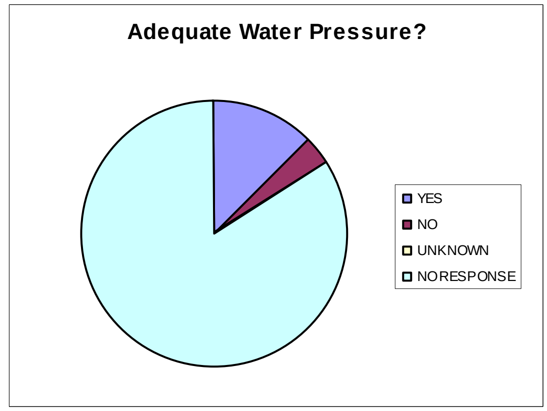
2.3 Homeowner Study Area Questionnaire Responses

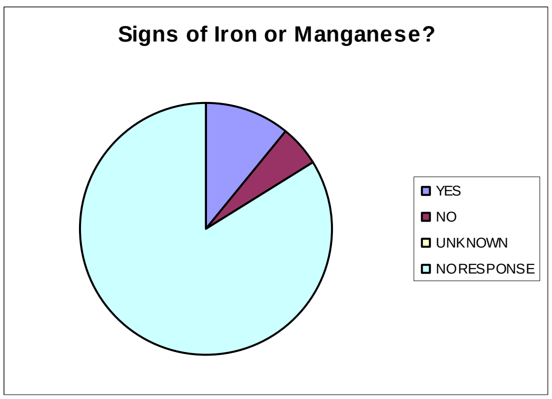
On December 8, 2008, the City of Chesapeake mailed 93 questionnaire forms to the residences and businesses within the Murray-Whittamore-Centerville study area. In the questionnaire, the City requested information about individual water wells and public opinion on connecting to the City water system. An example of the questionnaire is included in Appendix A.

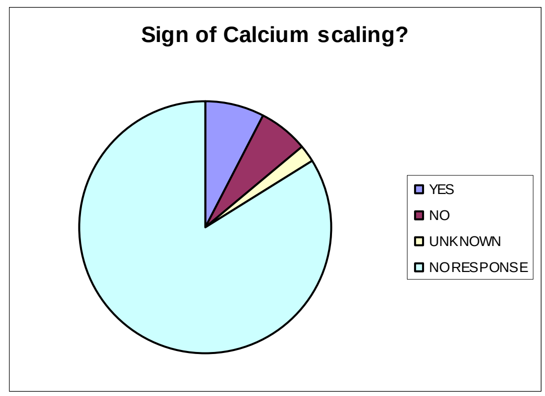
Table 1 in Appendix A summarizes the responses from this investigation. At the time this feasibility report was prepared (February 3, 2009), there were 15 responses, including two businesses. The following illustration summarizes some important responses contained on the questionnaire. Among the respondents, 85% expressed an interest in connecting to City water if it became available.

According to the survey results, the water wells were installed between 1950 and 2000. Most of them are accessible. Only three households indicated problems with water pressure. The respondents provided little, if any, information about the configuration of their wells, such as depth of the well. Seventy (70) % of the respondents have experienced iron or manganese issues, and 50% of the respondents have experienced calcium scaling. About half have installed individual treatment devices.









Resident Questionnaire Summary

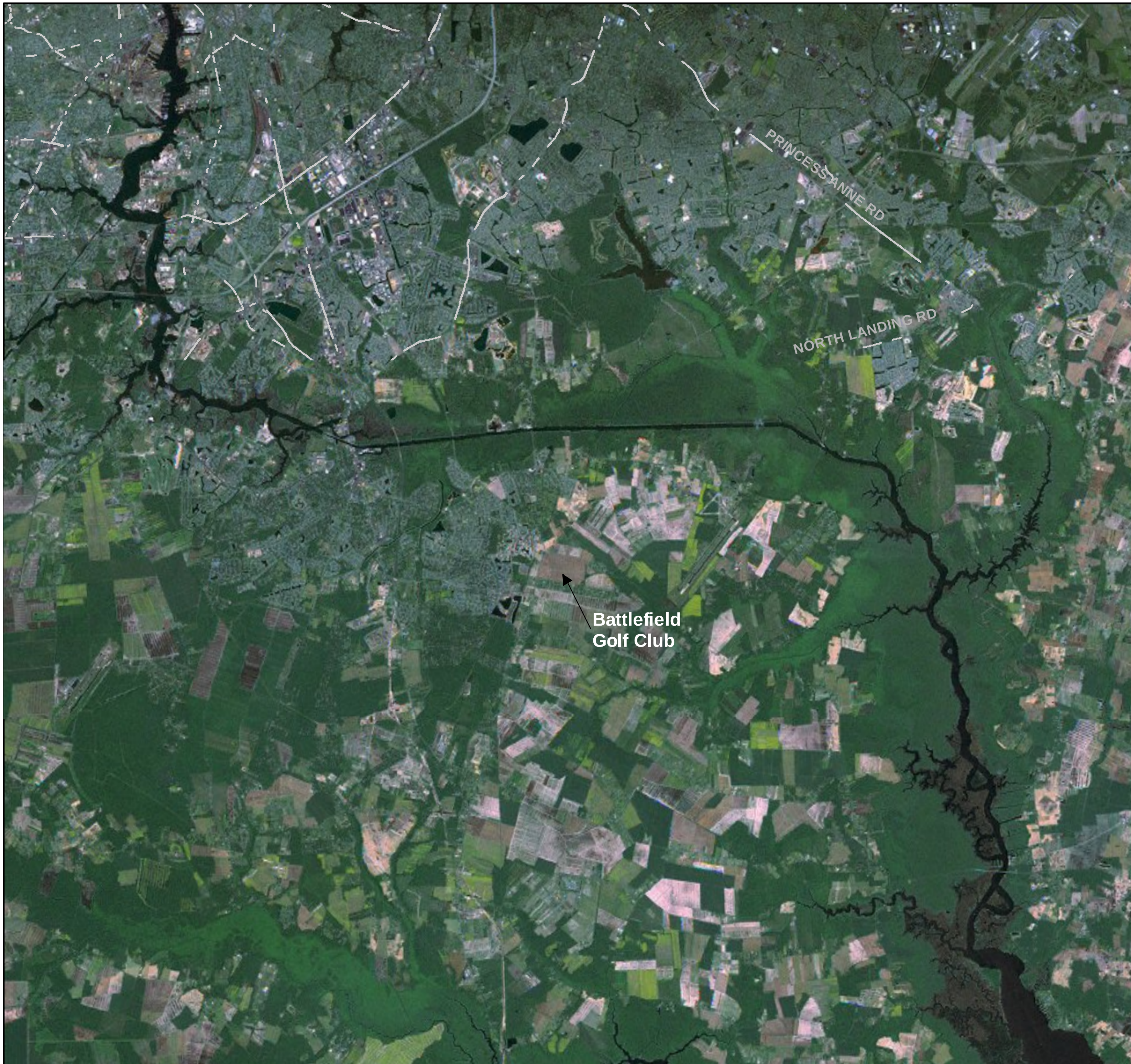
In the study area, three were tested for water quality by the City in July 2008; three had water quality tests performed in 2008, one in 2005, and another one in 1996.

2.4 Drinking Water Regulations

2.4.1 Introduction

The enactment by Congress in 1893 of the Interstate Quarantine Act provided federal authority to establish standards for drinking water systems. The first formal and comprehensive review and investigation of drinking water concerns was initiated in 1913. Federal regulation of drinking water began in 1914, when the U.S. Public Health Service set standards for the bacteriological quality of drinking water for contaminants capable of contagious disease. These standards were then revised and expanded in 1925, 1946, and 1962. The 1962 standards, regulating 28 substances, were the most comprehensive Federal drinking water standards in existence before the Safe Drinking Water Act (SDWA) of 1974.

In 1974 Congress passed the SDWA to ensure that public water supplies meet national standards that protect consumers from deleterious contaminants in the water. This law had



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Legend

Golf Club Boundary

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0 5,000 10,000 15,000 20,000 Feet

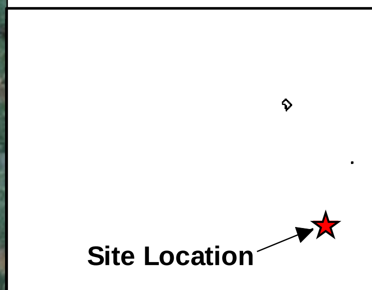


Figure 1
Site Location
Chesapeake, Virginia

G: Projects\Battlefield_Golf_Club\GIS\Projects\Location_Map.mxd significant amendments in 1986 and 1996 and is administered by the United States Environmental Protection Agency's Office of Groundwater and Drinking Water (EPA). These laws apply to all public water systems[1]. Both publicly or privately-owned community water systems are included in this definition.

2.4.2 Current Water Quality Regulations

The SDWA gave the EPA the authority to delegate the primary responsibility for enforcing drinking water regulations to states provided that they meet specific requirements. States that comply are considered to have "primacy." Virginia has assumed primacy and the State's Department of Health, Office of Drinking Water (VDH) receives grants from the EPA to help pay for the oversight of water systems. As a primacy state, Virginia drinking water regulations are at least as stringent as federal regulations. Appendix B presents the Water Quality Standards for the Commonwealth of Virginia. The Virginia Department of Environmental Quality (DEQ) is the agency in charge of enforcing water withdrawal and wastewater disposal regulations.

A summary of the EPA's National Primary Drinking Water Regulations and Secondary Drinking Water Regulations is presented in Appendix C. Primary Contaminants are legally enforceable standards that apply to public water supply systems. Primary standards protect public health by limiting the amount of contaminants in drinking water through maximum contaminant levels (MCLs). Contaminants may be microorganisms, inorganic chemicals, organic chemicals, disinfectants, disinfection-by-products, and radionuclides.

Secondary contaminants are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (e.g. tooth or skin discoloration) or aesthetic effects, such as taste, odors, or color in drinking water.

The following are also water quality regulations that apply to community or public water treatment plants and water distribution systems:

- EPA's Trihalomethane Regulation.
- EPA Requirement for Special Monitoring for Sodium and Corrosivity Characteristics.
- EPA's Phase I Regulations for 8 Volatile Organic Compounds (VOCs).
- EPA's Surface Water Treatment Rule (SWTR).
- EPA's revised Total Coliform Rule (TCR).
- EPA's Phase II Regulations for Synthetic Organic Compounds and Inorganic Compounds.
- EPA's Lead and Copper Rule.
- EPA's Phase V Drinking Water Regulations.
- EPA's Consumer Confidence Reports (CCRs).

[1] Public Water Systems provide water to at least 25 people or 15 service connections for at least 60 days per year. Today approximately 155,000 public water systems provide water to more than 292 million people.

- EPA's Stage 1 D/DBP Rule and the Interim Enhanced Surface Water Treatment Rule.
- EPA's Radionuclides Rule.
- EPA's Filter Backwashing Recycling Rule.
- EPA's Stage 2 D/DBP.
- EPA's Long-term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR).

Additionally, under the 1996 amendment to the SDWA the EPA publishes guidance to primacy states to carry out source water assessments within the state's boundary. This establishes a coordinated and comprehensive protection of groundwater resources within a state.

2.4.3 Contaminant Candidate List

The SDWA includes a process that the EPA must follow to identify new contaminants that may require future regulation. This list serves as the starting point for future regulations. The contaminants on this list are not subject to any current or proposed drinking water regulation. These contaminants are known or anticipated to occur in public water systems and may, in the future, require regulation. In February 2005, the EPA published the second Contaminant Candidate List (CCL) of 51 potential contaminants. Appendix D is a fact sheet of the Drinking Water Contaminant Candidate List published by the EPA along with a list of the chemical contaminant candidates. On February 21, 2008 the EPA published a draft of the third CCL in the Federal Registrar. This is presented in Appendix E.

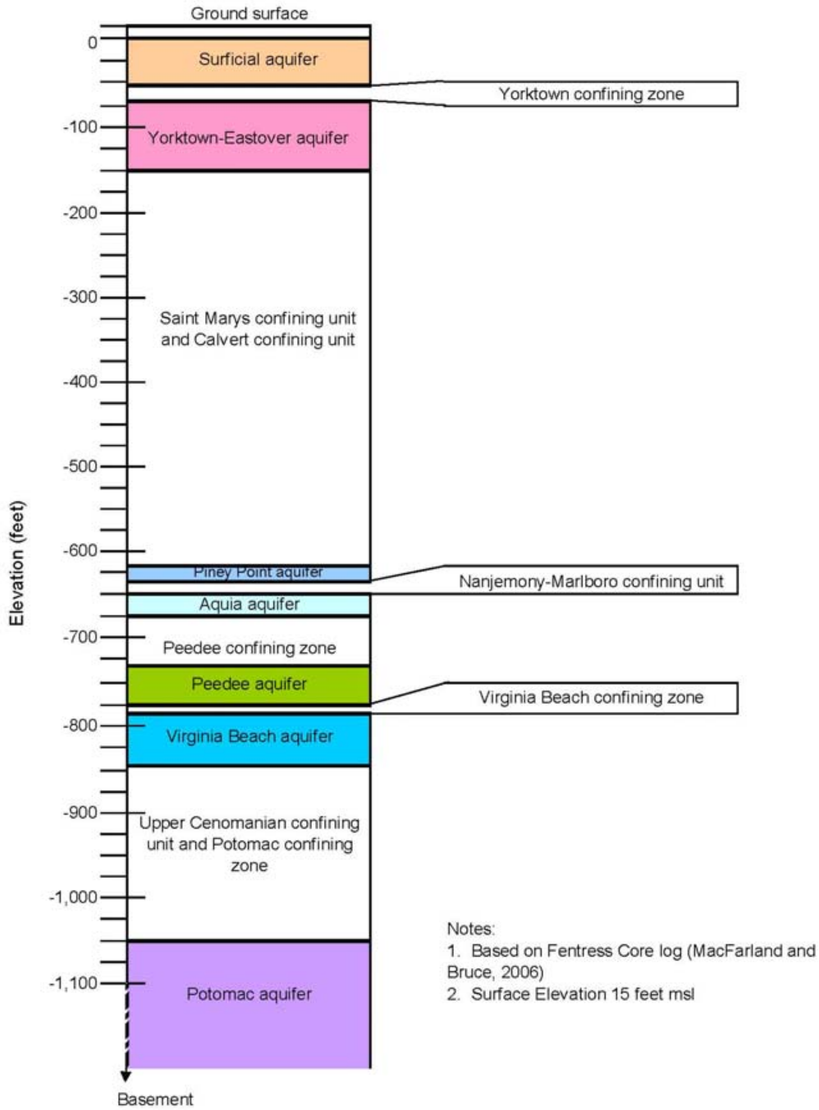
3.0 GROUNDWATER CONDITIONS

3.1 Regional Geology and Hydrogeology

The project area is located within the Coastal Plain Physiographic Province of Virginia. The Virginia Coastal Plain is "underlain by a seaward-dipping strata of unconsolidated to partially consolidated sediments of Cretaceous, Tertiary, and Quaternary age that unconformably overlie a basement of consolidated bedrock" (MacFarland and Bruce, 2006). This "wedge" of sediments extends from the Fall Line located near Richmond, VA and thickens to the east, and is estimated to reach a thickness in excess of 3,000 feet in the Chesapeake area.

The most recent published literature describes seven discrete aquifers and eight confining units that separate the aquifers in the vicinity of the project area. Each of these units is briefly discussed, from the deepest to the shallowest, in this section based on the interpretations presented in MacFarland and Bruce (2006) of lithologic and geophysical logs obtained from the Fentress Core. Figure 2 illustrates the location of the Fentress test wells/core. As the study area is located approximately two miles to the west (up dip) of this core hole, the actual depths will be somewhat shallower (+/- 10 to 20 feet) and the units will typically be thinner (+/- 10 feet). Figure 3 presents a stratigraphic cross-section of these units based on the Fentress Core.

Figure 3
General Hydrogeologic Section



The Potomac aquifer is the deepest aquifer in the area and directly overlies the bedrock. Historically, this aquifer was divided into three separate aquifers, termed the Lower, Middle, and Upper Potomac aquifers (Meng and Harsh, 1988). However, recent studies have concluded that the confining units described in previous studies are probably not present, and for purposes of this study, the Potomac aquifer is defined as a single aquifer as described by MacFarland and Bruce (2006).

The top of the Potomac aquifer is encountered at a depth of approximately 1,065 feet below ground surface (bgs), and extends to depths in excess of 3,000 feet. Because of its large lateral extent and coarse grained sediments, this aquifer is one of the predominantly used aquifers in the Virginia Coastal Plain. Capable of providing large quantities of groundwater, its depth and the brackish nature of its water quality in the eastern portion of

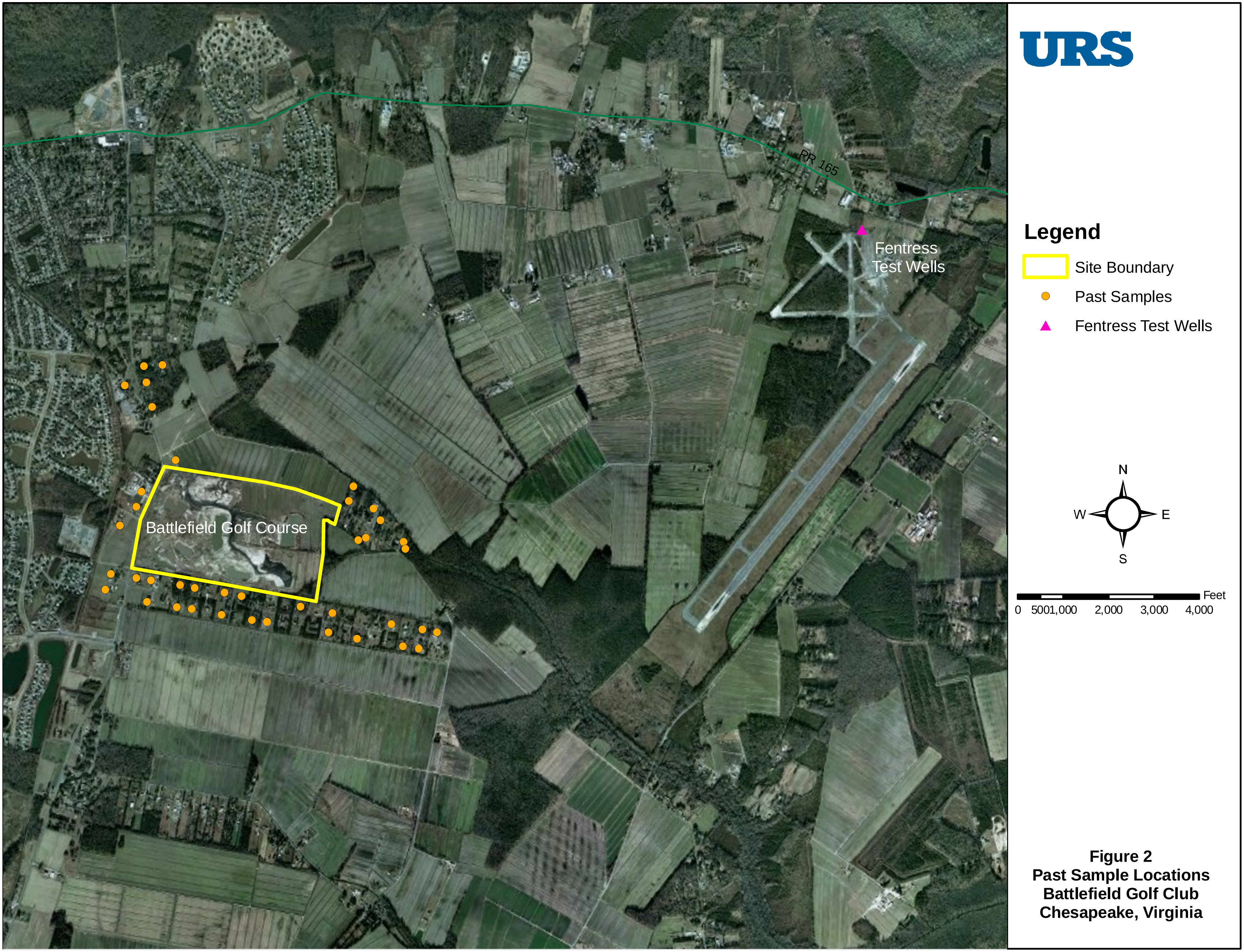


Figure 2
Past Sample Locations
Battlefield Golf Club
Chesapeake, Virginia

G: Projects\Bat lefield_Golf_Club\GIS\Projects\Samples.mxd the state limit its use to major water supply systems for industrial and municipal use, and the water must be treated to achieve potable water quality.

The Potomac Aquifer is overlain by the Potomac confining zone and the Upper Cenomanian confining unit that form a 200-foot thick sequence of fine grained sandy and silty clays. These confining beds are overlain by the Virginia Beach aquifer which is comprised of well-sorted sands. Extending from depths of approximately 800 feet to 855 feet bgs, this aquifer also has relatively poor water quality owing to its brackish nature, and water supplies obtained from this unit require treatment to achieve potable water quality.

The Virginia Beach confining zone overlies the Virginia Beach aquifer and is approximately 15 feet thick. The Peedee aquifer overlies the Virginia Beach confining zone and extends from depths of approximately 755 to 790 feet bgs. Owing to its depth, and limited areal extent in just the southern portions of Chesapeake and Virginia Beach, the Peedee aquifer it is considered to be unused as a source of groundwater in Virginia. It also is considered to contain brackish water; thus requiring treatment prior to use as a potable water source.

The Peedee confining zone overlies the Peedee aquifer, and is approximately 60 feet thick. The Aquia aquifer overlies the Peedee confining zone and extends from depths of approximately 665 to 690 feet bgs. The Aquia aquifer is a widespread aquifer in the Virginia Coastal Plain, and is comprised of medium- to coarse-grained sand. Due to its relative thinness, the Aquia aquifer is not a major water supply source, and wells installed into this aquifer typically do not produce quantities of water needed for large industrial, commercial, or municipal use in the area. This aquifer also contains brackish water, requiring the need for treatment prior to potable use.

The Nanjemony-Marlboro confining unit overlies the Aquia aquifer and is approximately 15 feet thick. The Piney Point aquifer overlies the Nanjemony-Marlboro confining unit, and extends from depths of approximately 630 to 650 feet bgs. A laterally extensive aquifer, it is a moderately used aquifer that provides water to small towns and can be used for low-density residential development. However, south of the James River, the Piney Point aquifer is not considered to be a productive groundwater source.

The Calvert confining unit overlies the Piney Point aquifer and is approximately 15 feet thick. This unit is overlain by the Saint Mary’s confining unit that measures approximately 425 feet thick. Together these two units comprise an extensive confining unit that separates the underlying Piney Point aquifer from the Yorktown-Eastover aquifer. The Yorktown-Eastover aquifer extends from depths of approximately 85 to 185 feet bgs. A laterally extensive aquifer across the Virginia Coastal Plain, this aquifer is heavily used as a groundwater supply source. With interbedded fossiliferous sands, water-supply well yields range from 10 to 300 gallons per minute (gpm), and average nearly 90 gpm (Siudyla, et al., 1981) with larger production wells located along the eastern shore of Virginia producing up to 300 gpm.

Water quality of the Yorktown-Eastover aquifer is typically good, although salinity is reported to increase with depth, particularly if wells are drilled into the finer grained and less productive Calvert confining unit that underlies the aquifer. Iron may also be present in local areas, and poses taste and staining issues.

The Yorktown confining zone overlies the Yorktown-Eastover aquifer and is approximately 15 feet thick. Based on the amount of silt and clay present, this unit varies laterally and in certain locations where coarser sediments are present, it does not serve as a confining unit between the Yorktown-Eastover aquifer and the Surficial aquifer.

Formerly referred to as the Columbia aquifer, the Surficial aquifer lies above the Yorktown confining zone and is an unconfined, water table aquifer that exists within sands that are interbedded with laterally discontinuous silts and clays. Extending to a depth of approximately 70 feet bgs, the Surficial aquifer serves as a water supply source of shallow water, although sustained well yields are typically less than 25 gpm. As a result of its existence as a water table aquifer, it is continuously recharged as fresh water infiltrates from precipitation. In general, the water quality is good, although iron, manganese, and sulfate may pose taste and discoloration issues locally, and because the aquifer is not confined, it may be subject to degradation from pollution.

3.2 Study Area Geology and Hydrogeology

To supplement the published literature and gain a greater understanding of the study area, hydrogeological data gathered during previous investigations at the Battlefield Golf Club were reviewed, and residential well records were obtained from the City of Chesapeake Health Department. In addition, two monitoring wells (MW-1 and MW-2) were installed as part of this study as detailed in Appendix F to gain an understanding of the local stratigraphy and hydrogeologic relationship between the Surficial aquifer and the underlying Yorktown-Eastover aquifer. Figure 4 depicts the locations of the two wells.

Based on the lithologic logs from the wells installed at the end of Bonney Road (see Appendix F) as part of this study, the Surficial aquifer was found to extend to a depth of 52 feet bgs where lean clays indicative of the Yorktown confining zone were encountered. These clays extended for 10 feet, and then sands indicative of the Yorktown-Eastover aquifer were encountered.

As part of this study, two undisturbed tube samples were collected from the Yorktown confining zone and vertical permeability tests indicate hydraulic conductivities of 8.3×10^{-7} centimeters per second (cm/sec) from the 55-57 feet bgs sample and 1.7×10^{-6} cm/sec from the 60-62 feet bgs sample. Appendix F contains the testing results.

Water level measurements were obtained from wells MW-1 and MW-2 installed as part of this study from December 10, 2008 through January 15, 2009 (see Appendix F). Well MW-1 was installed into the Yorktown-Eastover aquifer and well MW-2 was installed into the Surficial aquifer. The portion of the Yorktown-Eastover aquifer screened in well MW-

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Legend

Golf Club Boundary

Monitoring Well

Residential Well Samples

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W E

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500 1,000 1,500 Feet

Figure 4
Residential Sampling Locations
Chesapeake, Virginia

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1 was comprised of lean clays, clayey sand, and silty sand, and was not a productive water bearing zone. Consequently, during well development, the well was pumped dry, and the water level recovery was very slow. This is evidenced by the water levels recorded in well MW-1 which slowly rose over the monitoring period.

Based on the water levels measured in these two wells, and the reduced rate of recovery of the water level in well MW-1, it appears that the potentiometric surface of groundwater in the Yorktown-Eastover aquifer is approximately 1.5 feet lower than the water level in the Surficial aquifer. Using the mid-point of the screened intervals (40 feet bgs at MW-2 and 85 feet bgs in MW-1), a downward vertical gradient of approximately 0.03 ft/ft is calculated. This gradient indicates that the Yorktown confining zone retards the vertical migration of groundwater from the Surficial aquifer downward into the Yorktown-Eastover aquifer at the location of these wells as would be expected given the low vertical permeability of the lean clays encountered between the Surficial and Yorktown-Eastover aquifers, mentioned above.

While at the location of wells MW-1 and MW-2, the Yorktown confining zone appears to act as a confining unit, this unit is typically not extensively mappable as a confining unit, and when present, is usually leaky (T. Scott Bruce, DEQ, personal communication, 2008). A review of lithologic logs obtained from residential wells in the area obtained did not identify the Yorktown confining zone as being present, although the quality of the logs, which are typically made from soil cuttings observed during drilling, may not be an accurate representation of the stratigraphy in the area.

Based on the data obtained, it is concluded that, where present, the Yorktown confining zone may serve to retard the migration of groundwater from the Surficial aquifer downward into the Yorktown-Eastover aquifer. However, leakage through the Yorktown Confining zone occurs, albeit slowly, and if this confining zone is not present or has a higher sand content, groundwater in the Surficial aquifer will migrate into the underlying Yorktown-Eastover aquifer.

3.3 Project Area Groundwater Use

The properties within the study area utilize private water supply wells for domestic and small business use. Groundwater is also used for feeding livestock. The upper two aquifers, the Surficial and the partially confined Yorktown-Eastover Aquifer, are the major sources for the local water supply wells. Water levels obtained from wells installed at the Battlefield Golf Club as reported by Kimley-Horn and Associates (2008) indicate that groundwater flow in the unconfined Surficial aquifer is toward the southeast, away from the homes and businesses located west of South Centerville Turnpike.

To avoid potential contamination that potentially may occur in the future in the Surficial aquifer, the Yorktown-Eastover aquifer will be considered the main groundwater source for any proposed well installation, private or community systems. For the purpose of this study it has been assumed that all individual supply wells are capable of producing 400 gallons per day to be consistent with the Virginia “Waterworks Regulations”.

3.4 Existing Well Groundwater Quality

3.4.1 Well Information

Well records were located for 29 wells in the region at the City of Chesapeake Health Department. Among them, well yield information is available for 14 of the wells. Well information is summarized in Table 1 of Appendix G.

The average well yield is 19 gpm and the average well depth is 71 ft bgs. The screen interval data was reviewed to evaluate which wells withdraw water in the unconfined Surficial water table aquifer and which wells withdraw from the uppermost partially confined aquifer (Yorktown-Eastover aquifer). A small majority of the 29 wells with supporting data are believed to utilize water from the Surficial aquifer based on the recorded screen intervals. The remainder of the wells are advanced to deeper depths and resumed to be part of the Yorktown-Eastover aquifer.

3.4.2 Existing Well Water Quality Data

Past groundwater quality data for local water supply wells is summarized in Table 2 of Appendix G.

November and December 2001 Groundwater Tests

In November and December 2001, prior to the commencement of Battlefield Golf Course construction, 43 groundwater samples were taken from 40 homes in the region (Stokes Environmental Associates, Ltd., 2002). Sampling locations are indicated in Figure 4. Tests were conducted for the following elements:

- Primary contaminants: antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), copper (Cu), cyanide (CN), fluoride (F), mercury (Hg), lead (Pb), selenium (Se), thallium (Tl)
- Secondary contaminants: iron (Fe), manganese (Mn), silver (Ag), zinc (Zn)
- Other unregulated elements: nickel (Ni)

The test results indicate naturally elevated iron and manganese levels in the local groundwater, can be used as the baseline water quality data, and are summarized with respect to SDWA levels as indicated below:

Constituent	Detected	Above Regulatory Limit	Comments
Antimony (Sb)	No		
Arsenic (As)		No	Found at isolated locations
Barium (Ba)	No		
Beryllium (Be)		No	Found at isolated locations
Cadmium (Cd)		No	Found at 20 locations
Chromium (Cr)		No	Found at 5 locations
Copper (Cu)		2 Locations Above Primary Limit (1.30 mg/L)	Found at 9 locations
Cyanide (Cn)	No		
Fluoride (F)		No	Found at 29 locations
Iron (Fe)		16 Locations Above Secondary Limit (0.30 mg/L)	Found at 24 locations
Lead (Pb)		No	Found at 17 locations
Manganese (Mn)		9 Locations Above Secondary Limit (0.05 mg/L)	Found at 11 locations
Mercury (Hg)		No	Found at isolated locations
Nickel (Ni)	No		
Selenium (Se)	No		
Silver (Ag)		No	Found at isolated locations
Thallium (Tl)		1 Location Above Primary Limit (0.002 mg/L)	Found at 11 locations
Zinc (ZN)		No	Found at 7 locations

April and May 2008 Groundwater Tests

In April and May 2008, 89 samples were drawn from 81 homes in the region and were tested for the presence of the following ten elements.

- Primary contaminants: arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), mercury (Hg), lead (Pb), selenium (Se)
- Secondary contaminants: silver (Ag)
- Other unregulated elements: boron (B), vanadium (V)

Test results reflect the following:

Constituent	Detected	Above Regulatory Limit	Comments
Arsenic (As)	No		
Barium (Ba)		No	Found at 53 locations. Compared with the baseline data, the higher detectible rate was likely due to the lower detectible limit of the current test method.
Boron (B)		3 Locations Above World Health Organization (WHO) recommended limit (0.50 mg/L)	Found at nearly all the tested homes
Cadmium (Cd)		No	Found at 12 locations
Chromium (Cr)		No	Found at 1 location
Lead (Pb)		3 Locations Above "Action Level" (0.015 mg/L)	Found at 37 locations
Mercury (Hg)	No		
Selenium (Se)	No		
Silver (Ag)	No		
Vanadium (V)	No		
Zinc (Zn)		No	Found at 7 locations

July 2008 Groundwater Tests

In July 2008, the City retested the 24 homes along Murray Drive and Whittamore Road. Besides the ten elements originally tested in April 2008, four new elements were added in this round of tests. They were cobalt (Co), nickel (Ni), zinc (Zn) and manganese (Mn). Of these, manganese (Mn) and zinc (Zn) are regulated as secondary contaminants. Nickel (Ni), zinc (Zn) and manganese (Mn) were the elements in the baseline test.

According to the City's documentation, test results reflect the following:

Constituent	Detected	Above Regulatory Limit	Comments
Arsenic (As)	No		
Barium (Ba)		No	Found at 9 locations
Boron (B)		2 Locations Above World Health Organization (WHO) recommended limit (0.50 mg/L)	Found at all the tested locations
Cadmium (Cd)	No		
Chromium (Cr)	No		
Cobalt (Co)	No		
Lead (Pb)		1 Location Above "Action Level" (0.015 mg/L)	Found at 5 locations
Manganese (Mn)		At least 7 Secondary Limit (0.05 mg/L)	Found at 15 locations
Mercury (Hg)	No		
Nickel (Ni)	No		
Selenium (Se)		No	Found at 3 locations
Silver (Ag)	No		
Vanadium (V)	No		
Zinc (Zn)		No	Found at 10 locations

Based on the analysis on the past water quality tests, the existing water supply wells in the region have naturally high levels of iron and manganese, both of which are regulated as "secondary" contaminants. Approximately 40% of the wells exceed the secondary limit for iron, and 30% exceed the secondary limit for manganese. The elevated iron and manganese level were also observed by the local residents on the homeowner questionnaire. Boron was detected in local groundwater supply during the 2008 tests. The most recent test shows approximately 10% of the 24 tested wells had a boron level above the WHO recommended limit.

December 2008 Well Water Quality Data

Following the contact of selected homeowners by URS, water samples were collected on December 23, 2008 from two residences on Murray Drive:

- Sample A (Yorktown-Eastover aquifer well – 80 ft deep, screened from 67ft – 80ft)
- Sample B (Surficial aquifer well – 50 ft deep, screened from 40ft – 50 ft)

The results of the analytical tests are included in Appendix F. In summary, the water quality meets the primary drinking water regulations at both locations. However, the shallower well on Murray Drive exceeded the secondary drinking water criteria for iron, manganese, and aluminum, while the deeper well on Murray Drive met all primary and secondary drinking water criteria.

3.5 Background Well Water Quality Data

The aquifer water quality data was obtained from DEQ and has been evaluated to determine the appropriate aquifer to be utilized as the community potable water supply.

This data comes from a set of observation wells (Fentress Test Wells) installed approximately 2.5 miles to the east/northeast of the project area as illustrated in Figure 2. The information for 12 observation wells is summarized in Table 1.

Table 1 DEQ Observation Wells Summary

Well Name	Screen Interval (Elev MSL)	Aquifer
91-A / 61B 2	-77 to -82	Yorktown Eastover
91-B / 61B 5	-1,025 to -1,045	Potomac (top)
91-C / 61B 6	-745 to -765	Peedee
91-D / 61B 7	- 2 to -7	Surficial/Columbia
91-E / 61B 12	-1,806 to -1,816	Potomac
91-F / 61B 13	-1,365 to -1,365	Potomac
91-G / 61B 14	-1,078 to -1,088	Potomac (top)
91-H / 61B 15	-744 to -754	Peedee
91-J / 61B 16	-665 to -675	Aquia
91-K / 61B 17	-73 to -83	Yorktown Eastover
91-L / 61B 18	-42 to -52	Surficial/Columbia
91-M / 61B 19	5 to -5	Surficial/Columbia

Based on the screen interval data, three wells (91-D, -L and -M) are believed to be supplied by the Surficial aquifer. The water quality data for these wells is summarized in Table 2 along with the regulatory limits of the contaminants. Water in this uppermost aquifer appeared to have high levels of iron (Fe) and manganese (Mn), which exceeded the secondary drinking water standard. Two wells had a pH value of 5.7, which is also outside the secondary criteria range.

Table 2 Surficial Aquifer Water Quality

Parameter	Units	Secondary MCL	91-D	91-L	91-M
pH	std. units	6.5-8.5	5.7	6.5	5.7
HCO_3^-	mg/L		90	90	90
CO_3^{2-}	mg/L		0.0	0.0	0.0
Alkalinity	mg/L as $CaCO_3$		74	74	74
ANC	mg/L		64	116	62
Hardness	mg/L as $CaCO_3$		72	87	38
Ca^{2+}	mg/L		11.5	27.0	6.2
Mg^{2+}	mg/L		10.4	4.8	5.4
Na^+	mg/L		17.9	21.0	17.0
K^+	mg/L		1.1	3.3	1.1
Cl^-	mg/L	250	24.0	18.0	17.0
SO_4^{2-}	mg/L	250	12.0	11.0	15.0
SiO_2	mg/L		20.0	44.0	19.0
Fe_T	mg/L	0.30	12.0	5.0	13.0
Mn_T	mg/L	0.05	0.24	0.14	0.24
Al_T	mg/L	0.05- 0.20	0.020	0.020	0.020
TDS	mg/L	500	159	191	134
Specific Conductance	μS/cm		325	278	208
B – Boron*	mg/L		0.04	0.05	0.02

* Boron -WHO recommended limit of 0.5 mg/L.

There are two wells, 91-A and -K, with screen interval between -73 feet (MSL) and -83 feet (MSL). These wells are believed to be supplied by the Yorktown-Eastover aquifer. The water quality data, shown in Table 3, indicate high levels of hardness, chloride (Cl), iron (Fe) and total dissolved solids (TDS), and slightly elevated levels of boron (B). Water with a hardness of 250 mg/L (as $CaCO_3$) is usually considered as very hard. The levels of chloride, iron and TDS were above the secondary limits.

Table 3 Yorktown-Eastover Aquifer Water Quality

Parameter	Units	Secondary MCL	91-A	91-K
pH	std. units	6.5-8.5	7.4	7.3
HCO_3^-	mg/L		331	
CO_3^{2-}	mg/L		0	
Alkalinity	mg/L as $CaCO_3$		271	282
ANC	mg/L		291	276
Hardness	mg/L as $CaCO_3$		250	240
Ca^{2+}	mg/L		57.4	54.0
Mg^{2+}	mg/L		26.3	26.0
Na^+	mg/L		210	240
K^+	mg/L		22.8	21.0
Cl^-	mg/L	250	358	340
SO_4^{2-}	mg/L	250		20.0
SiO_2	mg/L		42.4	36.0
Fe_T	mg/L	0.30	5.00	1.00
Mn_T	mg/L	0.05	0.05	0.012
Al_T	mg/L	0.05 - 0.20	0.02	0.01
TDS	mg/L	500	1,070	905
Specific Conductance	μS/cm		1620	1620
B – Boron*	mg/L		0.47	0.32

* Boron -WHO recommended limit of 0.50 mg/L.

The DEQ data set also include two wells which advance deeply into the Upper Potomac aquifer with a screen interval between -1,025 feet (MSL) and -1,088 feet (MSL). The water quality in this aquifer shows decreases in both hardness and iron. However, significantly higher levels of chlorides and TDS in the Upper Potomac make the Yorktown-Eastover aquifer more appealing as a community potable water supply.

All background DEQ water quality summary information can be found in Appendix H.

3.6 Battlefield Golf Course Groundwater Quality

Kimley-Horn and Associates, Inc installed three monitoring wells at the Battlefield Golf Course on May 15, 2008. Groundwater samples were taken and tested in May, July and August 2008. Meanwhile, groundwater samples were also taken from three monitoring wells located outside of the golf course in July. All the test results are summarized in Appendix I.

Table 2A in Appendix I demonstrates the metal analysis for three onsite monitoring wells. Below is a list of the constituents exceeding the drinking water standards:

- Aluminum (Al) – average at approximately 56.0 mg/L (above the secondary limit of 0.20 mg/L)
- Arsenic (As) – average at approximately 0.053 mg/L (above the secondary limit of 0.010 mg/L)
- Chromium (Cr) – average at approximately 0.126 mg/L (slightly above the primary limit of 0.10 mg/L)
- Iron (Fe) – average at approximately 101.80 mg/L (above the secondary limit of 0.30 mg/L)
- Lead (Pb) – average at approximately 0.047 mg/L (above the “action level” of 0.015 mg/L)
- Manganese (Mn) – average at approximately 0.784 mg/L (above the secondary limit of 0.050 mg/L)

Table 2B in Appendix I summarizes the metal analysis for the three offsite monitoring wells. Except for one offsite monitoring well having a high level of beryllium (Be), the results indicate lower levels of constituents in the offsite groundwater samples than those from the golf course groundwater samples. However, the levels of aluminum, iron and manganese at all offsite locations and the level of lead at two offsite locations still exceeded the drinking water standards.

Table 3A in Appendix I shows that the groundwater samples taken from the golf course met the secondary drinking water criteria for the classical chemical parameters, chloride (Cl), fluoride (F), sulfate (SO_4), and total dissolved solids (TDS).

4.0 WATER SUPPLY ALTERNATIVES

Based on the City's concern for the public health of the community from the potential contamination that may migrate from the Battlefield Golf Course to impact the private wells, URS investigated water supply alternatives to serve the adjacent properties. Common issues to all the alternatives include plumbing costs and water taste. All alternatives will require plumbing modifications for each homeowner or business. This will be necessary whether a house connection is made to a proposed distribution system or improvements are contained on-site, i.e. new well (Alternative 4) or Point of Entry Device (Alternative 3). A new water source, even if water is taken from the same aquifer, may taste different to different people. The New Community Water Supply Alternative (2) assumes chlorine as a disinfectant to maintain a residual in the distribution system. Consumers may observe a "chlorinous" taste due to the "free" chlorine residual. The City water system extension (Alternative 1) uses chloramines to maintain a residual in the distribution system. This type of residual typically imparts less of a chlorinous taste than free chlorine. No disinfectants are normally required with Alternatives 3 and 4.

4.1 Alternative 1 - Extend City of Chesapeake Water Distribution System

Presently the City of Chesapeake has two water treatment plants (WTPs) and contracts to purchase water from the cities of Norfolk and Portsmouth. Additional water is available from an auxiliary well source. These many sources give the City of Chesapeake the capacity to deliver the necessary quantity of water to all of the homes/businesses in the region of the Battlefield Golf Club. The City anticipates that the existing system has adequate water supply to handle future growth rates, at the current pace, until approximately 2040. A transmission main would be constructed from the City's existing water distribution system to extend the water services to the homes on Centerville Turnpike, Murray Drive, and Whittamore Road (See Exhibit 1). All of the water produced for the City of Chesapeake meets SDWA regulations. Chesapeake monitors over 100 contaminants, including herbicides, pesticides, radionuclides, heavy metals *Cryptosporidia*, *Giardia*, and coliform bacteria. Every year the City of Chesapeake publishes its consumer confidence report (CCR) detailing the water sources, purification processes, and the results of water quality testing[2] to ensure that all provision and standards set forth by the Safe Water Drinking Act (SDWA) are met. The 2008 CCR is presented in Appendix J. The water quality table details the highest level and range for the detected compounds found in the City of Chesapeake's drinking water. In summary, the water supply meets all regulations set forth by the Federal and State Agencies.

Under this alternative, the City of Chesapeake would construct, operate, and maintain the extended water supply system. The basic function of the City of Chesapeake would be to treat water from one of its sources to an acceptable quality, and deliver the desired quantity

[2] More than 195,000 analyses throughout the water treatment process are performed annually for regulatory compliance.

of water though the established distribution system and proposed extension to the study area.

4.1.1 Water Main Extension

The extension of the existing City water distribution system will require the installation of a 16-inch transmission main along Centerville Turnpike and a 10- and 8-inch distribution system along Murray Drive and Whittamore Road.

Centerville Turnpike is predominately a 50-foot wide right-of-way, containing a two lane major collector street with roadside ditches for stormwater drainage. Additional widening for a center turn lane has been added to Centerville Turnpike at Whittamore Road along with additional right-of-way. The road widening for a center turn lane extends south with variable widening to Murray Drive.

Centerville Turnpike

Murray Drive is a 50-foot right-of-way section with curb and gutter serving adjacent homes with connection to Whittamore Road. Whittamore Road is a narrow rural 30-foot right-of-way, containing a two lane pavement section, with roadside ditches. In places the ditches are deep and close to the edge of pavement.

Murray Drive

The 16-inch line begins with a connection to the existing 16-inch just north of Etheridge Manor Blvd. and extends northward on the west side of Centerville Turnpike to a connection point with the proposed 16-inch line installed as part of the Albemarle Acres project for a distance of 7,730 feet. This line will be reinforced for flow and pressure with a 16-inch connection between Fentress Road and Centerville Turnpike along Blue Ridge Road. The new 16-inch line is needed to meet domestic and fire protection needs for the users along Centerville Turnpike, Murray Drive and Whittamore Road. Typically the 16-inch line will be installed in the shoulder along Centerville. The existing roadside ditch

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Chesapeake VIRGINIA

BATTLEFIELD GOLF CLUB WATER PROJECT

EXTEND CITY WATER DISTRIBUTION SYSTEM
EXHIBIT 1

DATE	1/26/09
PROJ. #	11657474
DRAWN	MES
DESIGNED	SDE
CHECKED	PSF
PROJ. MGR.	SDE

SCALE
HORIZONTAL
VERTICAL
None

DWG NUMBER
SHEET NUMBER

STATUS
CONCEPTUAL LAYOUT

REVISION
-

will be relocated away from the edge of the road to create the corridor for the water line. Where needed, a "Drainage, Water and Sewer Easement" will be acquired for construction that extends beyond the right-of-way. The design of the 16-inch interconnecting main in Blue Ridge Road will be coordinated with the Department of Public Works road project for the relocation of Blue Ridge Road. Fire hydrants will be place at 500-foot intervals to provide fire protection along this route.

The Murray Drive-Whittamore Road loop will be a combination of 10 and 8-inch lines as needed to meet the fire protection requirements. The loop begins with a connection at the Murray Drive and Centerville Turnpike intersection. The new line will be placed 2-feet behind the south curb and gutter line along Murray Drive to the intersection with Whittamore Road for a distance of 7,300 feet. In several places, the line will transition to the pavement to avoid certain groups of trees and physical improvements at driveways. Most driveways will be cut to allow a trench to be excavated for the installation of the water main. The driveway section will be replaced with "in-kind" materials, i.e., concrete, asphalt, gravel, etc. The distribution system loop along Whittamore Road from Murray Drive to Centerville will be 8,100 in length and placed under the existing pavement. Fire hydrants will be placed at 500-foot intervals along both roadways for fire protection. Easement will be acquired along Whittamore Road for the placement and access of the fire hydrants and water meters.

Whittamore Road

4.1.2 Water Service Connections

Each residence will have a separate service connection to the City of Chesapeake water supply. The City's Department of Public Utilities will furnish, install and maintain the service line from its water distribution main to the water meter, including the meter facilities. The plumbing connection from the meter to the house will be installed and maintained by the customer at their own expense and in accordance with the local plumbing code.

Each service would be separately metered. Charges for all water use would be on a metered rate basis as determined by the classification of the service and the applicable rate schedule. Cost of a new service connection shall be as provided in the City's rate schedule[3].

[3]From the City of Chesapeake's web site the connection fee for a standard 5/8" residential water meter is $3,697 plus a $150 installation charge for a total of $3,847, exclusive of other plumbing fees on private property.

4.1.3 Distribution Supply/ Fire Protection

The water supply would be sufficient to meet various water demand conditions and to meet normal demands during emergencies, such as power outages and disasters. The supply sources meet maximum day demands that occur for several consecutive days and are capable of meeting peak hour demands using water supplied from storage facilities. The system would be designed so that if any portion of the supply is placed out of service due to malfunction or maintenance the maximum day demand can still be met.

The City of Chesapeake will also provide fire flow protection to the new service area. The system will be capable of providing a minimum of 1,000 gpm at a pressure of at least 25 psi. A normal design criterion is to sustain fire flows for a minimum of 2 hours. Typical service pressure will be consistent with water supply throughout the citywide distribution system and be on the order of 40-60 psi.

4.1.4 Other Considerations

This alternative would include periodic sampling provisions from a series of monitoring wells to be installed by the City in the immediate vicinity of the Golf Course. Samples would be analyzed for constituents that may potentially leach from the Golf Course flyash, including:

- Primary contaminants: arsenic (As), barium (Ba),), beryllium (Be), cadmium (Cd), chromium (Cr), mercury (Hg), lead (Pb), selenium (Se), thallium (Tl)
- Secondary contaminants: silver (Ag)
- Other unregulated elements: boron (B), vanadium (V)

In this manner, homeowners could continue to use their existing well if they so desire. If the levels of any of the above contaminants begin to rise in the monitoring wells in the future to unsatisfactory levels, the homeowner could then decide if he/she wants to connect to the City system. Prevailing City connections fees would apply. Any homeowner who continues to use their existing well should grant the City a release of liability for failure to connect to City water when water system improvements have been offered by the City.

Recent reports from the City’s Department of Public Works indicate that the existing Whittamore Road is built on a questionable subbase and complete roadway restoration should be included in the design.

4.1.5 Advantages/Disadvantages

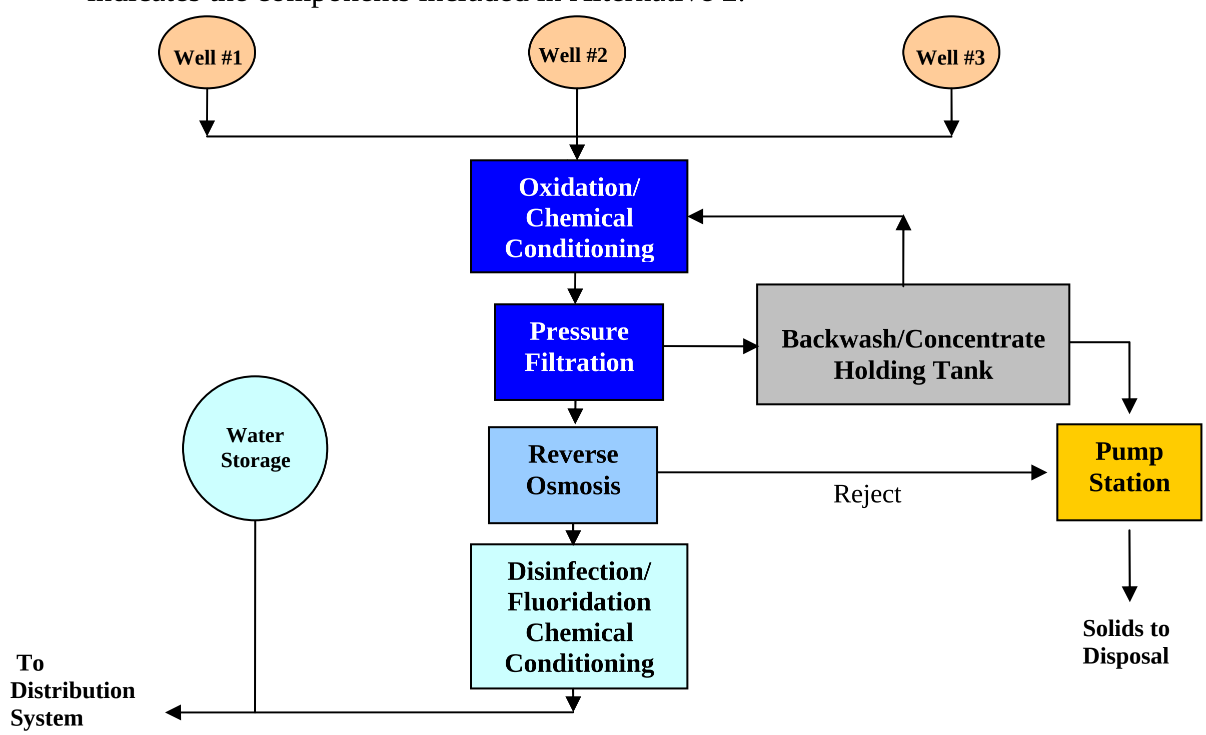
The advantages and disadvantages of providing an extension of the City distribution system to serve all homes in the study area include:

ADVANTAGES	DISADVANTAGES
• Access to the Highest Quality Water • Technically Easy Solution • Implemented Quickly • Benefit that eliminates Homeowner Operation and Maintenance Responsibility • Highest Level of Fire Protection • Protects Public Welfare • Minimizes Environmental Impact • Redundancy – Reliable Water • Possible Increase in Property Values	• Water Bill • Price of Connection Fee • Loss of Private Well * • Easements Necessary for Fire Hydrants, Water Meters & Drainage

* Private wells may be used for irrigation purposes provided a physical disconnection from the home's plumbing system is made.

4.2 Alternative 2 - New Community Water Supply System

The second alternative would be to provide a new community water supply system for the service area. This alternative would be a stand alone groundwater supply, treatment, and distribution system (See Exhibit 2). This alternative has five major functional components: raw water development (wells), raw water treatment, residuals and concentrate disposal, finished water storage, and finished water distribution as well as associated subcomponents. The subcomponents include valves, pumps, power transmission, fire hydrants, back-up generator, and control operations among others. The schematic below indicates the components included in Alternative 2.



4.2.1 Community Water Demand

There will be an assumed 100 homes to be provided water. The per diem water use per dwelling unit is 400 gallons per day (gpd). The expected community average daily use will be 40,000 gpd. The maximum daily demand will be much higher. Typical peaking factors (or multiplication factors) for water systems of this size are approximately 3.0 (for maximum daily demand compared to the average daily demand). The smaller the system the higher the peaking factor and this community system is considered a very small water system. A factor of 3.0 has been assumed such that the maximum daily demand is expected to be 120,000 gpd.

4.2.2 Raw Water Development: Proposed Aquifer Source

Based on its relatively shallow depth, reasonable water quality and productivity, and based on information from the hydrogeologic review, the Yorktown-Eastover aquifer was the selected source of water. The raw water characteristics have been summarized previously. The aquifer may be semi-confined in the study area and provides a mitigating aquitard that may retard the migration of potential contaminations from the Surficial aquifer while also having the least total dissolved solids of the other potential raw water sources. The Yorktown-Eastover aquifer is also a more generally treatable water source when compared to the other groundwater supplies available within the project area. Iron, manganese, zinc, and total dissolved solids (TDS) concentrations are above the EPA's secondary standards, but will be removed with treatment.

4.2.3 Proposed Well Information

Assuming an average need of 40,000 gallons per day (gpd), a maximum water quantity requirement of 120,000 gpd, and that the water needs to be produced in a 12 hour cycle, a well field capable of delivering 170 gpm is required to meet the maximum demand.

Based on published literature, production wells installed in the Yorktown-Eastover aquifer produce an average of 87 gpm with a reported range of 12 – 304 gpm (Siudyla, et al., 1981). For planning purposes, an average production rate of 90 gpm per well is assumed. VDH regulations require a minimum well production 50 gpm for this sized community. A total of two supply wells with one additional backup well is required to obtain the necessary quantity of water and provide a suitable backup for the system[4].

To avoid overlapping cones of depression that would reduce the yield of the well field; wells will need to be spaced a minimum of 1,500 feet apart, meaning that property for each well would need to be acquired and piping installed to transmit the water from each well to the treatment plant.

[4]*Recommended Standards for Water Works, Great Lakes – Upper Mississippi River Board of State Provincial Public Health and Environmental Standards* (Ten State Standards[4]) stipulates the total developed groundwater source capacity shall equal or exceed the maximum day demand with the largest production well out of service.

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BATTLEFIELD GOLF CLUB WATER PROJECT

COMMUNITY WELL
EXHIBIT 2

DATE	1/26/09
PROJ. #	11657474
DRAWN	MES
DESIGNED	SDE
CHECKED	PSF
PROJ. MGR.	SDE

SCALE
HORIZONTAL
VERTICAL
None

DWG NUMBER
SHEET NUMBER

STATUS
CONCEPTUAL LAYOUT

REVISION
-

4.2.4 Aquifer Water Quality and Treatment Requirements

The source of supply for the community system would be the Yorktown-Eastover Aquifer. The water quality of this source has been discussed in Section 3.5. There are several secondary drinking water levels that are expected to be exceeded prior to treatment and are illustrated below.

Contaminant	Expected Concentration Range (mg/L)	Secondary Standard (mg/L)
Iron - Fe	1.00 - 5.00	0.30
Manganese - Mn	0.012 - 0.050	0.05
Zinc - Zn	6.00 - 8.00	5.00
Chloride - Cl	340 - 350	250
Total Dissolved Solids - TDS	905 -1,070	500

Water with high levels of salts, measured as TDS, are less than palatable to consumers and impart a salty taste to the water. The EPA's secondary drinking water standard for aesthetic quality is 500 mg/L TDS; the World Health Organization guideline is 1,000 mg/L TDS maximum. Thus 905 – 1,070 mg/L is not within this range of 500 – 1,000 mg/L for the marginal acceptability of a water source as a drinking water supply. Removal of salts requires demineralization by ion exchange, electrodialysis, or reverse osmosis. While it is obvious that a new water treatment facility must meet the present drinking water regulations it is also prudent to consider future drinking water standards when planning a new treatment facility. Reverse Osmosis (RO), in addition to removing TDS, is capable of removing virtually all other contaminants present in a raw water source.

Other secondary contaminants in the water including iron, manganese, and zinc are also elevated. While the zinc and manganese concentrations are nearing their respectively taste thresholds, iron is significantly elevated. These contaminants are also problematic foulants to reverse osmosis membranes. Thus a pre-treatment system is required to remove these contaminants.

4.2.5 Reverse Osmosis Treatment

RO membrane filtration produces superior water that can meet even the most stringent drinking water regulations. The RO treatment acts as barrier to potential contaminants of the aquifer water source. RO is a physical process in which suitably pretreated water is delivered at moderate

Reverse Osmosis Unit

pressures against a semi-permeable membrane. The principle theory of RO is applying a pressure greater than the osmotic pressure of water. This pressure causes water to pass through a semi-permeable membrane from the high TDS side of the membrane to the lower TDS side. The membrane is designed to reject the salts in the water. The membrane rejects most solutes, ions and molecules, while allowing water of very low mineral content to pass. The phenomena by which certain membranes reject different species of ions differently is very complex. Nevertheless, an RO process produces a concentrated waste stream in addition to a clear permeate product. Reverse Osmosis systems have been successfully applied to saline ground waters, brackish waters, and seawater as well as for inorganic contaminants and other contaminants such as pesticides, viruses, bacteria, and protozoa and are presently used by the City of Chesapeake at the Northwest River Water Treatment Facility. For this community system the RO units would have a 2-pass configuration to minimize the volume of concentrate production due to the location of the facility and to enhance water recovery. Appendix M presents a detailed depiction of an RO system and is associated components sized for the community water system.

A generalized summary of contaminant removal capabilities of RO is shown in the Table below. Such removal rates are dependent upon many factors.[5]

Contaminant	Percent Removal
Inorganics	90 – 99
Volatile Organic Compounds	5 – 50
Pesticides and Synthetic Organic Compounds	90 – 99
Microbiological	> 99
Radiological	90 – 99

4.2.6 Pre-Treatment Processes

Pretreatment would be necessary to remove the elevated iron in the water. The precipitation/filtration process is a well known technology for iron removal. The process initially oxidizes the raw water to change the iron, manganese and other reduced species to an oxidized form which form insoluble precipitates with hydroxide ions in the water. Additional chemicals may also be necessary to adjust pH to an optimal level and to assist in the agglomeration of particles for filtration. Filtration occurs in pressure filter vessels where the insoluble iron/manganese particles are trapped in the media. The filters are backwashed once the vessels reach a predefined pressure differential which results from ferric hydroxide precipitate building up within the filter. Backwash waters can be voluminous and need proper management and the resulting concentrated solids must be handled either by sludge removal or pumped via a force main to the sanitary sewer system.

[5] These include membrane type, feed water pressures, number of passes, among others.

The pretreatment is also necessary to condition the raw water so that is does not damage the reverse osmosis equipment. All total suspended solids (TSS), oxidizable elements, scaling compounds must be significantly removed to reduce operational costs associated with RO water production.

4.2.7 Permitting Requirements

The project area is located within the Eastern Virginia Groundwater Management Area (9VAC 25-600-20), and the groundwater withdrawn for community well systems are permitted by DEQ. This alternative is projected to withdraw an average of more than 1 million gallons per month from the Yorktown-Eastover aquifer. In accordance with Virginia's Groundwater Management Act of 1992 (VA Code 62.1-254 et seq. and Virginia's Ground Water Withdrawal Regulations (VA Administrative Code 9 VAC 25-610-10 et seq.) a Ground Water Withdrawal Permit is required as more than 300,000 gallons of groundwater will be withdrawn per month under this alternative.

This process typically consists of preparing a Permit Application consisting of the installation of a test well, conduct of an aquifer test, and compilation of information in support of the permit application. This permit application is submitted to the DEQ and a public hearing is typically required. The test well is typically converted to one of the production wells to minimize capital costs.

As the Yorktown-Eastover aquifer is relatively heavily used in the region, additional withdrawals will be closely scrutinized by DEQ. In addition, one of the criteria that DEQ uses to evaluate these permit applications is the availability of alternative water sources (i.e., existing municipal water supplies). In light of the City's willingness to extend City water to this area, DEQ may not grant the permit because an alternate source is available.

The implementation of an RO facility requires that national, state, and local environmental regulations are met as well as local land use and zoning regulations. The water quality standards that the new facility must meet have been detailed extensively in Section 2.4. The waste disposal permitting associated with the concentrate disposal will require considerable effort. Regulations that pertain to concentrate discharge are complex and stringent. One initially discussed disposal alternative of delivering the brine to the Chesapeake Northwest River WTP and combining the waste stream with the brine produced at that plant has been rejected by the City because of such rigorous and inflexible permitting requirements that are presently in place at the facility. The present alternative to handle the liquid wastes generated by the proposed water treatment facility include the construction of a pump station and force main to convey the reject and backwash waters to the Hampton Roads Sanitation District's (HRSD) transport and treatment facilities. Approval from HRSD would be required for the disposal of brine waste originating from the RO facilities. (It should be noted that the study area of the City is not contained within the Sewer Service Franchise Area. This would require City Council approval to allow wastewater to be discharged into the City's sanitary sewer system.) Considering potential contaminants that may be introduced and that concentrated brine waste will be introduced (specifically chloride), it is unlikely that HRSD would accept the waste as it would interfere with treatment or reduce re-use options of their treated effluent. Present communication with Erwin Bonatz of HRSD indicates that major policy changes would be required to allow for the acceptance of the brine wastewater. This alternative at the present time is highly improbable.

The development of a community public water supply system would require construction and operation permits from the Virginia State Health Department, Office of Drinking Water (12VAC5-590-200). The procedure for obtaining the Construction Permit includes the following steps: (i) the submission of an application, (ii) a preliminary engineering conference, (iii) the submission of an engineer's report (Optional at the discretion of the Field Director), and (iv) the submission of plans specifications, design criteria and other requested data. Following the issuance of the Construction Permit, the project may proceed to construction. After the facilities have been constructed in accordance with the approved plans and specifications, certified by a professional engineer, the VDH may issue an Operation permit. It is extremely doubtful that the VDH would issue a Construction Permit since City water is a viable alternative.

4.2.8 Post Treatment Water Conditioning

RO produces finished water that has low alkalinity and pH because the bicarbonate ions do not generally pass through the membranes. This creates water that has little buffering capacity, is corrosive, and is objectionably soft. Lime and caustic soda are chemicals that are typically utilized to increase the alkalinity and pH following treatment.

4.2.9 Disinfection/Fluoridation Requirements

All drinking water must be disinfected to insure that no biological contamination is present in the water or the water distribution system. A chlorination system would be necessary to impart a residual chlorine level in the finished water prior to entry into the distribution system.

Fluoridation is the adjustment of the fluoride concentration of the public water supply in accordance with scientific and medical guidelines. A sodium fluoride saturator will be utilized to feed fluoride to the finished water. A saturated fluoride solution is pumped into the water as it leaves the WTP to the distribution system.

4.2.10 Distribution System Requirements

The 8-inch water line to support the community water supply will follow the route along Centerville Turnpike, Murray Drive and Whittamore Road described in paragraph 4.1.1 and shown on Exhibit 2. The water line will be connected to the well, treatment and storage facilities and fire hydrants will be provided at 500-foot centers along the route.

4.2.11 Water Storage Facilities – Fire Protection

Sufficient water storage volume must be provided to allow for fire protection, and domestic demand consumption. Required storage tank volumes are calculated by computing domestic demands as prescribed by VDH and fire flow demands (See Appendix K). The VDH requires a minimum storage of 200 gallons per equivalent residential connection or 20,000 gallons for the study area. This VDH requirement does not include fire protection.

While there is no specific legal requirement governing fire protection needs, insurance companies establish fire insurance premiums for residential and commercial properties based on measured fire flow capacities within a Town or community. AWWA M31 – Manual of Water Supply Practices, Distribution System Requirements for Fire Protection, outlines various methods of determining required fire storage needs. These values shall be a minimum 1,000 gpm for 2 hours. Considering the necessary duration and flow rate, 120,000 gallons of storage is required for fire protection. However, using VDH calculations for communities of less than 1,000 ERC, the fire flow storage requirements of 120,000 gallons also satisfy the domestic demands. This option will met fire codes; however, it does not have the same capability for fighting fires for as long a time period as Alternative1.

4.2.12 Land Acquisition

In order to implement a new community water supply system, the City would need to purchase land for the treatment facility itself as well as the proposed three supply wells and water storage tank. Depending on the location of the wells and treatment facility additional easements are likely necessary to install a raw water transmission main that would bring the raw water from the wells to the treatment location.

4.2.13 O&M Issues

The community system alternative would bring significant operational burdens to the City of Chesapeake. A full time operations staff would be necessary to operate the intricate treatment system and to address all maintenance items associated with the unit processes, residuals and waste stream handling, and distribution system. There would also be new analytical, energy, and chemical costs to operate the system.

Typically water utility billing rates cover capital improvement loans as well as operating and maintenance costs. The City of Chesapeake’s Public Utilities Charges effective July 1, 2008 for a 5/8” meter are $17.50 for the first 300 cubic feet (2,244 gallons) of water and $3.878 for usage over 300 cubic feet (Public Utility Charges are depicted in Appendix L). At this billing rate and at average water demands, only approximately 50% of the expected O& M costs for the community water system would be covered from the community system’s customers.

4.2.14 Other Considerations

This alternative should include periodic sampling provisions from a series of monitoring wells to be installed in the immediate vicinity of the Golf Course. Samples should be analyzed for constituents that may potentially leach from the Golf Course flyash, including:

- Primary contaminants: arsenic (As), barium (Ba),), beryllium (Be), cadmium (Cd), chromium (Cr), mercury (Hg), lead (Pb), selenium (Se), thallium (Tl)
- Secondary contaminants: silver (Ag)
- Other unregulated elements: boron (B), vanadium (V)

In this manner, homeowners could continue to use their existing well if they so desire. If the levels of any of the above contaminants begin to rise in the future to unsatisfactory levels, the homeowner could then decide if he/she wants to connect to the City system. Prevailing City connections fees would apply. Any homeowner who continues to use their existing well should grant the City a release of liability for failure to connect to City water when water system improvements have been offered by the City.

4.2.15 Advantages/Disadvantages

The advantages and disadvantages of providing a new community supply, treatment, storage and distribution system to serve all homes in the study area include:

ADVANTAGES	DISADVANTAGES
• Access to High Quality Water	• Exorbitant Water Production Costs
• Limited Fire Protection	• Water Bill
• Eliminates Homeowner Operation and Maintenance Responsibility	• Price of Connection Fee
• Protects Public Welfare	• Loss of Private Well*
• Redundancy – Moderately Reliable Water	• Extensive Permitting Issues
	• Brine Waste Disposal is extremely cost prohibitive
	• Obtaining Groundwater Withdrawal Permit May Not Be Feasible
	• VDH Construction Permit Unlikely to Be Approved
	• Technically Challenging Solution
	• Operationally Expensive
	• Introduction of Potentially Hazardous Water Treatment Chemicals in Neighborhood
	• Long Implementation Schedule
	• Land Acquisition Necessary
	• Easements Necessary for Fire Hydrants, Water Meters & Drainage
	• Large Capital Expense
	• Great Environmental Impact

* Private wells may be used for irrigation purposes provided a physical disconnection from the home's plumbing system is made.

4.3 Alternative 3 – Individual Point of Entry (POE)[6] Treatment System for Existing Wells

This alternative uses similar treatment technologies previously discussed in Alternative 2. However, this alternative places the treatment system at each home or business to treat water from each existing well. The same pre-treatment methods are required. These systems are designed for an individual homeowner up to 400 gallons per day (gpd). Perhaps the biggest difference between the individual systems and the community system is the efficiency of water treatment. While the recovery of the community system can reach 92% recovery of the raw water the individual systems only reach approximately 40%[7]. The consequence of this reduced recovery is that a home creates over twice the amount of rejected, unusable water as a waste brine needing disposal as the amount of potable water actually produced.

A pretreatment system will consist of a 40 gallon raw water tank that will store water pumped from the well. An RO system requires significant energy to pass the water through the membrane and the existing wells will not provide the required energy for this. A booster pump will then pump the water through the RO system and into a new 40 gal pressurized "bladder" tank that will supply water pressure to the home. The bladder tank eliminates the need for the well pump and RO system to turn on every time there is a user demand. Prefiltration is also necessary to preserve the membranes. Typical pretreatment will include a manganese dioxide mineral filter, ion exchange vessel, and carbon filtration. Appendix N gives a detailed depiction of a Point of Entry RO system and its associated components.

4.3.1 Housing Requirements

The individual RO units required are approximately 3' x 4' x 5.5' The RO units typically are on fiberglass mounting skid. With the required pre-treatment system, the motor, electrical controls, conductivity monitor, pressure gauges, control valves, pressure switches, and high pressure piping will require a set-up location outside of the house. An 8' x 10'

POE Reverse Osmosis Unit

[6] It is an important to differentiate between Point of Use (POU) treatment and Point of Entry (POE) Treatment. POU systems treat water at a single "tap" and are typically installed "under the kitchen sink." POU system can process only a small percentage of the necessary total average residential design flow of 400 gpd/ERC. Whole house (POE) systems can process this requirement of 400 gpd/ERC.

[7] High efficiency systems are available at much higher costs. These higher efficiency systems are more complicated as well because reject water is fed back to the feed tank to increase the efficiency. High efficiency systems typically operate at 125 -235 psi and have high quality components such as fiberglass membrane housings, as well as a feed tank with level controls to control recirculation rate of the reject water and to maintain flow across the membranes to optimize their performance.

storage shed with concrete floor will be needed to house the system.

4.3.2 Brine Handling

The reverse osmosis unit will reject TDS a concentrate that will have a brine concentration of approximately 1,300 mg/L. The concentrated brine will need to be properly disposed. According to VDH, the brine reject would not be permitted to enter a septic tank and leach field which is how the home's wastewater needs are presently served. Liquid hauling may be an expensive alternative if an approved discharge location could not be identified.

The present alternative to handle the liquid wastes generated by the proposed POE treatment systems include the construction of a pump station and force main to convey the reject water to the Hampton Roads Sanitation District's (HRSD) transport and treatment facilities. Approval from HRSD would be required for the disposal of brine waste originating from the RO facilities. (It should be noted that the study area of the City is not contained within the Sewer Service Franchise Area. This would require City Council approval to allow wastewater to be discharged into the City's sanitary sewer system.) Considering potential contaminants that may be introduced and that concentrated brine waste will be introduced (specifically chloride), it is unlikely that HRSD would accept the waste as it would interfere with treatment or reduce re-use options of their treated effluent. Present communication with Erwin Bonatz of HRSD indicates that major policy changes would be required to allow for the acceptance of the brine wastewater.

4.3.3 O&M Issues

There are problems with the POE systems that are hard to overlook. These include noise, poor aesthetics of equipment & tanks, complicated process to operate/repair, costly maintenance contracts, and the concern that the existing well may not produce sufficient water to create the needed clean water flow. Preliminary discussion with VDH indicates their desire to have the City maintain the individual systems because of their water treatment expertise and to maintain continuity following the transfer of properties when homes are sold. This task could be contracted by the City to a qualified private vendor. Vehicular access would be needed in the event that heavy equipment needed to be removed. The treatment housing units would need to be positioned in front yards which are typically not fenced, to provide uninhibited access now and in the future. There may be safety concerns by some residents who are uncomfortable with he additional "foot traffic" on their property. Each property owner would be required to enter into access and maintenance agreements with the City to allow these functions to be performed. This added expense would be billed to the residents by the City.

4.3.4 Other Considerations

Any homeowner who continues to use their existing well should grant the City a release of liability for failure to connect to City water when water system improvements have been offered by the City.

4.3.5 Advantages/Disadvantages

The advantages and disadvantages of providing new point of entry RO treatment systems for all homes include:

ADVANTAGES	DISADVANTAGES
• Access to High Quality Water	• Extra Building On Property
• Protects Public Welfare	• Access Agreement Needed For City or Third Party Maintenance
• Continued Use of Private Well	• High Electrical Expense to Owner
	• Water Bill For City Maintenance
	• Chemical Storage on Site
	• Noise (can be attenuated in sound proof housing)
	• Brine Waste Disposal would be the Responsibility of the Homeowner and would be Extremely Cost Prohibitive
	• Increased Homeowner Burden
	• Permitting Issues May Be Prohibitive
	• No Redundancy
	• No Fire Protection
	• Significant Environmental Impact

4.4 Alternative 4 – Development and Installation of New Individual Home Owner Supply Wells

This alternative consists of drilling and installing new individual residential water supply wells into an aquifer that is less susceptible to impacts from degradation of water quality should monitoring data indicate the release of contaminants from the Battlefield Golf Club into the Surficial aquifer and migration of these contaminants toward the residential wells.

4.4.1 Current Groundwater Conditions and Ongoing Investigations

As discussed in Section 3.4, analytical data obtained from home owner wells in the study area indicate that the current groundwater quality supplied from wells installed into both the Surficial and Yorktown-Eastover aquifers have naturally high levels of iron and manganese, which are both regulated as “secondary” contaminants, but the water is generally suitable for potable use. However, monitoring wells installed and sampled at the Battlefield Golf Club have detected inorganics in the groundwater at concentrations that may pose health threats (Kimley-Horn, 2008) in the Surfical aquifer.

As groundwater flow in the Surficial aquifer is generally toward the southeast based on available information, residential wells installed in this aquifer that are located in this direction from the golf club may be impacted in the future. Currently, insufficient data exists to accurately predict if (or when) the detected analytes could migrate to the location of existing residential monitoring wells. However, ongoing investigations may provide adequate data to make this determination.

4.4.2 New Well Installation

Based on the results of ongoing studies, should it be determined that the Surficial aquifer is impacted, that the contaminants are migrating toward the residential wells, and that the underlying Yorktown confining zone serves to protect the underlying Yorktown-Eastover aquifer from these contaminants, installation of replacement wells into the Yorktown-Eastover aquifer could be successful. These wells would be designed and installed to seal off the Surficial aquifer and withdraw water from the Yorktown-Eastover aquifer.

Typical Well Installation

The number of residential wells currently installed into the Surficial aquifer as opposed to the Yorktown-Eastover aquifer is unknown, as residential well records were not found for all of the wells located in the area, and home owners who responded to the questionnaires sent out as part of this study did not know the depth of their wells. Based on the records that were obtained from the City of Chesapeake Department of Health, it is assumed that half of the wells are installed into each aquifer. However, the well construction techniques used for wells installed into the Yorktown-Eastover aquifer may not sufficiently seal off the Surficial aquifer; thus providing a conduit for water to migrate from the Surficial aquifer downward into the Yorktown-Eastover aquifer.

Therefore, this alternative consists of proper abandonment of all existing homeowner wells, followed by the installation of new water supply wells into the Yorktown-Eastover aquifer that appropriately seal off the Surficial aquifer. Based on responses to questionnaires, some homeowners have installed water softeners to improve water quality, and this alternative includes the installation of such treatment along with filters, pressure tanks and other appurtenances typically associated with residential well systems.

4.4.3 Permitting Requirements

The City of Chesapeake Department of Health regulates the installation of private water supply wells (Class III wells) in accordance with the Virginia *Waterworks Regulations*. A

Virginia licensed well driller is required to install the wells and these companies are familiar with obtaining the required permits. Since each private well will withdraw a relatively small volume of water, the provisions of the Eastern Virginia Groundwater Management Area are not applicable. However, DEQ may question this approach since the combined withdrawal is equivalent to Alternative 2 using a series of community water supply wells.

4.4.4 Other Considerations

This option does not guarantee a reliable solution from potential contamination and homeowners' fears may continue.

4.4.5 Advantages/Disadvantages

The advantages and disadvantages of providing new, deeper homeowner wells include:

ADVANTAGES	DISADVANTAGES
• Inexpensive • Continued Use of Private Well (Surficial Aquifer only) for irrigation purposes	• Potential for Future Water Quality Issues • No Redundancy • Does Not Minimize All Risk or Allay Homeowners Concerns • No Fire Protection • Continued Homeowner Maintenance

5.0 COST EVALUATION AND RECOMMENDATIONS

5.1 Present Worth Opinion of Cost evaluations

The cost to install the four alternatives has been evaluated. Costs include all capital and operation and maintenance (O&M) costs. Using life cycle cost analyses helps correctly assess the most effective alternative. In a present worth comparison of alternatives, the costs associated with each alternative are all converted to a present sum of money, and the least of these values represents the best financial alternative. Annual costs over thirty years, future payments, and gradients must be brought to present value.

The present worth comparisons utilized in this report are *strictly for comparisons* and not actual cost estimations/determinations of the respective alternatives. Costs for site preparation, mobilization, demobilization, indirect costs, restoration, etc. were extrapolated from anticipated costs and scaled to match the anticipated requirements of each alternative. Important differences for each of the respective alternatives were also included to facilitate a comparison of the four alternatives present worth values. No brine disposal costs were included for Alternatives 2 and 3 since our investigations did not discover any solutions that were not extremely cost prohibitive. These alternatives are considered no longer viable. Estimated cost data for the four alternatives are shown below. See Appendix O for the detailed present worth alternative comparison.

	Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 4**
Capital Cost	$7,221,756	$8,2411,704[8]	$2,770,149[8]	$803,000
Useful Life	30 Years	30 Years	30 Years	30 Years
O & M costs				
• City	$3,000/yr	$187,227/yr[8]	$460,879/yr[8]	$0/yr
• Homeowners	$0/yr[9]	$0/yr[9]	$166,923/yr[8]	$10,000/yr
Present Worth	$7,267,873	$11,289,844	$9,854,989	$956,725

Alternative 1: Provide City of Chesapeake Water via a Water Main Extension.
Alternative 2: Install a Community Groundwater Supply, Treatment, Storage, and Distribution System.
Alternative 3: Install Point of Entry (POE) Treatment Systems on Existing Private Wells.
Alternative 4: Development and Installation of New Private Wells into Yorktown-

[8] Costs do not include brine disposal

[9] Each residential connection shall have a separate service connection to the City of Chesapeake water supply. The city will maintain all service connections, including the meter facilities. ***The house connection shall be installed and maintained by the customer at their own expense and in accordance with the standards established by the City Public Utilities Department***. The customer shall, at their own risk and expense, furnish, install and maintain in safe condition all equipment that may be required for receiving, controlling and utilizing water as the house connection.

Eastover aquifer.

The present worth value of each alternative is displayed above assuming:

1) Money is worth 5%, annual compounding,
2) Zero salvage value,
3) All other costs equal for all alternatives,

Present worth was determined as in the below example for Alternative 2:

Present Worth (Alternative 2) = P + A (P/A, 5%, 30)

$$= P + A\frac{\left[(1+i)^N - 1\right]}{\left[i(1+i)^N\right]}$$

$$= 7{,}226{,}226 + 192{,}143\frac{\left[(1+0.05)^{30} - 1\right]}{\left[0.05(1+0.05)^{30}\right]}$$

$$= 10{,}179{,}934$$

Alternative 4 is the least costly, while Alternatives 1 and 3 are comparable from a capital cost perspective, and Alternative 2 is the most expensive. Alternatives 1 and 4 benefit from a considerably reduced operations and maintenance (O&M) cost. The capital cost and O&M costs required for Alternative 2 make this choice not preferred from a present worth analysis. Likewise, Alternative 3 has such extensive O&M costs, that it is the least preferred from a present worth analysis perspective.

O&M costs have been divided between the City and Homeowners for each option. Alternatives 1 and 2 depict all the O&M costs being paid by the City. Alternative 3 shows a division of cost responsibility with the City absorbing the operations and sampling cost of the individual treatment units, while the homeowners pay for the electric and sanitary sewer disposal costs for the brine. All operational costs associated with Alternative 4 will be paid by the homeowner and would include electric and maintenance of the well system.

5.2 Alternative Evaluation Matrix

While a present worth analysis is invaluable in evaluating alternatives it should not be the only consideration. In this evaluation a decision matrix was developed which considered six categories of criteria to assess the alternatives. The six categories are as follows:

1. Regulatory Compliance – Water Quality
2. Property Owner Impact
3. Operational Requirements
4. Technical Feasibility
5. Present Worth

6. Permitting / Administrative Burdens

Each category was further sub-divided into specific criteria and given a relative weight of importance on a scale of 0 - 10 (no importance rated 0, most important rated 10). The amount of "relative importance" is a comparison between the importances of the criteria. For example, as discussed below Regulatory Compliance is considered more important than Operational Requirements. A brief description of each follows below with a justification of its relative weight of importance.

Regulatory Compliance-Water Quality
The two specific criteria for this category are:

1) Meets VA Drinking Water Standards, and
2) Long Term Compliance.

The criterion of providing safe drinking water that meets all applicable standards is the baseline for all future actions and was given a rank of 10. Equally important is insuring future water quality and maintaining long term compliance. This was also given a rank of 10. Overall Regulatory Compliance – Water Quality contributes 20% to the overall weighted score.

Property Owner Impact
An important component for the evaluation of alternatives is property owner impact. This category was subdivided into two criteria:

1) Affect Property Value, and
2) Homeowner responsibilities, increased burdens, safety

Obviously an inherent component to a home's marketability and value is the assumption that safe and potable drinking water is reliably available to perpetuity. The effect of the alternatives on the Home Property Value was given a rank of an 8. Equally important is the added burden to the homeowner to have this safe potable drinking water. The burdens include costs to obtain water (connections fees), cost for water use, increased energy consumption, access issues for City of Chesapeake run facilities, safety concerns with unknown personnel required to monitor systems among others. The Homeowner Responsibilities/Increased Burdens/Safety was given a rank of an 8. Overall Property Owner Impact contributes 16% to the overall weighted score.

Operational Requirements
The alternative selected should minimize waste generation, conserve resources, reduce energy expenditure and minimize greenhouse gases, and minimize impact on public resources (aquifers). These were collectively grouped into the criteria of Sustainability and given a rank of 8. Secondly, operational requirements should be fail safe. The selected alternative should have enough redundancy and reliability that future operational risks are minimized or eliminated. Also the selected alternative should have minimum complexity and ease of use so that safe water will always be available with a minimum of any

interruption of service. Reliability was given a rank of 8. Overall Operational Requirements contribute to 16% of the overall weighted score.

Technical Feasibility
This category is governed by the time required for implementation, constructability, and the protection of the public welfare. Time is an important component in the alternative matrix because of the ramifications of a rapidly affected water source. In the event that water quality conditions in a water source were to decline, a rapidly implementable alternative for supplying potable water will be of utmost importance. The course of action should avoid complexity and reduce potential exposure to injury and/or release of contaminants. Constructability was given a rank of 6. Time for Implementation was given a rank of 8. This category contributes to 14% of the overall weighted score.

Present Worth
The present worth comparisons as described in the previous section were utilized in this category. The criteria of this category were capital and O&M costs. The necessary capital outlay to construct the project was given a rank of 10 while the O&M costs were given a rank of 10. This decision matrix weighted the Present Value of Costs as 20% of the overall importance.

Permitting / Administrative Burdens
This final category considers the necessary administration effort required to make the selected alternative a reality. Such burdens include permitting, zoning, pilot testing, public meetings and discussions, and administering construction contracts, among others. The permitting was given a rank of 8. The level of effort criterion was given a rank of 6. Overall the administrative burdens contribute 14% of the overall weighted score.

After the assignment of a relative weight between the various criteria each of the four alternatives was given a rating according to their anticipated performance with respect to the various criteria. The ratings follow a scale of 0 to 5 (exceptionally unfavorable rated 0 and exceptionally favorable rated 5). These rating were than multiplied by the relative weight to get a weighted rating. The sum of the weighted ratings for each of the alternatives resulted in total score with the highest score being the most favored. The details of the alternative decision matrix is presented in Appendix P.

The decision matrix shows Alternative 1 as the most desirable.

5.3 Recommended Alternative

It is understood that other, more comprehensive groundwater studies are currently being conducted in the area. Groundwater movement in this region is difficult to accurately predict in terms of leakage from one aquifer to another. The thickness and homogeneous characteristics of the confining zones could significantly vary in the study area, even from one street to the next. Therefore, the level of protection that may be provided by the confining zone between the Surfical and Yorktown-Eastover aquifer can not guarantee the prevention of downward migration. Further, well construction techniques for most, if not all, of the existing wells withdrawing from the Yorktown-Eastover aquifer were most likely installed utilizing well construction methods that actually facilitate migration between the two aquifers. The migration or leakage (which has not been confirmed) could take place along the outside of the casing pipe since grouting between the exterior of the pipe and the confining zone typically is installed only 20 feet from the surface. The confining zone at the site is typically located some 50-60 feet below the surface.

The potential introduction of contaminants from the Golf Course fly ash into the Surficial aquifer through a leaching effect is a time consuming investigation and was beyond the scope of this study. However, the intent of this study was to identify implementable water source alternatives in an expeditious manner in the event that contamination was to occur. Based on the available information, it is not known if contaminants will leach from the fly ash and result in contamination of nearby wells. The data that was available to URS for this study does not show conclusive evidence that groundwater contamination from the Battlefield Golf Course property has migrated to residential water wells in the immediate vicinity. However, the threat of such an event is possible.

With the study area located within the Eastern Virginia Groundwater Management Area, it is considered unlikely that DEQ would approve a large groundwater withdrawal in this area with the availability of high quality City water in the vicinity. The City's drinking water meets all state and federal drinking water regulations and is closely monitored on a daily basis. The identification of regulatory-acceptable and cost effective means of brine waste disposal from an RO process – community system or individual systems, is doubtful.

Based on the investigations of the alternatives evaluated to supply potable water to the homes in the vicinity of the Battlefield Golf Course, it is recommend that the City proceed with the construction of Alternative 1 and extend the City distribution system to serve these areas. The provision of City water would allow for a safe, reliable, monitored water supply that would be most protective against any potential future impacts to the existing aquifer supply.

6.0 REFERENCES

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APPENDIX A
Resident Questionnaire

Table 1: Resident Questionnaire Summary

Water Supply Feasibility Study
Murray Drive -- Whittamore Road Project
City of Chesapeake, VA

Address	Residence(R)/ Business(B)	Willing to Connect to City Water ?	Location of Well	Well Accessibility	Year of Well Installation	Well Pump Location	Well Pump Information	Adequate Water Pressure?	Well Driller's Log	Well Depth (ft)	Water Treatment Device	Signs of Fe/Mn	Signs of Ca	Water Quality Test	Non-domestic Use	Consultant Future Visit
825 Centreville Turnpike S.	R	Yes	Known	Yes	1985	Known	Yes	Yes	No	78	Yes (For Iron Removal)	No	No	2005	No	Yes
1020 Centreville Turnpike S. (John Deere Landscapes)	B		Known	Yes	2000	Warehouse	Yes	Yes	No	Unknown	No	Yes	Yes	N/A	Yes (Bussiness/Irrigation)	Yes
1102 Centreville Turnpike S.	R	Yes	Known	Yes	1988	Well House	No	Yes	No	Unknown	Yes (Self-serviced Softening Device)	No	No	No	No	Yes
1305 Centreville Turnpike S.	R	Yes	Known	Yes	Unknown	Unknown	Yes	Yes	No	Unknown	Yes	No	No	Oct. 2008	Yes (Livestock)	Yes
1112 Murry Drive	R		Unknown	Yes	1983	Garage	No	Yes	No	Unknown	No	Yes	No	Sep. 2008	Yes, very little (Livestock)	Yes
1120 Murry Drive	R	Yes	Known	Yes	1977	Garage	Flotec FP4112-08	Yes	No	Unknown	No	Yes	Yes	Summer 2008 (By City)	Yes (Swimming Pool)	Yes
1215 Murry Drive	R	Yes (At no charge to the resident)	Known	Yes	1990	Garage	Yes	Yes	No	Unknown	Yes	Yes	Yes	2008 (By City)	No	Yes
1300 Murry Drive	R	Yes	Known	Yes	1990	Garage	Yes	Yes	No	Unknown	Yes	Yes	Yes	No	Yes	Yes
1441 Fentress Road 1431 Fentress Road 1401 Blueridge Road (Crossroads Properties)	B	Yes	Known	Yes	Unknown	Unknown	No	Yes	No	Unknown	No	Yes	N/A	No	Yes (Bussiness)	Yes
1405 Whittamore Road	R	Yes	Known	Yes	1994	Shed	JET	No	No	Unknown	Yes	No	No	1996	No	Yes
1417 Whittamore Road	R	Yes	Known	Yes	Unknown	Yard	No	No	No	Unknown	No	Yes	Yes	Yes	No	Yes
1425 Whittamore Road	R	Yes	Unknown		60 Years??	Outside House	No	No	No	Unknown	No	Yes	No	No	No	Yes
1457 Whittamore Road	R	Yes	Known		1950	Unknown	No	Yes		50	Yes	No		Jul-08	No	
1469 Whittamore Road	R	No	Unknown				No	No	No		No	Yes	Yes	No	No	Yes
1605 Whittamore Road	R	Yes	Known	Yes	2001-2002	Laundry room of house	Yes	Yes	No	Unknown	Yes (for treating iron, hardness, impurities)	Yes	Yes	Spring 2008	No	Yes
1609 Whittamore Road	R	Yes	Known	No	Unknown	Shed	No	Yes		47	Yes	Yes	Yes	2008 (By City)	No	Yes

APPENDIX B
Virginia Water Quality Standards

Commonwealth of Virginia Department of Environmental Quality

Water Quality Standards
For toxic analytes

Adapted from

STATE WATER CONTROL BOARD

9 VAC 25-260 Virginia Water Quality Standards.

Statutory Authority: § 62.1-44.15 3a of the Code of Virginia.

WITH AMENDMENTS EFFECTIVE AUGUST 10, 2005

Refer to 9 VAC 25-260 for detailed comments on the standards summarized herein!

9 VAC 25-260-140. Criteria for surface water.

A. Instream water quality conditions shall not be acutely[2] or chronically[3] toxic except as allowed in 9 VAC 25-260-20 B mixing zones. The following are definitions of acute and chronic toxicity conditions:

"Acute toxicity" means an adverse effect that usually occurs shortly after exposure to a pollutant. Lethality to an organism is the usual measure of acute toxicity. Where death is not easily detected, immobilization is considered equivalent to death.

"Chronic toxicity" means an adverse effect that is irreversible or progressive or occurs because the rate of injury is greater than the rate of repair during prolonged exposure to a pollutant. This includes low level, long-term effects such as reduction in growth or reproduction.

B. The following table is a list of numerical water quality criteria for specific parameters.

When information has become available from the Environmental Protection Agency to calculate additional aquatic life or human health criteria not contained in the table, the board may employ these values in establishing effluent limitations or other limitations pursuant to 9 VAC 25-260-20 A necessary to protect designated uses until the board has completed the regulatory standards adoption process.

Table of Parameters [6]

PARAMETER CAS Number	USE DESIGNATION					
	AQUATIC LIFE				HUMAN HEALTH	
	FRESHWATER		SALTWATER			
	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]	Public Water Supply [3]	All Other Surface Waters[4]
Acenapthene(µg/l) 83329					1,200	2,700
Acrolein (µg/l) 107028					320	780
Acrylonitrile (µg/l) 107131 Known or suspected carcinogen; human health criteria at risk level 10^{-5}.					0.59	6.6
Aldrin (µg/l) 309002 Known or suspected carcinogen; human health criteria at risk level 10^{-5}.	3.0		1.3		0.0013	0.0014
Ammonia (µg/l) 766-41-7 Chronic criterion is a 30-day average concentration not to be exceeded more than once every three 3 years on the average. (see 9 VAC 25-260-155)						
Anthracene (µg/l) 120127					9,600	110,000
Antimony (µg/l) 7440360					14	4,300
Arsenic (µg/l [5]) 7440382	340	150	69	36	10	
Bacteria (see 9 VAC 25-260-160 and 170)						
Barium (µg/l) 7440393					2,000	
Benzene µg/l 71432 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					12	710
Benzidine (µg/l) 92875 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					0.0012	0.0054
Benzo (a) anthracene (µg/l) 56553 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					0.044	0.49

PARAMETER CAS Number	USE DESIGNATION					
	AQUATIC LIFE				HUMAN HEALTH	
	FRESHWATER		SALTWATER			
	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]	Public Water Supply[3]	All Other Surface Waters[4]
Benzo (b) fluoranthene (μg/l) 205992 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					0.044	0.49
Benzo (k) fluoranthene (μg/l) 207089 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					0.044	0.49
Benzo (a) pyrene (μg/l) 50328 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					0.044	0.49
Bis2-Chloroethyl Ether 111444 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					0.31	14
Bis2-Chloroisopropyl Ether (μg/l) 39638329					1,400	170,000
Bromoform (μg/l) 75252 Known or suspected carcinogen; human health criteria at risk level 10^{-5}.					44	3,600
Butyl benzyl phthalate (μg/l) 85687					3,000	5,200

PARAMETER CAS Number	USE DESIGNATION					
	AQUATIC LIFE				HUMAN HEALTH	
	FRESHWATER		SALTWATER			
	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]	Public Water Supply[3]	All Other Surface Waters[4]
Cadmium (µg/l[5]) 7440439 Freshwater values are a function of total hardness as calcium carbonate $CaCO_3$ mg/l and the WER. The minimum hardness allowed for use in the equation below shall be 25 and the maximum hardness shall be 400 even when the actual ambient hardness is less than 25 or greater than 400. **Freshwater acute criterion** (µg/l) $WER\ [e^{\{1.128[\ln(\text{hardness})] - 3.828\}}]$ **Freshwater chronic criterion** (µg/l) $WER\ [e^{\{0.7852[\ln(\text{hardness})] - 3.490\}}]$ WER = Water Effect Ratio = 1 unless shown otherwise under 9 VAC 25-260-140.F and listed in 9 VAC 25-260-310 e = natural antilogarithm ln = natural logarithm	3.9 WER = 1 $CaCO_3$=100	1.1 WER = 1 $CaCO_3$ = 100	40 WER=1	8.8 WER=1	5	
Carbon tetrachloride (µg/l) 56235 Known or suspected carcinogen; human health criteria at risk level 10^{-5}.					2.5	44
Chlordane (µg/l) 57749 Known or suspected carcinogen; human health criteria at risk level 10^{-5}	2.4	0.0043	0.09	0.0040	0.021	0.022
Chloride (µg/l) 16887006 Human Health criterion to maintain acceptable taste and aesthetic quality and applies at the drinking water intake.	860,000	230,000			250,000	
Chlorine, Total Residual (µg/l) 7782505 In DGIF class i and ii trout waters (9 VAC 25-260 subsections 390-540) or waters with threatened or endangered species are subject to the halogen ban (subsection 110.)	19 See 9 VAC 25-260-110	11 See 9 VAC 25-260-110				
Chlorine Produced Oxidant (µg/l) 7782505			13	7.5		
Chlorobenzene (µg/l) 108907					680	21,000
Chlorodibromomethane (µg/l) 124481 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					4.1	340

PARAMETER CAS Number	USE DESIGNATION					
	AQUATIC LIFE				HUMAN HEALTH	
	FRESHWATER		SALTWATER			
	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]	Public Water Supply[3]	All Other Surface Waters[4]
Chloroform ($\mu g/l$) 67663 Known or suspected carcinogen; however, non-carcinogen calculation used and is protective of carcinogenic effects. Use 30Q5 as default design flow (see footnote 6.)					350	29,000
2-Chloronaphthalene ($\mu g/l$) 91587					1,700	4,300
2-Chlorophenol ($\mu g/l$) 95578					120	400
Chlorpyrifos ($\mu g/l$) 2921882	0.083	0.041	0.011	0.0056		
Chromium III ($\mu g/l$[5]) 16065831 Freshwater values are a function of total hardness as calcium carbonate $CaCO_3$ mg/l and the WER. The minimum hardness allowed for use in the equation below shall be 25 and the maximum hardness shall be 400 even when the actual ambient hardness is less than 25 or greater than 400. **Freshwater acute criterion $\mu g/l$** $WER\left[e^{\{0.8190[\ln(hardness)]+3.7256\}}\right](CF_a)$ **Freshwater chronic criterion $\mu g/l$** $WER\left[e^{\{0.8190[\ln(hardness)]+0.6848\}}\right](CF_c)$ WER = Water Effect Ratio = 1 unless shown otherwise under 9 VAC 25-260-140.F and listed in 9 VAC 25-260-310 e = natural antilogarithm ln=natural logarithm CF_a=0.316 CF_c=0.860	570 (WER=1; $CaCO_3$=100)	74 (WER=1; $CaCO_3$=100)			100 (total Cr)	
Chromium VI ($\mu g/l$[5]) 18540299	16	11	1,100	50		
Chrysene ($\mu g/l$) 218019 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					0.044	0.49

PARAMETER CAS Number	USE DESIGNATION					
	AQUATIC LIFE				HUMAN HEALTH	
	FRESHWATER		SALTWATER			
	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]	Public Water Supply[3]	All Other Surface Waters[4]
Copper ($\mu g/l^5$) 7440508 Freshwater values are a function of total hardness as calcium carbonate $CaCO_3$ mg/l and the WER. The minimum hardness allowed for use in the equation below shall be 25 and the maximum hardness shall be 400 even when the actual ambient hardness is less than 25 or greater than 400. **Freshwater acute criterion** ($\mu g/l$) $WER\left[e^{\{0.9422[\ln(hardness)]-1.700\}}\right](CF_a)$ **Freshwater chronic criterion** $\mu g/l$ $WER\left[e^{\{0.8545[\ln(hardness)]-1.702\}}\right](CF_c)$ WER = Water Effect Ratio = 1 unless shown otherwise under 9 VAC 25-260-140.F and listed in 9 VAC 25-260-310. e = natural antilogarithm ln=natural logarithm $CF_a = 0.960$ $CF_c = 0.960$ Acute saltwater criterion is a 24-hour average not to be exceeded more than once every three years on the average.	13 WER=1 $CaCO_3$=100	9.0 WER=1 $CaCO_3$=100	9.3 WER=1	6.0 WER=1	1,300	
Cyanide ($\mu g/l$) 57125	22	5.2	1.0	1.0	700	220,000
DDD ($\mu g/l$) 72548 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					0.0083	0.0084
DDE ($\mu g/l$) 72559 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					0.0059	0.0059
DDT ($\mu g/l$) 50293 Known or suspected carcinogen; human health criteria at risk level 10^{-5}	1.1	0.0010	0.13	0.0010	0.0059	0.0059
Demeton ($\mu g/l$) 8065483		0.1		0.1		

PARAMETER CAS Number	USE DESIGNATION					
	AQUATIC LIFE				HUMAN HEALTH	
	FRESHWATER		SALTWATER			
	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]	**Public Water Supply**[3]	**All Other Surface Waters**[4]
Dibenz (a,h) anthracene (μg/l) 53703 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					0.044	0.49
Dibutyl phthalate μg/l 84742					2,700	12,000
Dichloromethane (μg/l) 75092 Known or suspected carcinogen; human health criteria at risk level 10^{-5} Synonym = Methylene Chloride					47	16,000
1,2–Dichlorobenzene (μg/l0) 95501					2,700	17,000
1,3– Dichlorobenzene (μg/l) 541731					400	2,600
1,4 Dichlorobenzene (μg/l) 106467					400	2,600
3,3 Dichlorobenzidine 91941 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					0.4	0.77
Dichlorobromomethane (μg/l) 75274 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					5.6	460
1,2 Dichloroethane (μg/l) 107062 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					3.8	990
1,1 Dichloroethylene (μg/l) 75354					310	17,000
1,2-trans-dichloroethylene (μg/l) 156605					700	140,000
2,4 Dichlorophenol (μg/l) 120832					93	790

PARAMETER CAS Number	USE DESIGNATION					
	AQUATIC LIFE				HUMAN HEALTH	
	FRESHWATER		SALTWATER			
	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]	Public Water Supply[3]	All Other Surface Waters[4]
2,4 Dichlorophenoxy acetic acid (2,4-D) (μg/l) 94757					100	
1,2-Dichloropropane (μg/l) 78875 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					5.2	390
1,3-Dichloropropene (μg/l) 542756					10	1,700
Dieldrin (μg/l) 60571 Known or suspected carcinogen; human health criteria at risk level 10^{-5}.	0.24	0.056	0.71	0.0019	0.0014	0.0014
Diethyl Phthalate (μg/l) 84662					23,000	120,000
Di-2-Ethylhexyl Phthalate (μg/l) 117817 Known or suspected carcinogen; human health criteria at risk level 10^{-5}. Synonym = Bis2-Ethylhexyl Phthalate.					18	59
2,4 Dimethylphenol (μg/l) 105679					540	2,300
Dimethyl Phthalate (μg/l) 131113					313,000	2,900,000
Di-n-Butyl Phthalate (μg/l) 84742					2,700	12,000
2,4 Dinitrophenol (μg/l) 51285					70	14,000
2-Methyl-4,6-Dinitrophenol (μg/l) 534521					13.4	765
2,4 Dinitrotoluene (μg/l) 121142 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					1.1	91

PARAMETER CAS Number	USE DESIGNATION					
	AQUATIC LIFE				HUMAN HEALTH	
	FRESHWATER		SALTWATER			
	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]	Public Water Supply[3]	All Other Surface Waters[4]
Dioxin 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin (ppq) 1746016 Criteria are based on a risk level of 10^{-5} and potency of 1.75 x 10^{-4} mg/kg–day^{-1} To calculate an average effluent permit limit, use mean annual stream flow.					1.2	1.2
1,2-Diphenylhydrazine (µg/l) 122667 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					0.40	5.4
Dissolved Oxygen (mg/l) (See 9 VAC 25-260-50 and 9 VAC 25-260-55)						
Alpha-Endosulfan (µg/l) 959988	0.22	0.056	0.034	0.0087	110	240
Beta-Endosulfan (µg/l) 33213659	0.22	0.056	0.034	0.0087	110	240
Endosulfan Sulfate (µg/l) 1031078					110	240
Endrin (µg/l) 72208	0.086	0.036	0.037	0.0023	0.76	0.81
Endrin Aldehyde (µg/l) 7421934					0.76	0.81
Ethylbenzene (µg/l) 100414					3,100	29,000
Fecal Coliform (see 9 VAC 25-260-160 and 9 VAC 25-260-170)						
Fluoranthene (µg/l) 206440					300	370
Fluorene (µg/l) 86737					1,300	14,000

PARAMETER CAS Number	USE DESIGNATION					
	AQUATIC LIFE				HUMAN HEALTH	
	FRESHWATER		SALTWATER			
	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]	Public Water Supply[3]	All Other Surface Waters[4]
Foaming Agents (μg/l) Criterion measured as methylene blue active substances. Criterion to maintain acceptable taste, odor, or aesthetic quality of drinking water and applies at the drinking water intake.					500	
Guthion (μg/l) 86500		0.01		0.01		
Heptachlor (μg/l) 76448 Known or suspected carcinogen; human health criteria at risk level 10^{-5}.	0.52	0.0038	0.053	0.0036	0.0021	0.0021
Heptachlor Epoxide (μg/l) 1024573 Known or suspected carcinogen; human health criteria at risk level 10^{-5}.	0.52	0.0038	0.053	0.0036	0.0010	0.0011
Hexachlorobenzene (μg/l) 118741 Known or suspected carcinogen; human health criteria at risk level 10^{-5}.					0.0075	0.0077
Hexachlorobutadiene (μg/l) 87683 Known or suspected carcinogen; human health criteria at risk level 10^{-5}.					4.4	500
Hexachlorocyclohexane Alpha-BHC (μg/l) 319846 Known or suspected carcinogen; human health criteria at risk level 10^{-5}.					0.039	0.13
Hexachlorocyclohexane Beta-BHC (μg/l) 319857 Known or suspected carcinogen; human health criteria at risk level 10^{-5}.					0.14	0.46
Hexachlorocyclohexane (μg/l) (Lindane) Gamma-BHC 58899 Known or suspected carcinogen; human health criteria at risk level 10^{-5}.	0.95		0.16		0.19	0.63
Hexachlorocyclopentadiene (μg/l) 77474					240	17,000
Hexachloroethane (μg/l) 67721 Known or suspected carcinogen; human health criteria at risk level 10^{-5}.					19	89
Hydrogen sulfide (μg/l) 7783064		2.0		2.0		

PARAMETER CAS Number	USE DESIGNATION					
	AQUATIC LIFE				HUMAN HEALTH	
	FRESHWATER		SALTWATER			
	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]	Public Water Supply[3]	All Other Surface Waters[4]
Indeno (1,2,3,-cd) pyrene (μg/l) 193395 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					0.044	0.49
Iron (μg/l) 7439896 Criterion to maintain acceptable taste, odor or aesthetic quality of drinking water and applies at the drinking water intake.					300	
Isophorone (μg/l) 78591 Known or suspected carcinogen; human health criteria at risk level 10^{-5}.					360	26,000
Kepone (μg/l) 143500		zero		zero		
Lead (μg/l)[5] 7439921 Freshwater values are a function of total hardness as calcium carbonate $CaCO_3$ mg/l and the water effect ratio. The minimum hardness allowed for use in the equation below shall be 25 and the maximum hardness shall be 400 even when the actual ambient hardness is less than 25 or greater than 400. **Freshwater acute criterion (μg/l)** $WER\left[e^{\{1.273[\ln(hardness)]-1.084\}}\right]$ **Freshwater chronic criterion (μg/l)** $WER\left[e^{\{1.273[\ln(hardness)]-3.259\}}\right]$ WER = Water Effect Ratio =1 unless shown otherwise under 9 VAC 25-260-140.F and listed in 9 VAC 25-260-310 e = natural antilogarithm ln = natural logarithm	120 WER=1 $CaCO_3$=100	14 WER =1 $CaCO_3$= 100	240 WER=1	9.3 WER=1	15	
Malathion (μg/l) 121755		0.1		0.1		
Manganese (μg/l) 7439965 Criterion to maintain acceptable taste, odor or aesthetic quality of drinking water and applies at the drinking water intake.					50	
Mercury μg/l[5] 7439976	1.4	0.77	1.8	0.94	0.050	0.051

PARAMETER CAS Number	USE DESIGNATION					
	AQUATIC LIFE				HUMAN HEALTH	
	FRESHWATER		SALTWATER			
	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]	Public Water Supply[3]	All Other Surface Waters[4]
Methyl Bromide (μg/l) 74839					48	4,000
Methoxychlor (μg/l) 72435		0.03		0.03	100	
Mirex (μg/l) 2385855		zero		zero		
Monochlorobenzene (μg/l) 108907					680	21,000
Nickel (μg/L[5]) 744002 Freshwater values are a function of total hardness as calcium carbonate $CaCO_3$ mg/l and the WER. The minimum hardness allowed for use in the equation below shall be 25 and the maximum hardness shall be 400 even when the actual ambient hardness is less than 25 or greater than 400. **Freshwater acute criterion μg/l** $WER[e^{\{0.8460[\ln(hardness)] + 1.312\}}] (CF_a)$ **Freshwater chronic criterion (μg/l)** $WER[e^{\{0.8460[\ln(hardness)] - 0.8840\}}](CF_c)$ WER =Water Effect Ratio = unless shown otherwise under 9 VAC 25-260-140.F and listed in 9 VAC 25-250-310 e = natural antilogarithm ln = natural logarithm $(CF_a) = 0.998$ $(CF_c) = 0.997$	180 WER =1 $CaCO_3$ = 100	20 WER = 1 $CaCO_3$ = 100	74 WER=1	8.2 WER=1	610	4,600
Nitrate as N (μg/l) 14797558					10,000	
Nitrobenzene (μg/l) 98953					17	1,900
N-Nitrosodimethylamine (μg/l) 62759 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					0.0069	81

PARAMETER CAS Number	USE DESIGNATION					
	AQUATIC LIFE				HUMAN HEALTH	
	FRESHWATER		SALTWATER			
	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]	Public Water Supply[3]	All Other Surface Waters[4]
N-Nitrosodiphenylamine (µg/l) 86306 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					50	160
N-Nitrosodi-n-propylamine (µg/l) 621647 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					0.05	14
Parathion (µg/l) 56382	0.065	0.013				
PCB 1260 (µg/l) 11096825		0.014		0.030		
PCB 1254 (µg/l) 11097691		0.014		0.030		
PCB 1248 (µg/l) 12672296		0.014		0.030		
PCB 1242 (µg/l) 53469219		0.014		0.030		
PCB 1232 (µg/l) 11141165		0.014		0.030		
PCB 1221 (µg/l) 11104282		0.014		0.030		
PCB 1016 (µg/l) 12674112		0.014		0.030		
PCB Total (µg/l) 1336363 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					0.0017	0.0017

PARAMETER CAS Number	USE DESIGNATION					
	AQUATIC LIFE				HUMAN HEALTH	
	FRESHWATER		SALTWATER			
	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]	Public Water Supply[3]	All Other Surface Waters[4]
Pentachlorophenol (µg/l) 87865 Known or suspected carcinogen; human health criteria risk level at 10^{-5} **Freshwater acute criterion (µg/l)** $e^{(1.005(pH)-4.869)}$ **Freshwater chronic criterion (µg/l)** $e^{(1.005(pH)-5.134)}$	8.7 pH = 7.0	6.7 pH = 7.0	13	7.9	2.8	82
pH See § 9VAC25-260-50						
Phenol (µg/l) 108952					21,000	4,600,000
Phosphorus Elemental (µg/l) 7723140				0.10		
Pyrene (µg/l) 129000					960	11,000
Radionuclides **Gross Alpha Particle Activity (pCi/L)** **Beta Particle & Photon Activity (mrem/yr)** (formerly man-made radio nuclides) **Strontium 90 (pCi/L)** **Tritium (pCi/L)**					15 4 8 20,000	15 4 8 20,000
Selenium (µg/l[50] 7782492 WER shall not be used for freshwater acute and chronic criteria.	20	5.0	300 WER=1	71 WER=1	170	11,000
Silver (µg/l)[5] 7440224 Freshwater values are a function of total hardness as calcium carbonate ($CaCO_3$) mg/l and the WER. The minimum hardness allowed for use in the equation below shall be 25 and the maximum hardness shall be 400 even when the actual ambient hardness is less than 25 or greater than 400.	3.4 WER=1; $CaCO_3$= 100		2.0 WER=1			

PARAMETER CAS Number	USE DESIGNATION					
	AQUATIC LIFE				HUMAN HEALTH	
	FRESHWATER		SALTWATER			
	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]	Public Water Supply [3]	All Other Surface Waters[4]
Freshwater acute criterion (μg/l) WER $[e^{\{1.72[\ln(\text{hardness})]-6.52\}}]$ (CF_a) WER = Water Effect Ratio =1 unless shown otherwise under 9 VAC 25-260-140.F and listed in 9 VAC 25-260-310 e = natural antilogarithm ln=natural logarithm (CF_a)= 0.85						
Sulfate (μg/l) Criterion to maintain acceptable taste, odor or aesthetic quality of drinking water and applies at the drinking water intake.					250,000	
Temperature See 9 VAC 25-260-50						
1,1,2,2-Tetrachloroethane (μg/l) 79345 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					1.7	110
Tetrachloroethylene (μg/l) 127184 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					8.0	89
Thallium (μg/l) 7440280					1.7	6.3
Toluene (μg/l) 108883					6,800	200,000
Total Dissolved Solids (μg/l) Criterion to maintain acceptable taste, odor or aesthetic quality of drinking water and applies at the drinking water intake.					500,000	
Toxaphene (μg/l) 8001352 The chronic aquatic life criteria have been calculated to also protect wildlife from harmful effects through ingestion of contaminated tissue. Known or suspected carcinogen; human health criteria at risk level 10^{-5}	0.73	0.0002	0.21	0.0002	0.0073	0.0075
Tributyltin (μg/l) 60105	0.46	0.063	0.38	0.001		

PARAMETER CAS Number	USE DESIGNATION					
	AQUATIC LIFE				HUMAN HEALTH	
	FRESHWATER		SALTWATER			
	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]	Public Water Supply[3]	All Other Surface Waters[4]
1, 2, 4 Trichlorobenzene (μg/l) 120821					260	940
1,1,2-Trichloroethane (μg/l) 79005 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					6.0	420
Trichloroethylene (μg/l) 79016 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					27	810
2, 4, 6 –Trichlorophenol 88062 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					21	65
2–(2, 4, 5 –Trichlorophenoxy propionic acid (Silvex) (μg/l)					50	
Vinyl Chloride (μg/l) 75014 Known or suspected carcinogen; human health criteria at risk level 10^{-5}					0.23	61
Zinc (μg/l)[5] Freshwater values are a function of total hardness as calcium carbonate ($CaCO_3$) mg/l and the WER. The minimum hardness allowed for use in the equation below shall be 25 and the maximum, hardness shall be 400 even when the actual ambient hardness is less than 25 or greater than 400 . **Freshwater acute criterion μg/l** $\mathrm{WER}\left[e^{\{0.8473[\ln(\mathrm{hardness})]+0.884\}}\right](CF_a)$ **Freshwater chronic criterion μg/l** $\mathrm{WER}\left[e^{\{0.8473[\ln(\mathrm{hardness})]+0.884\}}\right](CF_c)$ WER =Water Effect Ratio =1 unless shown otherwise under 9 VAC 25-260-140.F and listed in 9 VAC 25-260-310 e = base e exponential function. ln = log normal function $CF_a = 0.978$ $CF_c = 0.986$	120 WER=1 $CaCO_3$= 100	120 WER=1 $CaCO_3$= 100	90 WER=1	81 WER=1	9,100	69,000

[1] One hour average concentration not to be exceeded more than once every 3 years on the average, unless otherwise noted.

[2] Four-day average concentration not to be exceeded more than once every 3 years on the average, unless otherwise noted.

[3] Criteria have been calculated to protect human health from toxic effects through drinking water and fish consumption, unless otherwise noted and apply in segments designated as PWS in 9 VAC 25-260-390-540.

[4] Criteria have been calculated to protect human health from toxic effects through fish consumption, unless otherwise noted and apply in all other surface waters not designated as PWS in 9 VAC 25-260-390-540.

[5] Acute and chronic saltwater and freshwater aquatic life criteria apply to the biologically available form of the metal and apply as a function of the pollutant's water effect ratio (WER) as defined in 9 VAC 25-260-140 F (WER X criterion.) Metals measured as dissolved shall be considered to be biologically available, or, because local receiving water characteristics may otherwise affect the biological availability of the metal, the biologically available equivalent measurement of the metal can be further defined by determining a Water Effect Ratio (WER) and multiplying the numerical value shown in 9 VAC 25-260-140 B by the WER. Refer to 9 VAC 25-260-140 F. Values displayed above in the table are examples and correspond to a (WER) of 1.0. Metals criteria have been adjusted to convert the total recoverable fraction to dissolved fraction using a conversion factor. Criteria that change with hardness have the conversion factor listed in the table above.

6 = The flows listed below are default design flows for calculating steady state waste load allocations unless statistically valid methods are employed which demonstrate compliance with the duration and return frequency of the water quality criteria.

Aquatic Life:

Acute criteria	1Q10
Chronic criteria	7Q10
Chronic criteria (ammonia)	30Q10

Human Health:

Non-carcinogens	30Q5
Carcinogens	Harmonic mean (An exception to this is for the carcinogen dioxin. The applicable stream flow for dioxin is the mean annual stream flow.)

The following are defined for this section:

"1Q10" means the lowest flow averaged over a period of one day which on a statistical basis can be expected to occur once every 10 climatic years.

"7Q10" means the lowest flow averaged over a period of seven consecutive days that can be statistically expected to occur once every 10 climatic years.

"30Q5" means the lowest flow averaged over a period of 30 consecutive days that can be statistically expected to occur once every five climatic years.

"30Q10" means the lowest flow averaged over a period of 30 consecutive days that can be statistically expected to occur once every 10 climactic years.

"Averaged" means an arithmetic mean.

"Climatic year" means a year beginning on April 1 and ending on March 31.

C. Application of freshwater and saltwater numerical criteria.

The numerical water quality criteria listed in subsection B of this section (excluding dissolved oxygen, pH, temperature) shall be applied according to the following classes of waters (see 9 VAC 25-260-50) and boundary designations:

CLASS OF WATERS	NUMERICAL CRITERIA
I and II (Estuarine Waters)	Saltwater criteria apply
II (Transition Zone)	More stringent of either the freshwater or saltwater criteria apply
II (Tidal Freshwater,) III, IV, V, VI and VII	Freshwater criteria apply

The following describes the boundary designations for Class II, (estuarine, transition zone and tidal freshwater waters) by river basin:

1. Rappahannock Basin.

Tidal freshwater is from the fall line of the Rappahannock River to Buoy 37 near Tappahannock, Virginia, including all tidal tributaries that enter the tidal freshwater Rappahannock River.

Transition zone is from Buoy 37 to Buoy 11 near Morattico, Virginia, including all tidal tributaries that enter the transition zone of the Rappahannock River.

Estuarine waters are from Buoy 11 to the mouth of the Rappahannock River (Buoy 6), including all tidal tributaries that enter the estuarine waters of the Rappahannock River.

2. York Basin.

Tidal freshwater is from the fall line of the Mattaponi River to Clifton, Virginia, and from the fall line of the Pamunkey River to Sweet Hall Landing, Virginia, including all tidal tributaries that enter the tidal freshwaters of the Mattaponi and Pamunkey Rivers.

Transition zone of the Mattaponi River is from Clifton, Virginia to the York River and the transition zone of the Pamunkey River is from Sweet Hall Landing, Virginia, to the York River. The transition zone for the York River is from West Point, Virginia, to Buoy 13 near Poropotank Bay. All tidal tributaries that enter the transition zones of the Mattaponi, Pamunkey, and York Rivers are themselves in the transition zone.

Estuarine waters are from Buoy 13 to the mouth of the York River (Tue Marsh Light) including all tidal tributaries that enter the estuarine waters of the York River.

3. James Basin.

Tidal Freshwater is from the fall line of the James River to the confluence of the Chickahominy River Buoy 70, including all tidal tributaries that enter the tidal freshwater James River.

Transition zone is from (Buoy 70) to Buoy 47 near Jamestown Island including all tidal tributaries that enter the transition zone of the James River.

Estuarine waters are from Buoy 47 to the mouth of the James River (Buoy 25) including all tidal tributaries that enter the estuarine waters of the James River.

4. Potomac Basin.

Tidal Freshwater includes all tidal tributaries that enter the Potomac River from its fall line to Buoy 43 near Quantico, Virginia.

Transition zone includes all tidal tributaries that enter the Potomac River from Buoy 43 to Buoy 33 near Dahlgren, Virginia.

Estuarine waters includes all tidal tributaries that enter the Potomac River from Buoy 33 to the mouth of the Potomac River (Buoy 44B.)

5. Chesapeake Bay, Atlantic Ocean, and small coastal basins.

Estuarine waters include the Atlantic Ocean tidal tributaries, and the Chesapeake Bay and its small coastal basins from the Virginia state line to the mouth of the bay (a line from Cape Henry drawn through Buoys 3 and 8 to Fishermans Island), and its tidal tributaries, excluding the Potomac tributaries and those tributaries listed above.

6. Chowan River Basin.

Tidal freshwater includes the Northwest River and its tidal tributaries from the Virginia-North Carolina state line to the free flowing portion, the Blackwater River and its tidal tributaries from the Virginia-North Carolina state line to the end of tidal waters at approximately state route 611 at river mile 20.90, the Nottoway River and its tidal tributaries from the Virginia-North Carolina state line to the end of tidal waters at approximately Route 674, and the North Landing River and its tidal tributaries from the Virginia-North Carolina state line to the Great Bridge Lock.

Transition zone includes Back Bay and its tributaries in the City of Virginia Beach to the Virginia-North Carolina state line.

D. Site-specific modifications to numerical water quality criteria.

1. The board may consider site-specific modifications to numerical water quality criteria in subsection B of this section where the applicant or permittee demonstrates that the alternate numerical water quality criteria are sufficient to protect all designated uses (see 9 VAC 25-260-10) of that particular surface water segment or body.

2. Any demonstration for site-specific human health criteria shall be restricted to a reevaluation of the bioconcentration or bioaccumulation properties of the pollutant. The exceptions to this restriction are for site-specific criteria for taste, odor, and aesthetic compounds noted by double asterisks in subsection B of this section and nitrates.

3. Site-specific temperature requirements are found in 9 VAC 25-260-90.

4. Procedures for promulgation and review of site-specific modifications to numerical water quality criteria resulting from subdivisions 1 and 2 of this subsection.

a. Proposals describing the details of the site-specific study shall be submitted to the board's staff for approval prior to commencing the study.

b. Any site-specific modification shall be promulgated as a regulation in accordance with the Administrative Process Act. All site-specific modifications shall be listed in 9 VAC 25-260-310 (Special standards and requirements).

E. Variances to water quality standards.

1. A variance from numeric criteria may be granted to a discharger if it can be demonstrated that one or more of the conditions in 9 VAC 25-260-10 G limit the attainment of one or more specific designated uses.

a. Variances shall apply only to the discharger to whom they are granted and shall be reevaluated and either continued, modified or revoked at the time of permit issuance. At that time the permittee shall make a showing that the conditions for granting the variance still apply.

b. Variances shall be described in the public notice published for the permit. The decision to approve a variance shall be subject to the public participation requirements of the Virginia Pollutant Discharge Elimination System (VPDES) Permit Regulation, 9 VAC 25-31 (Permit Regulation).

c. Variances shall not prevent the maintenance and protection of existing uses or exempt the discharger or regulated activity from compliance with other appropriate technology or water quality-based limits or best management practices.

d. Variances granted under this section shall not apply to new discharges.

e. Variances shall be submitted by the department's Division of Scientific Research or its successors to the

Environmental Protection Agency for review and approval/disapproval.

f. A list of variances granted shall be maintained by the department's Division of Scientific Research or its successors.

2. None of the variances in subsection E of this section shall apply to the halogen ban section 9 VAC 25-260-110 or temperature criteria in 9 VAC 25-260-50 if superseded by § 316a of the Clean Water Act requirements. No variances in subsection E of this section shall apply to the criteria that are designed to protect human health from carcinogenic and noncarcinogenic toxic effects subsection B of this section with the exception of the metals, and the taste, odor, and aesthetic compounds noted by double asterisks and nitrates, listed in subsection B of this section.

F. Water effect ratio.

1. A water effects ratio (WER) shall be determined by measuring the effect of receiving water (as it is or will be affected by any discharges) on the bioavailability or toxicity of a metal by using standard test organisms and a metal to conduct toxicity tests simultaneously in receiving water and laboratory water. The ratio of toxicities of the metal(s) in the two waters is the WER (toxicity in receiving water divided by toxicity in laboratory water = WER. Once an acceptable WER for a metal is established, the numerical value for the metal in subsection B of this section is multiplied by the WER to produce an instream concentration that will protect designated uses. This instream concentration shall be utilized in permitting decisions.

2. The WER shall be assigned a value of 1.0 unless the applicant or permittee demonstrates to the department's satisfaction in a permit proceeding that another value is appropriate, or unless available data allow the department to compute a WER for the receiving waters. The applicant or permittee is responsible for proposing and conducting the study to develop a WER. The study may require multiple testing over several seasons. The applicant or permittee shall obtain the department's Division of Scientific Research or its successor approval of the study protocol and the final WER.

3. The Permit Regulation at 9 VAC 25-31-230 C requires that permit limits for metals be expressed as total recoverable measurements. To that end, the study used to establish the WER may be based on total recoverable measurements of the metals.

4. The Environmental Protection Agency views the WER in any particular case as a site-specific criterion. Therefore, the department's Division of Scientific Research or its successor shall submit the results of the study to the Environmental Protection Agency for review and approval/disapproval within 30 days of the receipt of certification from the state's Office of the Attorney General. Nonetheless, the WER is established in a permit proceeding, shall be described in the public notice associated with the permit proceeding, and applies only to the applicant or permittee in that proceeding. The department's action to approve or disapprove a WER is a case decision, not an amendment to the present regulation.

The decision to approve or disapprove a WER shall be subject to the public participation requirements of the Permit Regulation, 9 VAC 25-31-260 et seq. A list of final WERs will be maintained by the department's Division of Scientific Research or its successor.

5. A WER shall not be used for the freshwater and saltwater chronic mercury criteria or the freshwater acute and chronic selenium criteria.

9 VAC 25-260-150. (Repealed.)

APPENDIX C
National Primary and Secondary Drinking Water Standards

EPA National Primary Drinking Water Standards

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Acrylamide	TT[8]	Nervous system or blood problems;	Added to water during sewage/wastewater increased risk of cancer treatment	zero
OC	Alachlor	0.002	Eye, liver, kidney or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops	zero
R	Alpha particles	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation	zero
IOC	Antimony	0.006	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder	0.006
IOC	Arsenic	0.010 as of 1/23/06	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards, runoff from glass & electronics production wastes	0
IOC	Asbestos (fibers >10 micrometers)	7 million fibers per Liter (MFL)	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits	7 MFL
OC	Atrazine	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops	0.003
IOC	Barium	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits	2
OC	Benzene	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills	zero
OC	Benzo(a)pyrene (PAHs)	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines	zero
IOC	Beryllium	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries	0.004
R	Beta particles and photon emitters	4 millirems per year	Increased risk of cancer	Decay of natural and man-made deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation	zero
DBP	Bromate	0.010	Increased risk of cancer	Byproduct of drinking water disinfection	zero
IOC	Cadmium	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints	0.005
OC	Carbofuran	0.04	Problems with blood, nervous system, or reproductive system	Leaching of soil fumigant used on rice and alfalfa	0.04
OC	Carbon tetrachloride	0.005	Liver problems; increased risk of cancer	Discharge from chemical plants and other industrial activities	zero
D	Chloramines (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort, anemia	Water additive used to control microbes	MRDLG=4[1]

LEGEND

D	Dinsinfectant	IOC	Inorganic Chemical	OC	Organic Chemical
DBP	Disinfection Byproduct	M	Microorganism	R	Radionuclides

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Chlordane	0.002	Liver or nervous system problems; increased risk of cancer	Residue of banned termiticide	zero
D	Chlorine (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort	Water additive used to control microbes	MRDLG=4[1]
D	Chlorine dioxide (as ClO_2)	MRDL=0.8[1]	Anemia; infants & young children: nervous system effects	Water additive used to control microbes	MRDLG=0.8[1]
DBP	Chlorite	1.0	Anemia; infants & young children: nervous system effects	Byproduct of drinking water disinfection	0.8
OC	Chlorobenzene	0.1	Liver or kidney problems	Discharge from chemical and agricultural chemical factories	0.1
IOC	Chromium (total)	0.1	Allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits	0.1
IOC	Copper	TT[7]; Action Level = 1.3	Short term exposure: Gastrointestinal distress. Long term exposure: Liver or kidney damage. People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level	Corrosion of household plumbing systems; erosion of natural deposits	1.3
M	*Cryptosporidium*	TT[3]	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
IOC	Cyanide (as free cyanide)	0.2	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories	0.2
OC	2,4-D	0.07	Kidney, liver, or adrenal gland problems	Runoff from herbicide used on row crops	0.07
OC	Dalapon	0.2	Minor kidney changes	Runoff from herbicide used on rights of way	0.2
OC	1,2-Dibromo-3-chloropropane (DBCP)	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards	zero
OC	o-Dichlorobenzene	0.6	Liver, kidney, or circulatory system problems	Discharge from industrial chemical factories	0.6
OC	p-Dichlorobenzene	0.075	Anemia; liver, kidney or spleen damage; changes in blood	Discharge from industrial chemical factories	0.075
OC	1,2-Dichloroethane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	zero
OC	1,1-Dichloroethylene	0.007	Liver problems	Discharge from industrial chemical factories	0.007
OC	cis-1,2-Dichloroethylene	0.07	Liver problems	Discharge from industrial chemical factories	0.07
OC	trans-1,2-Dichloroethylene	0.1	Liver problems	Discharge from industrial chemical factories	0.1
OC	Dichloromethane	0.005	Liver problems; increased risk of cancer	Discharge from drug and chemical factories	zero
OC	1,2-Dichloropropane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	zero
OC	Di(2-ethylhexyl) adipate	0.4	Weight loss, live problems, or possible reproductive difficulties	Discharge from chemical factories	0.4
OC	Di(2-ethylhexyl) phthalate	0.006	Reproductive difficulties; liver problems; increased risk of cancer	Discharge from rubber and chemical factories	zero
OC	Dinoseb	0.007	Reproductive difficulties	Runoff from herbicide used on soybeans and vegetables	0.007
OC	Dioxin (2,3,7,8-TCDD)	0.00000003	Reproductive difficulties; increased risk of cancer	Emissions from waste incineration and other combustion; discharge from chemical factories	zero
OC	Diquat	0.02	Cataracts	Runoff from herbicide use	0.02
OC	Endothall	0.1	Stomach and intestinal problems	Runoff from herbicide use	0.1

LEGEND

D	Dinsinfectant	IOC	Inorganic Chemical	OC	Organic Chemical
DBP	Disinfection Byproduct	M	Microorganism	R	Radionuclides

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Endrin	0.002	Liver problems	Residue of banned insecticide	0.002
OC	Epichlorohydrin	TT[8]	Increased cancer risk, and over a long period of time, stomach problems	Discharge from industrial chemical factories; an impurity of some water treatment chemicals	zero
OC	Ethylbenzene	0.7	Liver or kidneys problems	Discharge from petroleum refineries	0.7
OC	Ethylene dibromide	0.00005	Problems with liver, stomach, reproductive system, or kidneys; increased risk of cancer	Discharge from petroleum refineries	zero
IOC	Fluoride	4.0	Bone disease (pain and tenderness of the bones); Children may get mottled teeth	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories	4.0
M	*Giardia lamblia*	TT[3]	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
OC	Glyphosate	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use	0.7
DBP	Haloacetic acids (HAA5)	0.060	Increased risk of cancer	Byproduct of drinking water disinfection	n/a[6]
OC	Heptachlor	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide	zero
OC	Heptachlor epoxide	0.0002	Liver damage; increased risk of cancer	Breakdown of heptachlor	zero
M	Heterotrophic plate count (HPC)	TT[3]	HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.	HPC measures a range of bacteria that are naturally present in the environment	n/a
OC	Hexachlorobenzene	0.001	Liver or kidney problems; reproductive difficulties; increased risk of cancer	Discharge from metal refineries and agricultural chemical factories	zero
OC	Hexachlorocyclopentadien e	0.05	Kidney or stomach problems	Discharge from chemical factories	0.05
IOC	Lead	TT[7]; Action Level = 0.015	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities; Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits	zero
M	*Legionella*	TT[3]	Legionnaire's Disease, a type of pneumonia	Found naturally in water; multiplies in heating systems	zero
OC	Lindane	0.0002	Liver or kidney problems	Runoff/leaching from insecticide used on cattle, lumber, gardens	0.0002
IOC	Mercury (inorganic)	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands	0.002
OC	Methoxychlor	0.04	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, livestock	0.04
IOC	Nitrate (measured as Nitrogen)	10	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	10
IOC	Nitrite (measured as Nitrogen)	1	Infants below the age of six months who drink water containing nitrite in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	1

LEGEND

D	Dinsinfectant	IOC	Inorganic Chemical	OC	Organic Chemical
DBP	Disinfection Byproduct	M	Microorganism	R	Radionuclides

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Oxamyl (Vydate)	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes	0.2
OC	Pentachlorophenol	0.001	Liver or kidney problems; increased cancer risk	Discharge from wood preserving factories	zero
OC	Picloram	0.5	Liver problems	Herbicide runoff	0.5
OC	Polychlorinated biphenyls (PCBs)	0.0005	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfills; discharge of waste chemicals	zero
R	Radium 226 and Radium 228 (combined)	5 pCi/L	Increased risk of cancer	Erosion of natural deposits	zero
IOC	Selenium	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum refineries; erosion of natural deposits; discharge from mines	0.05
OC	Simazine	0.004	Problems with blood	Herbicide runoff	0.004
OC	Styrene	0.1	Liver, kidney, or circulatory system problems	Discharge from rubber and plastic factories; leaching from landfills	0.1
OC	Tetrachloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from factories and dry cleaners	zero
IOC	Thallium	0.002	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and drug factories	0.0005
OC	Toluene	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories	1
M	Total Coliforms (including fecal coliform and *E. coli*)	5.0%[4]	Not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present[5]	Coliforms are naturally present in the environment as well as feces; fecal coliforms and *E. coli* only come from human and animal fecal waste.	zero
DBP	Total Trihalomethanes (TTHMs)	0.10 0.080 after 12/31/03	Liver, kidney or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection	n/a[6]
OC	Toxaphene	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle	zero
OC	2,4,5-TP (Silvex)	0.05	Liver problems	Residue of banned herbicide	0.05
OC	1,2,4-Trichlorobenzene	0.07	Changes in adrenal glands	Discharge from textile finishing factories	0.07
OC	1,1,1-Trichloroethane	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories	0.20
OC	1,1,2-Trichloroethane	0.005	Liver, kidney, or immune system problems	Discharge from industrial chemical factories	0.003
OC	Trichloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from metal degreasing sites and other factories	zero
M	Turbidity	TT[3]	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing micro-organisms such as viruses, parasites and some bacteria. These organisms can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.	Soil runoff	n/a
R	Uranium	30 ug/L as of 12/08/03	Increased risk of cancer, kidney toxicity	Erosion of natural deposits	zero

LEGEND

D	Dinsinfectant	IOC	Inorganic Chemical	OC	Organic Chemical
DBP	Disinfection Byproduct	M	Microorganism	R	Radionuclides

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Vinyl chloride	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories	zero
M	Viruses (enteric)	TT[3]	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
OC	Xylenes (total)	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories	10

NOTES

1 Definitions

- Maximum Contaminant Level Goal (MCLG)—The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.
- Maximum Contaminant Level (MCL)—The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.
- Maximum Residual Disinfectant Level Goal (MRDLG)—The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.
- Maximum Residual Disinfectant Level (MRDL)—The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.
- Treatment Technique (TT)—A required process intended to reduce the level of a contaminant in drinking water.

2 Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million (ppm).

3 EPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:

- *Cryptosporidium* (as of 1/1/02 for systems serving >10,000 and 1/14/05 for systems serving <10,000) 99% removal.
- *Giardia lamblia*: 99.9% removal/inactivation
- Viruses: 99.99% removal/inactivation
- *Legionella:* No limit, but EPA believes that if *Giardia* and viruses are removed/inactivated, *Legionella* will also be controlled.
- Turbidity: At no time can turbidity (cloudiness of water) go above 5 nephelolometric turbidity units (NTU); systems that filter must ensure that the turbidity go no higher than 1 NTU (0.5 NTU for conventional or direct filtration) in at least 95% of the daily samples in any month. As of January 1, 2002, for systems servicing >10,000, and January 14, 2005, for systems servicing <10,000, turbidity may never exceed 1 NTU, and must not exceed 0.3 NTU in 95% of daily samples in any month.
- HPC: No more than 500 bacterial colonies per milliliter
- Long Term 1 Enhanced Surface Water Treatment (Effective Date: January 14, 2005); Surface water systems or (GWUDI) systems serving fewer than 10,000 people must comply with the applicable Long Term 1 Enhanced Surface Water Treatment Rule provisions (e.g. turbidity standards, individual filter monitoring, *Cryptosporidium* removal requirements, updated watershed control requirements for unfiltered systems).
- Filter Backwash Recycling: The Filter Backwash Recycling Rule requires systems that recycle to return specific recycle flows through all processes of the system's existing conventional or direct filtration system or at an alternate location approved by the state.

4 No more than 5.0% samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or *E. coli* if two consecutive TC-positive samples, and one is also positive for *E. coli* fecal coliforms, system has an acute MCL violation.

5 Fecal coliform and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Disease-causing microbes (pathogens) in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms. These pathogens may pose a special health risk for infants, young children, and people with severely compromised immune systems.

6 Although there is no collective MCLG for this contaminant group, there are individual MCLGs for some of the individual contaminants:

- Haloacetic acids: dichloroacetic acid (zero); trichloroacetic acid (0.3 mg/L)
- Trihalomethanes: bromodichloromethane (zero); bromoform (zero); dibromochloromethane (0.06 mg/L)

7 Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.

8 Each water system must certify, in writing, to the state (using third-party or manufacturers certification) that when it uses acrylamide and/or epichlorohydrin to treat water, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows: Acrylamide = 0.05% dosed at 1 mg/L (or equivalent); Epichlorohydrin = 0.01% dosed at 20 mg/L (or equivalent).

LEGEND

D	Dinsinfectant	IOC	Inorganic Chemical	OC	Organic Chemical
DBP	Disinfection Byproduct	M	Microorganism	R	Radionuclides

National Secondary Drinking Water Standards

National Secondary Drinking Water Standards are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards.

Contaminant	Secondary Standard
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

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APPENDIX D
The Second Contaminant Candidate List
(EPA, 2005)

Fact Sheet: The Drinking Water Contaminant Candidate List -- The Source of Priority Contaminants for the Drinking Water Program

EPA has drinking water regulations for more than 90 contaminants. The Safe Drinking Water Act (SDWA) includes a process that we must follow to identify new contaminants which may require regulation in the future. EPA must periodically release a Contaminant Candidate List (CCL). EPA uses this list of unregulated contaminants to prioritize research and data collection efforts to help us to determine whether we should regulate a specific contaminant.

In February 2005, we published the second CCL of 51 contaminants. We also provided an update on our work to improve the CCL process for the future that is based, in part, on recommendations from the National Research Council and the National Drinking Water Advisory Council. In addition to making the process used for selecting contaminants easier to understand, our goals for the future are to:

- evaluate a wider range of information
- screen contaminants more systematically, and
- develop a more comprehensive CCL by expanding the number of contaminants being reviewed for inclusion on the next CCL.

You can find more information on the CCL on EPA's website at **www.epa.gov/safewater/ccl/**

Questions and Answers

What is the drinking water CCL?
The drinking water CCL is the primary source of priority contaminants on which we conduct research and make decisions about whether regulations are needed. The contaminants on the list are known or anticipated to occur in public water systems. However, they are currently unregulated by existing national primary drinking water regulations.

How often is the CCL published?
The Safe Drinking Water Act directs that we periodically publish a CCL. We published the first CCL of 60 contaminants in March 1998 and the second CCL in February 2005 after deciding to continue research on the list of contaminants on the first CCL.

What contaminants are included in CCL 2?
The CCL (published in 2005) carries forward 51 (of the original 60) unregulated contaminants from the first CCL, including nine microbiological contaminants and 42 chemical contaminants or contaminant groups (see table). In July 2003, EPA announced its final determination for a subset of nine contaminants from the first CCL, which concluded that sufficient data and

information was available to make the determination not to regulate Acanthamoeba, aldrin, dieldrin, hexachlorobutadiene, manganese, metribuzin, naphthalene, sodium, and sulfate. These nine contaminants were not carried forward to the 2005 CCL.

Does the CCL impose any requirements on public water systems?

No. The CCL alone does not impose any requirements on public water systems. However, we may regulate contaminants on the list in the future. Public water systems would have to follow specific requirements to comply with a regulation.

What happens to contaminants on the CCL?

We carry out studies to develop analytical methods for detecting the contaminants, determine whether they occur in drinking water, and evaluate treatment technologies to remove them from drinking water. We also investigate potential health effects from the contaminants. These efforts help us to determine if actions such as drinking water guidance, health advisories or regulations need to be developed for contaminants on the CCL, or if no action is necessary at this time.

What is a regulatory determination?

A regulatory determination is a formal decision on whether we should issue a national primary drinking water regulation for a specific contaminant. The law requires that we make regulatory determinations for five or more contaminants from the most recent CCL.

In 2003, we made regulatory determinations for nine contaminants from the first CCL. We plan to propose the second cycle of preliminary regulatory determinations from the second CCL in the summer of 2005 and make final regulatory determinations in August of 2006.

It is important to note that we are not limited to making regulatory determinations for only those contaminants on the CCL. We can also decide to regulate other unregulated contaminants if information becomes available showing that a specific contaminant presents a public health risk.

What criteria do EPA consider to make regulatory determinations?

When making a "determination" to regulate, the law requires that we consider three areas:

- projected adverse health effects from the contaminant,
- the extent of occurrence of the contaminant in drinking water, and
- whether regulation of the contaminant would present a "meaningful opportunity" for reducing risks to health.

What is EPA doing to improve future CCLs?

During development of the first CCL, we received comments that indicated a need for a broader, more comprehensive approach for selecting contaminants. In response, we sought the advice of the National Research Council (NRC) on how we could improve the process for selecting contaminants. The NRC's 2001 report provided us with a framework for how we could evaluate a larger number of contaminants and make decisions about those contaminants by applying innovative technologies and expert advice.

We then asked the National Drinking Water Advisory Council (NDWAC) to advise us on how to address the NRC's recommended classification process. The NDWAC's May 2004 report provided us with a number of recommendations on how the process should be managed and principles that we should use in developing future CCLs. We are reviewing the NDWAC recommendations and are on schedule to meet the February 2008 deadline for the third CCL. You can review the NDWAC report on EPA's web site at www.epa.gov/safewater/ndwac/pdfs/report_ccl_ndwac_07-06-04.pdf.

Where can I find more information about this notice and the CCL?
For information on the CCL and the contaminant selection process, please visit www.epa.gov/safewater/ccl/. For general information on drinking water, please visit the EPA Safewater website at www.epa.gov/safewater or contact the Safe Drinking Water Hotline at 1-800-426-4791. The Safe Drinking Water Hotline is open Monday through Friday, excluding legal holidays, from 9:00 a.m. to 5:00 p.m. Eastern time.

Drinking Water Contaminant Candidate List 2

Microbial Contaminant Candidates
Adenoviruses
Aeromonas hydrophila
Caliciviruses
Coxsackieviruses
Cyanobacteria (blue-green algae), other freshwater algae, and their toxins
Echoviruses
Helicobacter pylori
Microsporidia (Enterocytozoon & Septata)
Mycobacterium avium intracellulare (MAC)

Chemical Contaminant Candidates	CASRN
1,1,2,2-tetrachloroethane	79-34-5
1,2,4-trimethylbenzene	95-63-6
1,1-dichloroethane	75-34-3
1,1-dichloropropene	563-58-6
1,2-diphenylhydrazine	122-66-7
1,3-dichloropropane	142-28-9
1,3-dichloropropene	542-75-6
2,4,6-trichlorophenol	88-06-2
2,2-dichloropropane	594-20-7
2,4-dichlorophenol	120-83-2
2,4-dinitrophenol	51-28-5
2,4-dinitrotoluene	121-14-2
2,6-dinitrotoluene	606-20-2
2-methyl-Phenol (o-cresol)	95-48-7
Acetochlor	34256-82-1

Chemical Contaminant Candidates	CASRN
Alachlor ESA & other acetanilide pesticide degradation products	N/A
Aluminum	7429-90-5
Boron	7440-42-8
Bromobenzene	108-86-1
DCPA mono-acid degradate	887-54-7
DCPA di-acid degradate	2136-79-0
DDE	72-55-9
Diazinon	333-41-5
Disulfoton	298-04-4
Diuron	330-54-1
EPTC (s-ethyl-dipropylthiocarbamate)	759-94-4
Fonofos	944-22-9
p-Isopropyltoluene (p-cymene)	99-87-6
Linuron	330-55-2
Methyl bromide	74-83-9
Methyl-t-butyl ether (MTBE)	1634-04-4
Metolachlor	51218-45-2
Molinate	2212-67-1
Nitrobenzene	98-95-3
Organotins	N/A
Perchlorate	14797-73-0
Prometon	1610-18-0
RDX	121-82-4
Terbacil	5902-51-2
Terbufos	13071-79-9

Chemical Contaminant Candidates	CASRN
Triazines & degradation products of triazines	including, but not limited to Cyanazine 21725-46-2 and atrazine-desethyl 6190-65-4
Vanadium	7440-62-2

APPENDIX E
The Third Contaminant Candidate List
(Draft, EPA, 2008)

Federal Register

Thursday,

February 21, 2008

Part II

Environmental Protection Agency

Drinking Water Contaminant Candidate List 3—Draft; Notice

ENVIRONMENTAL PROTECTION AGENCY

[EPA–HQ–OW–2007–1189 FRL–8529–7]

RIN 2040–AD99

Drinking Water Contaminant Candidate List 3—Draft

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice.

SUMMARY: EPA is publishing for public review and comment a draft list of contaminants that are currently not subject to any proposed or promulgated national primary drinking water regulations, that are known or anticipated to occur in public water systems, and which may require regulations under the Safe Drinking Water Act (SDWA). This is the third Contaminant Candidate List (CCL 3) published by the Agency since the SDWA amendments of 1996.

This draft CCL 3 includes 93 chemicals or chemical groups and 11 microbiological contaminants. The EPA seeks comment on the draft CCL 3, the approach used to develop the list, and other specific contaminants.

DATES: Comments must be received on or before May 21, 2008.

ADDRESSES: Submit your comments, identified by Docket ID No. EPA–HQ–OW–2007–1189, by one of the following methods:

• *http://www.regulations.gov:* Follow the on-line instructions for submitting comments.

• *Mail:* Water Docket, Environmental Protection Agency, Mailcode: 2822T, 1200 Pennsylvania Ave., NW., Washington, DC 20460.

• *Hand Delivery:* Water Docket, EPA Docket Center (EPA/DC) EPA West, Room 3334, 1301 Constitution Ave., NW., Washington, DC. Such deliveries are only accepted during the Docket's normal hours of operation, and special arrangements should be made for deliveries of boxed information.

Instructions: Direct your comments to Docket ID No. EPA–HQ–OW–2007–1189. EPA's policy is that all comments received will be included in the public docket without change and may be made available online at *http://www.regulations.gov*, including any personal information provided, unless the comment includes information claimed to be Confidential Business Information (CBI) or other information whose disclosure is restricted by statute. Do not submit information that you consider to be CBI or otherwise protected through *http://www.regulations.gov* or e-mail. The *http://www.regulations.gov* Web site is an "anonymous access" system, which means EPA will not know your identity or contact information unless you provide it in the body of your comment. If you send an e-mail comment directly to EPA without going through *http://www.regulations.gov* your e-mail address will be automatically captured and included as part of the comment that is placed in the public docket and made available on the Internet. If you submit an electronic comment, EPA recommends that you include your name and other contact information in the body of your comment and with any disk or CD–ROM you submit. If EPA cannot read your comment due to technical difficulties and cannot contact you for clarification, EPA may not be able to consider your comment. Electronic files should avoid the use of special characters, any form of encryption, and be free of any defects or viruses. For additional instructions on submitting comments, go to Unit I.B of the **SUPPLEMENTARY INFORMATION** section of this document.

Docket: All documents in the docket are listed in the *http://www.regulations.gov* index. Although listed in the index, some information is not publicly available, e.g., CBI or other information whose disclosure is restricted by statute. Certain other material, such as copyrighted material, will be publicly available only in hard copy. Publicly available docket materials are available either electronically in *http://www.regulations.gov* or in hard copy at the Water Docket, EPA/DC, EPA West, Room 3334, 1301 Constitution Ave., NW., Washington, DC. The Public Reading Room is open from 8:30 a.m. to 4:30 p.m., Monday through Friday, excluding legal holidays. The telephone number for the Public Reading Room is (202) 566–1744, and the telephone number for the EPA Docket Center is (202) 566–2426.

FOR FURTHER INFORMATION CONTACT: For information on chemical contaminants contact Thomas Carpenter, Office of Ground Water and Drinking Water, Standards and Risk Management Division, at (202) 564–4885 or e-mail *carpenter.thomas@epa.gov*. For information on microbial contaminants contact Tracy Bone, Office of Ground Water and Drinking Water, at 202–564–5257 or e-mail *bone.tracy@epa.gov*. For general information contact the EPA Safe Drinking Water Hotline at (800) 426–4791 or e-mail: *hotline-sdwa@epa.gov*.

Abbreviations and Acronyms

$<$—less than
$\leq$—less than or equal to
$>$—greater than
$\geq$—greater than or equal to
μ—microgram, one-millionth of a gram
μg/L—micrograms per liter
ATSDR—Agency for Toxic Substances and Disease Registry
AWWA—American Water Works Association
CASRN—Chemical Abstract Services Registry Number
CDC—Centers for Disease Control and Prevention
CCL—Contaminant Candidate List
CCL 1—EPA's First Contaminant Candidate List
CCL 2—EPA's Second Contaminant Candidate List
CCL 3—EPA's Third Contaminant Candidate List
CFR—Code of Federal Regulations
CUS/IUR—Chemical Update System/Inventory Update Rule
DBP—disinfection byproduct
DWEL—drinking water equivalent level
EPA—United States Environmental Protection Agency
ESA—ethanesulfonic acid
FDA—United States Food and Drug Administration
FR—**Federal Register**
g—gram
HAAs—haloacetic acids
IOCs—inorganic contaminants
IRIS—Integrated Risk Information System
kg—kilogram
L—liter
LD_{50}—lethal dose 50; an estimate of a single dose that is expected to cause the death of 50 percent of the exposed animals; it is derived from experimental data.
lbs—pounds
LOAEL—lowest-observed-adverse-effect level
MCL—maximum contaminant level
MCLG—maximum contaminant level goal
MRDD—maximum recommended daily dose
mg/kg—milligrams per kilogram body weight
mg/kg/day—milligrams per kilogram body weight per day
mg/L—milligrams per liter
MMWR—*Morbidity and Mortality Weekly Report*
NAS—National Academy of Sciences
NCI—National Cancer Institute
NCOD—National Contaminant Occurrence Database
NDWAC—National Drinking Water Advisory Council
NOAEL—no-observed-adverse-effect level

NRC—National Academy of Sciences' National Research Council
NPDWR—national primary drinking water regulation
NTP—National Toxicology Program
OPP—Office of Pesticide Programs
PFOA—perfluorooctanoic acid
PFOS—perfluorooctane sulfonic acid
PWS—public water system
RfD—reference dose
SAB—Science Advisory Board
SDWA—Safe Drinking Water Act
TCR—Total Coliform Rule
TD_{50}—tumorigenic dose 50; The dose-rate which if administered chronically for the standard life-span of the species will have a 50% probability of causing tumors at some point during that period.
TRI—Toxics Release Inventory
TDS—training data set
UCM—Unregulated Contaminant Monitoring
UCMR 1—First Unregulated Contaminant Monitoring Regulation
UCMR 2—Second Unregulated Contaminant Monitoring Regulation
US—United States of America
USDA—United States Department of Agriculture
USGS—United States Geological Survey
WBDO—waterborne disease outbreak
WHO—World Health Organization
yr—year

SUPPLEMENTARY INFORMATION:

I. General Information

A. Does This Action Impose Any Requirements on My Public Water System?

The draft Contaminant Candidate List 3 (CCL 3) or the final CCL 3, when published, will not impose any requirements on anyone. Instead, this action notifies interested parties of the availability of EPA's draft CCL 3 and seeks comment on the contaminants listed.

B. What Should I Consider as I Prepare My Comments for EPA?

You may find the following suggestions helpful for preparing your comments:

- Explain your views as clearly as possible.
- Describe any assumptions that you used.
- Provide any technical information and/or data you used that support your views.
- Provide specific examples to illustrate your concerns.
- Offer alternatives.

Make sure to submit your comments by the comment period deadline. To ensure proper receipt by EPA, identify the appropriate docket identification number in the subject line on the first page of your response. It would also be helpful if you provided the name, date, and **Federal Register** citation related to your comments.

II. Purpose, Background, and Summary of This Action

This section briefly summarizes the purpose of this action, the statutory requirements, previous activities related to the Contaminant Candidate List (CCL), and the approach used to develop the CCL 3.

A. What Is the Purpose of This Action?

The Safe Drinking Water Act (SDWA), as amended in 1996, requires EPA to publish a list of currently unregulated contaminants that may pose risks for drinking water (referred to as the Contaminant Candidate List, or CCL) and to make determinations on whether to regulate at least five contaminants from the CCL with a national primary drinking water regulation (NPDWR) (section 1412(b)(1)). The 1996 SDWA requires the Agency to publish both the CCL and the regulatory determinations every five years. The purpose of this action is to present EPA's draft list of contaminants on the CCL 3, a description of the selection process, and the rationale used to make the list.

This action also includes a request for comment on the Agency's draft CCL 3, the approach used to develop the list, and other specific contaminants.

B. Background on the CCL, Regulatory Determinations, and Unregulated Contaminant Monitoring

1. Statutory Requirements for CCL and Regulatory Determinations

Section 1412(b) (1) of SDWA, as amended in 1996, requires EPA to publish the Contaminant Candidate List every five years. SDWA specifies that the list must include contaminants that are not subject to any proposed or promulgated NPDWRs, are known or anticipated to occur in public water systems (PWSs), and may require regulation under SDWA.

The 1996 SDWA Amendments also specify three criteria to determine whether a contaminant may require regulation:

- The contaminant may have an adverse effect on the health of persons;
- The contaminant is known to occur or there is a substantial likelihood that the contaminant will occur in public water systems with a frequency and at levels of public health concern; and
- In the sole judgment of the Administrator, regulation of such contaminant presents a meaningful opportunity for health risk reduction for persons served by public water systems.

In developing the draft CCL 3, the Agency considered the best available data and information for unregulated contaminants. As required under the Safe Drinking Water Act, EPA evaluated substances identified in section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and substances registered as pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act. In addition to these required data sources, the Agency also developed the National Contaminant Occurrence Database (NCOD) established under section 1445(g) of SDWA. Substances from NCOD were included in the initial set of contaminants considered for the draft CCL 3.

SDWA also directs the Agency to consider the health effects and occurrence information for unregulated contaminants to identify those contaminants that present the greatest public health concern related to exposure from drinking water. In selecting contaminants for the draft CCL 3, adverse health effects that may pose a greater risk to subgroups which represent a meaningful portion of the population were considered. Adverse health effects associated with infants, children, pregnant women, the elderly, and individuals with a history of serious illness were evaluated for both chemicals and microbes. The specific analyses and evaluations used by the Agency are discussed and cited in the relevant sections of this notice.

2. The First Contaminant Candidate List

Following the 1996 SDWA Amendments, EPA sought input from the National Drinking Water Advisory Council (NDWAC) on the process that should be used to identify contaminants for inclusion on the first CCL (CCL 1). For chemical contaminants, the Agency developed screening and evaluation criteria based on the recommendations provided by NDWAC. For microbiological contaminants, NDWAC recommended that the Agency seek external expertise to identify and select potential waterborne pathogens. As a result, an external group of microbiologists and public health experts developed the criteria for screening, conducted an evaluation of microbial agents, and selected the initial list of microbiological contaminants for the CCL 1.

The draft CCL 1 was published on October 6, 1997 (62 *FR* 52193 (USEPA, 1997)). After consideration of all comments, EPA published the final CCL 1, which included 50 chemical and 10 microbiological contaminants, on March 2, 1998 (63 *FR* 10273 (USEPA, 1998 b)). A more detailed discussion of how EPA developed CCL 1 can be found in the 1997 and the 1998 **Federal Register** notices (62 *FR* 52193 (USEPA, 1997) and 63 *FR* 10273 (USEPA, 1998 b)).

3. The Regulatory Determinations for CCL 1

EPA published its preliminary regulatory determinations for a subset of contaminants listed on CCL 1 on June 3, 2002 (67 *FR* 38222 (USEPA, 2002 b)). The Agency published its final regulatory determinations on July 18, 2003 (68 *FR* 42898 (USEPA, 2003 a)). EPA identified 9 contaminants from the 60 contaminants listed on CCL 1 that had sufficient data and information available to make regulatory determinations. The 9 contaminants were *Acanthamoeba*, aldrin, dieldrin, hexachlorobutadiene, manganese, metribuzin, naphthalene, sodium, and sulfate. The Agency determined that a national primary drinking water regulation was not necessary for any of these 9 contaminants. The Agency issued guidance on *Acanthamoeba* and health advisories for magnesium, sodium, and sulfate.

4. The Second Contaminant Candidate List

The Agency published its draft second CCL (CCL 2) **Federal Register** notice on April 2, 2004 (69 *FR* 17406 (USEPA, 2004)) and the final CCL 2 **Federal Register** notice on February 24, 2005 (70 *FR* 9071 (USEPA, 2005 b)). The CCL 2 carried forward the 51 remaining chemical and microbial contaminants that were listed on CCL 1.

5. The Regulatory Determinations for CCL 2

EPA published its preliminary regulatory determinations for a subset of contaminants listed on CCL 2 on May 1, 2007 (72 *FR* 24015 (USEPA, 2007 d)). EPA identified 11 contaminants from the 51 contaminants listed on CCL 2 that had sufficient data and information available to make preliminary regulatory determinations. The 11 contaminants are boron, the dacthal mono- and di-acid degradates, 1,1-dichloro-2,2-bis (p-chlorophenyl) ethylene (DDE), 1,3-dichloropropene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, s-ethyl propylthiocarbamate (EPTC), fonofos, terbacil, and 1,1,2,2-tetrachloroethane. The Agency has made a preliminary determination that a national primary drinking water regulation is not necessary for any of these 11 contaminants. The Agency is scheduled to publish its final regulatory determinations in 2008. In the May 1, 2007 *FR* notice, the Agency indicated that additional information was needed to make the regulatory determinations for perchlorate and methyl tertiary butyl ether (MTBE) and provided a summary of the current health effects, occurrence, and exposure information.

6. The Unregulated Contaminant Monitoring Rule

SDWA provides EPA with the authority to require all large and a subset of small systems to monitor for unregulated contaminants. EPA may require monitoring for up to 30 contaminants under the Unregulated Contaminant Monitoring Rule (UCMR). Since the 1996 SDWA amendments, the Agency has issued two UCMRs (UCMR 1 and UCMR 2). UCMR 1 was promulgated on September 17, 1999 (64 *FR* 50556 (USEPA, 1999)) and UCMR 2 on January 4, 2007 (72 *FR* 367 (USEPA, 2007 a)), followed by two revisions published later in January 2007 (72 *FR* 3916 (USEPA, 2007 b) and 72 *FR* 4328 (USEPA, 2007 c)). Monitoring under UCMR 2 will take place during the 2008–2010 time period.

UCMR 2 requires monitoring for several pesticides and pesticide degradates, five polybrominated diphenyl ether (PBDE) flame retardants, a group of nitrosamines and two munitions (TNT and RDX). All of the chemicals on UCMR 2 were included among the contaminants evaluated for CCL 3. Data collected under the UCMR are an important source of occurrence information for the CCL process.

7. The Third Contaminant Candidate List

In 1998, the Agency sought advice from the National Academy of Sciences' National Research Council (NRC) on how to improve the CCL process. The NRC published its recommendations on the CCL process in 2001 (NRC, 2001). The NRC proposed a broader, more reproducible process to identify the CCL than the process used by EPA in the first CCL. The NRC recommended that EPA develop and use a multi-step process for creating CCL 3 and future CCLs, whereby a broadly defined "universe" of potential drinking water contaminants is identified, assessed, and reduced to a preliminary CCL (PCCL) using simple screening criteria. All of the contaminants on the PCCL would then be assessed in more detail using a classification tool to evaluate the likelihood that specific contaminants could occur in drinking water at levels and at frequencies that pose a public health concern.

In 2002, the Agency sought input from the National Drinking Water Advisory Council (NDWAC) on how to implement the NRC's recommendations to improve the CCL process. NDWAC agreed that EPA should proceed with the NRC's recommendations and provided some additional considerations, including the overarching principles the Agency should follow. The NDWAC workgroup met 10 times between September 2002 and May 2004. The NDWAC issued its recommendations in "The National Drinking Water Advisory Council Report on the CCL Classification Process to the U.S. Environmental Protection Agency" (NDWAC, 2004).

NDWAC recommended two guiding principles for construction of the CCL universe, which are:

• The universe should include those contaminants that have demonstrated or have potential occurrence in drinking water, and

• The universe should include those contaminants that have demonstrated or have potential adverse health effects.

These inclusionary principles apply to the selection of contaminants for initial CCL consideration.

The NDWAC also recommended that the universe of contaminants should be screened based on widely available data elements that indicate important health effects and occurrence information. This screening step should be as simple as possible and capable of identifying contaminants of the greatest significance for further consideration. Consideration of a classification approach was also recommended to increase the transparency and reproducibility of the CCL decision process. NDWAC recommended that EPA pursue classification models that build on the screening criteria to further characterize the adverse health effects and occurrence of chemical contaminants. NDWAC noted that the classification models are tools to help prioritize contaminants for the CCL. The model results, available information used by the model, and expert reviews should be used to determine which contaminants are listed for the next CCL. The process to develop the models should be viewed as iterative, and EPA should involve experts and allow opportunities for meaningful public comment on the evaluation of contaminants.

NDWAC recommended several overarching principles that EPA should use to develop the CCL. In addition to the need for transparency and public participation, these overarching recommendations include:

• Integrate expert judgment throughout the CCL process. Expert judgment is inherent throughout the development of the CCL process and in implementing that process once it is developed. Critical reviews, involving various types of expert consultation and collaboration, will be useful at key points in the new, evolving CCL process.

• Conduct an active surveillance and nomination/evaluation processes to ensure timely identification of information relevant to new and emerging agents.

• Apply an adaptive management approach (i.e., an approach that can be refined in future iterations as more knowledge is acquired) to implement the CCL process. The development of any model should be an adaptive process, and should be reviewed by experts with consideration given to updating the process with each successive CCL cycle.

NDWAC also recognized that there were significant differences in the methods and information used to characterize chemical and microbiological contaminants. Chemical contaminants tend to be characterized by toxicological and occurrence data that can be modeled or estimated if measurement is not possible. These discrete characteristics are often captured in data sources. For microbes, the adverse health effects from exposure are characterized by clinical or epidemiological data and there are few methods to estimate or model their occurrence. Limited sources of tabular data for microbes may require evaluation of primary literature, technical reports, monographs, and reference books to identify a universe of microbes for consideration. NDWAC recommended the Agency use human pathogens as the starting point for identifying microorganisms considered for inclusion in the CCL and apply a two-step evaluation of those pathogens.

C. Summary of the Approach Used To Identify and Evaluate Candidates for CCL 3

The Agency revised the CCL process used in previous efforts based on the knowledge and experience it has gained from evaluating unregulated contaminants and the recommendations and advice from NRC and NDWAC. Based on these recommendations the Agency developed and implemented a classification approach that identifies priority drinking water contaminants in a transparent and reproducible manner that is amenable to an adaptive management approach.

The Agency's approach to classifying contaminants is based on available data to characterize the occurrence and adverse health risks a contaminant may pose to consumers of public water systems. EPA developed and implemented the following multi-step CCL process to identify contaminants for inclusion on the Draft CCL 3.

• Identify a broad universe of potential drinking water contaminants (called the CCL 3 Universe). EPA evaluated 284 data sources that may identify potential chemical and microbial contaminants and selected a set of approximately 7,500 chemical and microbial contaminants from these data sources for initial consideration.

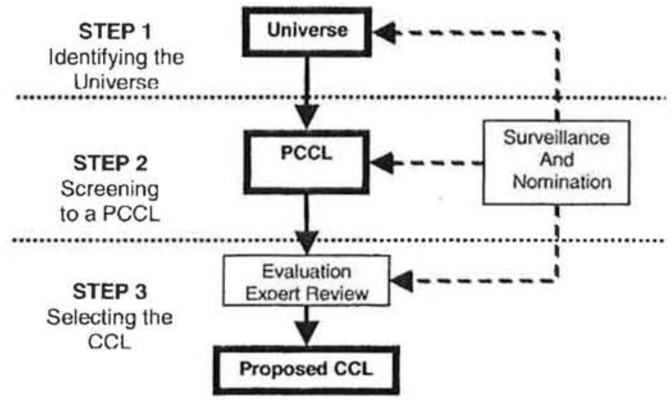
• Apply screening criteria to the CCL 3 Universe to identify those contaminants that should be further evaluated. Contaminants not passing the screening criteria remained in the universe. The screening criteria EPA developed are based on a contaminant's potential to occur in public water systems and the potential for public health concern. Applying these criteria narrows the universe of contaminants to a Preliminary-CCL (or PCCL).

• Identify contaminants from the PCCL to include on the CCL based on a more detailed evaluation of occurrence and health effects. For chemicals, EPA used structured classification models as tools to evaluate and identify drinking water priority contaminants. Decisions to include chemicals were made using the model results and the best available data to identify contaminants that may occur in PWSs and may cause adverse health effects. EPA used a decision tree approach for microbial contaminants to identify those contaminants that have the potential to occur in PWSs and transmit waterborne disease. These two approaches resulted in a draft list of chemicals and microbes for inclusion on the Draft CCL 3.

• Incorporate public input and expert review in the CCL process. EPA sought public input by asking for nominations of contaminants to consider for the CCL (71 *FR* 60704 (USEPA, 2006 b)) and incorporated these nominations in the three key steps already discussed. EPA also convened several expert panels for both chemicals and microbes to review, and provide input and comment, on the CCL 3 process and on a review of a preliminary draft CCL 3.

Exhibit 1 illustrates the CCL multi-step approach that resulted from the Agency's efforts, input, and collaboration with NRC and NDWAC. This generalized process is applied to both chemical and microbial contaminants, though the specific execution of particular steps differs in detail.

Exhibit 1. Schematic of CCL classification process



EPA provides a more detailed discussion of the analyses and decisions it made to develop the Draft CCL 3 in the EPA Water Docket. EPA prepared several support documents that are available for review at *http://www.regulations.gov*. These documents include:

- Three comprehensive support documents for the chemicals entitled, "Contaminant Candidate List 3 Chemicals: Identifying the Universe" (USEPA, 2008 a), "Contaminant Candidate List 3 Chemicals: Screening to a PCCL" (USEPA, 2008 b), and "Contaminant Candidate List 3 Chemicals: Classification of the PCCL to the CCL" (USEPA, 2008 c). These documents describe in detail how the classification process was developed and used to select the chemicals for the Draft CCL.
- Three comprehensive support documents for the microbes entitled, "Contaminant Candidate List 3 Microbes: Identifying the Universe" (USEPA, 2008 d), "Contaminant Candidate List 3 Microbes: Screening to the PCCL" (USEPA, 2008 e), and "Contaminant Candidate List 3 Microbes: PCCL to CCL Process" (USEPA, 2008 f). These documents describe the microbial listing process in detail.
- The Agency also prepared summaries of stakeholder involvement and reviews conducted on the CCL process and draft list. These documents are also available in the EPA Water Docket and at *http://www.regulations.gov*.
- National Drinking Water Advisory Council Report on the CCL Classification Process to the U.S. Environmental Protection Agency, May 19, 2004.
- A nominations and surveillance report, entitled "Summary of the Nominations for the Third Contaminant Candidate List" (USEPA, 2008 g), which describes the nominations process and the contaminants that were nominated as part of EPA's process.
- Two documents summarizing the expert review of the chemical and microbial processes, entitled "Chemical Expert Input and Review for the Third Contaminant Candidate List" (USEPA, 2008 h) and "Microbial Expert Input and Review for the Third Contaminant Candidate List" (USEPA, 2008 i).

D. What Is on EPA's Draft CCL 3?

EXHIBIT 2.—DRAFT CONTAMINANT CANDIDATE LIST 3: MICROBIAL CONTAMINANTS

Pathogens
Caliciviruses
Campylobacter jejuni
Entamoeba histolytica
Escherichia coli (0157)
Helicobacter pylori
Hepatitis A virus
Legionella pneumophila
Naegleria fowleri
Salmonella enterica
Shigella sonnei
Vibrio cholerae

CHEMICAL CONTAMINANTS

Common name—registry name	CASRN
alpha-Hexachlorocyclohexane	319–84–6
1,1,1,2-Tetrachloroethane	630–20–6
1,1-Dichloroethane	75–34–3
1,2,3-Trichloropropane	96–18–4
1,3-Butadiene	106–99–0
1,3-Dinitrobenzene	99–65–0
1,4-Dioxane	123–91–1
1-Butanol	71–36–3
2-Methoxyethanol	109–86–4
2-Propen-1-ol	107–18–6
3-Hydroxycarbofuran	16655–82–6
4,4'-Methylenedianiline	101–77–9
Acephate	30560–19–1
Acetaldehyde	75–07–0
Acetamide	60–35–5
Acetochlor	34256–82–1
Acetochlor ethanesulfonic acid (ESA)	187022–11–3
Acetochlor oxanilic acid (OA)	184992–44–4
Acrolein	107–02–8
Alachlor ethanesulfonic acid (ESA)	142363–53–9
Alachlor oxanilic acid (OA)	171262–17–2
Aniline	62–53–3
Bensulide	741–58–2
Benzyl chloride	100–44–7
Butylated hydroxyanisole	25013–16–5
Captan	133–06–2
Chloromethane (Methyl chloride)	74–87–3
Clethodim	110429–62–4
Cobalt	7440–48–4
Cumene hydroperoxide	80–15–9
Cyanotoxins (3).	
Dicrotophos	141–66–2
Dimethipin	55290–64–7
Dimethoate	60–51–5
Disulfoton	298–04–4
Diuron	330–54–1
Ethion	563–12–2
Ethoprop	13194–48–4
Ethylene glycol	107–21–1
Ethylene oxide	75–21–8
Ethylene thiourea	96–45–7
Fenamiphos	22224–92–6
Formaldehyde	50–00–0
Germanium	7440–56–4
HCFC–22	75–45–6
Hexane	110–54–3
Hydrazine	302–01–2
Methamidophos	10265–92–6
Methanol	67–56–1
Methyl bromide (Bromomethane)	74–83–9
Methyl tert-butyl ether	1634–04–4

CHEMICAL CONTAMINANTS—Continued

Common name—registry name	CASRN
Metolachlor	51218–45–2
Metolachlor ethanesulfonic acid (ESA)	171118–09–5
Metolachlor oxanilic acid (OA)	152019–73–3
Molinate	2212–67–1
Molybdenum	7439–98–7
Nitrobenzene	98–95–3
Nitrofen	1836–75–5
Nitroglycerin	55–63–0
N-Methyl-2-pyrrolidone	872–50–4
N-nitrosodiethylamine (NDEA)	55–18–5
N-nitrosodimethylamine (NDMA)	62–75–9
N-nitroso-di-n-propylamine (NDPA)	621–64–7
N-Nitrosodiphenylamine	86–30–6
N-nitrosopyrrolidine (NPYR)	930–55–2
n-Propylbenzene	103–65–1
o-Toluidine	95–53–4
Oxirane, methyl-	75–56–9
Oxydemeton-methyl	301–12–2
Oxyfluorfen	42874–03–3
Perchlorate	14797–73–0
Permethrin	52645–53–1
PFOA (perfluorooctanoic acid)	335–67–1
Profenofos	41198–08–7
Quinoline	91–22–5
RDX (Hexahydro–1,3,5–trinitro–1,3,5–triazine)	121–82–4
sec-Butylbenzene	135–98–8
Strontium	7440–24–6
Tebuconazole	107534–96–3
Tebufenozide	112410–23–8
Tellurium	13494–80–9
Terbufos	13071–79–9
Terbufos sulfone	56070–16–7
Thiodicarb	59669–26–0
Thiophanate-methyl	23564–05–8
Toluene diisocyanate	26471–62–5
Tribufos	78–48–8

CHEMICAL CONTAMINANTS—Continued

Common name—registry name	CASRN
Triethylamine	121–44–8
Triphenyltin hydroxide (TPTH)	76–87–9
Urethane	51–79–6
Vanadium	7440–62–2
Vinclozolin	50471–44–8
Ziram	137–30–4

III. What Analyses Did EPA Use To Develop the Draft CCL 3?

A. Classification Approach for Chemicals

1. Identifying the Universe

In the first step in the approach, EPA compiled potential data sources, including sources identified at a stakeholder workshop sponsored by the American Water Works Association (AWWA), to develop a broad universe of potential drinking water contaminants, as shown in Exhibit 1. This compilation identified the 284 data sources that were assessed for the CCL Universe.

EPA developed a decision tree for data source selection that was based on four assessment factors, which were applied to all of the potential data sources:

• Relevance. Ensures that the data source provided information on demonstrated or potential health effects, occurrence, or potential occurrence using surrogate information (e.g., environmental release, environmental fate, and transport properties);

• Completeness. Ensures that the data source had minimum record requirements—contact name, description of the data elements, and how the data were obtained;

• Redundancy. Ensures that the data source does not contain information identical to other more comprehensive data sources; and

• Retrievability. Ensures that the data in the source are formatted for automated retrieval. Each source was accessed on-line (or as provided by the source) and reviewed.

Basic information about the source, its purpose, and the data elements it contained, was compiled and documented. Every source was evaluated using all assessment factors sequentially. Those sources that met all four factors became the prime sources that formed the "Universe of Data Sources." Sources that passed the first three factors, but were not retrievable, were designated as supplemental data sources, to be consulted as necessary (e.g., to fill in data gaps) in the development of the CCL. Some of the sources that were not easily retrievable were identified as "unique" or "exceptional" because of the importance of their data (i.e., the Hazardous Substance Database). EPA included chemicals from these sources in the Universe.

After application of the four assessment factors, 39 sources (Exhibit 3) met all four factors or were considered as exceptional. These sources were the primary sources used to develop the CCL Chemical Universe. The details of the how EPA compiled the list of data sources is discussed in the document entitled, "CCL 3 Chemicals: Identifying the Universe" (USEPA, 2008 a).

EXHIBIT 3.—SOURCES THAT COMPRISE THE CHEMICAL UNIVERSE OF DATA SOURCES FOR THE CCL PROCESS

Name of data source
1. ATSDR CERCLA Priority List.
2. ATSDR Minimal Risk Levels (MRLs).
3. Chemical Toxicity Database—Ministry of Health and Welfare, Japan.
4. Chemical Update System/Inventory Update Rule (CUS/IUR)—EPA.
5. Cumulative Estimated Daily Intake/Acceptable Daily Intake (CEDI/ADI) Database—FDA.
6. Database of Sources of Environmental Releases of Dioxin-Like Compounds in the United States—EPA.
7. Distributed Structure Searchable Toxicity Public Database Network (DSSTox)—EPA.
8. Everything Added to Food in the United States (EAFUS) Database—FDA.
9. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) List—EPA.
10. Generally Regarded As Safe (GRAS) Substance List—FDA.
11. Guidelines for Canadian Drinking Water Quality (CADW): Summary of Guidelines—Health Canada.
12. Hazardous Substances Data Bank (HSDB)—NLM.
13. Health Advisories (HA) Summary Tables—EPA.
14. High Production Volume (HPV) Chemical List—EPA.
15. Indirect Additives Database—FDA.
16. Integrated Risk Information System (IRIS)—EPA.
17. International Agency for Research on Cancer (IARC) Monographs.
18. International Toxicity Estimates for Risk (ITER) Database—TERA.
19. Joint Meeting On Pesticide Residues (JMPR)—2001 Inventory of Pesticide Evaluations—WHO, FAO.
20. National Drinking Water Contaminant Occurrence Database (NCOD)—Round 1&2—EPA.
21. National Drinking Water Contaminant Occurrence Database (NCOD)—Unregulated Contaminant Monitoring Rule (UCMR)—EPA.
22. National Inorganics and Radionuclides Survey (NIRS)—EPA.
23. National Pesticide Use Database—NCFAP.

EXHIBIT 3.—SOURCES THAT COMPRISE THE CHEMICAL UNIVERSE OF DATA SOURCES FOR THE CCL PROCESS—Continued

Name of data source
24. National Reconnaissance of Emerging Contaminants (NREC)—USGS Toxic Substances Hydrology Program.
25. National Toxicology Program (NTP) Studies.
26. National Water Quality Assessment (NAWQA)—USGS.
27. OSHA 1988 Permissible Exposure Limits (PELs)—NIOSH.
28. Pesticide Data Program—USDA.
29. Pesticides Pilot Monitoring Program—USGS/EPA.
30. Risk Assessment Information System (RAIS)—Department of Energy—Chemical Factors.
31. Risk Assessment Information System (RAIS)—Department of Energy—Health Effects Data.
32. State of California Chemicals Known to the State to Cause Cancer or Reproductive Toxicity.
33. Substances Registry System (SRS)—EPA.
34. Syracuse Research Corporation (SRC)—BIODEG.
35. The Toxics Release Inventory (TRI)—EPA.
36. Toxic Substances Control Act (TSCA) List—EPA.
37. Toxicity Criteria Database—California Office of Environmental Health Hazard Assessment (OEHHA).
38. University of Maryland—Partial List of Acute Toxins/Partial List of Teratogens.
39. WHO Guidelines for Drinking Water Quality: Summary Tables.

There were approximately 26,000 unique substances identified from the 39 data sources. Because of the large number of unique substances identified, EPA developed an initial universe selection process. In the first phase of the data evaluation process, EPA identified the chemicals that were present in both health effects and occurrence data sources. The Agency queried the data sources and found that approximately 7,300 chemicals, or about one-third of the chemicals, were present in both health effects and occurrence data sources. Occurrence was defined broadly to include production data and environmental occurrence data. EPA placed these chemicals in the chemical universe to be further evaluated for screening to the PCCL. EPA then examined the rest of the approximately 18,600 chemicals left in the initial universe more closely to determine whether they were found only in health effects data sources or only in occurrence data sources. EPA found that approximately 5,100 chemicals were in health effects data sources only. Many of these chemicals were biochemical compounds (e.g., amino acids, sugars, steroids); mixtures and natural products (e.g., coal tar, petroleum related substances, rocks, stone, wool); and other entries that were identified as unique "substances" in the data sources but were not chemicals (e.g., turbidity, boot and shoe manufacture, surgical implants). EPA evaluated these to identify which ones are chemicals of greatest toxicological concern. Many of the chemicals fell into the category of greatest toxicological concern due to their classification as carcinogens. This is described in the report entitled, "CCL 3 Chemicals: Screening to a PCCL" (USEPA, 2008 b). Through this process, a total of 122 chemicals with only toxicity data were added to the 7,300 chemicals already in the CCL Chemical Universe.

The chemicals found only in occurrence sources were also categorized. The approximately 13,500 chemicals with only occurrence data were a diverse group, comprised of many different types of chemicals. Data sources that provide the amount of an individual chemical that is manufactured and produced account for 70 percent (or 9,344) of the total. The remaining 30 percent of chemicals are from various other data sources (i.e., finished water, ambient water, environmental release, environmental fate and transport properties, and food additives). EPA grouped these chemicals by the type of occurrence data for further evaluation. These included the following groupings:

• Chemicals with Finished or Ambient Water Data
• Chemicals with Release Data
• Chemicals with High Production Volumes

EPA added 42 chemicals with finished or ambient water data to the Universe despite the lack of health effects information in the data sources because of their demonstrated occurrence in ambient or potable water. In addition, disinfection byproducts and water treatment additives were added to the Chemical Universe. While there may not have been measured occurrence data for these chemicals in the universe of data sources, they are considered to have "default" occurrence data because they are formed in, or intentionally added to, drinking water supplies.

EPA also added 36 chemicals with an environmental release data source (e.g., those on the Toxics Release Inventory or with pesticide application data) to the Chemical Universe even though they lacked health effects data.

The largest group of chemicals found only in occurrence data sources had only production information. These contaminants include: organometallics, elements, salts of the inorganic elements, salts of organic acids, natural product organics (including oils, fatty acids, sugars, intermediary metabolites), and mixtures (e.g., petroleum related compounds, hydrocarbons, and others). Over half of the production chemicals are compounds and/or complexes of elemental constituents; for example, there were about 750 sodium or potassium salt compounds alone. In these cases, health effects data are not available for the exact compound, but are generally available for other related compounds or the key ion or elemental constituent (e.g., sodium). Nearly all elements found in inorganic or organic salts are represented in the Universe by other compounds with both health effects and occurrence data. EPA found only 10 elements (excluding carbon, hydrogen, and oxygen, and the inert gasses krypton, neon, and xenon) that did not otherwise have representative compounds with health effects data in the Universe. EPA added these compounds (i.e., europium, gadolinium, gold, lanthanum, praseodymium, platinum, polonium, samarium, terbium, and yttrium) to the Universe. After evaluation of the characteristics of the chemicals with production data and the amounts produced on a yearly basis, and because the primary constituents (i.e., elements) of the chemicals were already in the Chemical Universe, EPA decided to move only those produced at greater than 1 billion pounds per year to the CCL Chemical Universe when they lacked health effects information.

EPA added a total of 269 chemicals with only occurrence data to the CCL 3 Chemical Universe. The rest of the substances included in the original data sources were not included in the Universe.

The initial selection process brought into the CCL Chemical Universe all substances from the data sources that met the defined selection criteria, described above. Upon further review, EPA found the Chemical Universe also contained regulated as well as unregulated compounds, mixtures, and some substances that were not really chemicals. To further refine the initial list, EPA removed chemicals with a national primary drinking water regulation. These contaminants are already regulated; thus, their inclusion in the CCL process is unnecessary and does not meet the statutory requirement for selection of the CCL. EPA removed 1,006 chemicals, which is more than the number of primary drinking water standards. This is because regulated contaminants can be found in many forms and because many contaminants are regulated as part of a class or group(s). For example, EPA removed approximately 780 radionuclides from the initial list, because they are regulated as alpha and beta emitters. Also removed were various salts of regulated elements, and entries for individual trihalomethanes, haloacetic acids, polychlorinated biphenyls and polyaromatic hydrocarbons that are regulated as a group. The Agency has determined that it is inappropriate to include aldicarbs (aldicarb, aldicarb sulfoxide, and aldicarb sulfone) and nickel on the CCL. These contaminants are subject to regulation under SDWA section 1412(b)(2) and thus are not part of the contaminant selection process specified under SDWA section 1412(b)(1). In response to an administrative petition from the manufacturer Rhone-Poulenc, the Agency issued an administrative stay of the effective date of the maximum contaminant levels (MCLs) for aldicarbs, and they never became effective. NPDWRs for nickel were promulgated on July 17, 1992 (57 *FR* 31776 (USEPA, 1992)), but the MCL was later vacated and remanded by the D.C. Court of Appeals in response to a joint motion by EPA and industry parties challenging the nickel MCL and MCLG. Because these contaminants are subject to separate regulatory consideration, EPA has not included them in the CCL process.

EPA also removed substances that are considered a mixture of chemicals. EPA defines a mixture in this case as a combination of two or more chemicals/items that are not defined as a unique substance. Examples of substances in this category include "chlorinated compounds, aliphatic alcohols with more than 14 carbon atoms (c>14), coal-tar-containing shampoo, petroleum-related substances, resin acids, and rosin acids." Undefined mixtures, such as "diesel engine exhaust" were also included in this group.

EPA also removed "non-chemically defined" entries from further consideration for the initial list. Examples include: "solar radiation, wood dust, surgical implants, and welding fumes." Some of these substances are present in the data sources because they have been evaluated for their potential to cause cancer.

The final step removed biological agents from the initial list. Contaminants in this category are biological organisms that are being evaluated as part of the CCL 3 Microbiological Universe. Entries for biological entities were uploaded from the universe of data sources from various health effects data sources and pesticide data sources. Many biological entities were also removed as non-chemically defined.

During this phase of the data evaluation, 1,717 chemicals or substances were removed from the initial Chemical Universe, leaving approximately 6,000 chemicals that were designated as the CCL 3 Universe. A list of the CCL Chemical Universe is provided in the docket. EPA further evaluated these 6,000 chemicals in the next key step of the process.

2. Screening from the Universe to a PCCL

The next step in the CCL selection approach involved narrowing the Universe of chemicals to a PCCL, as shown in Exhibit 1. EPA considered and built upon NDWAC recommendations that the screening process be based on a contaminant's potential to occur in public water systems and the potential for public health concern, to select those contaminants that should move to the PCCL for further evaluation. The screening approach:

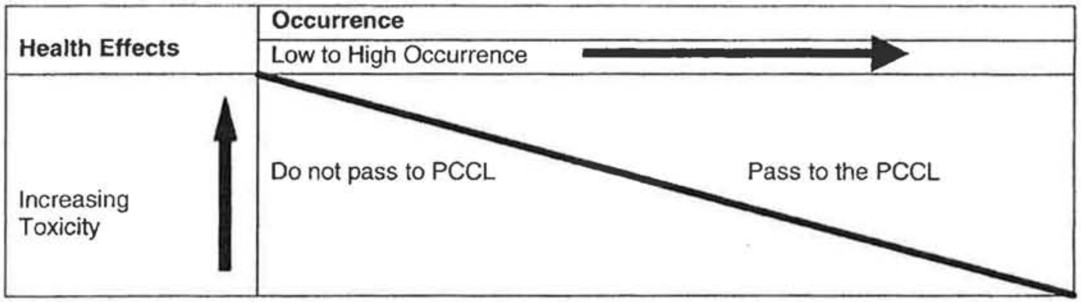
- Identifies chemicals that have relatively high toxicity with high potential to occur in PWSs;
- Identifies chemicals that have relatively high toxicity with minimal actual or potential occurrence in drinking water;
- Identifies chemicals that have high potential to occur in PWSs with relatively moderate toxicity; and
- Considers and uses as many of the available types of health effects and occurrence data identified in the data source evaluations as practical.

EPA compared the chemicals' health effects relative to their occurrence and developed analyses that specifically incorporate many types of available data into the screening criteria. The health effects information included quantitative, descriptive, or categorical information. Within each of these broad types of health effects information, there are multiple types of reported health related values from multiple sources. The health effects analyses conducted by EPA identified approaches to compare each of these data types and identified similarities among chemicals that could be used to define toxicity categories. The occurrence information also included many types of available data representative of a chemical's potential to occur in water. Occurrence data ranged from quantified detection in PWSs, to environmental release, to production data.

The basic framework EPA used in screening is shown in Exhibit 4. EPA categorized the CCL Chemical Universe contaminants by their toxicity along the vertical axis and by their occurrence on the horizontal axis. This allows for separation of chemicals into those that move to the PCCL based on their toxicity and occurrence properties (e.g., upper right in Exhibit 4) and those that are not further evaluated and remain in the CCL Chemical Universe (e.g., lower left in Exhibit 4).

EPA used a set of test chemicals to develop the screening criteria. This set of chemicals included regulated and unregulated chemicals that provided comprehensive information on health effects and occurrence in finished and/or ambient water as well as environmental release and production volume. EPA then used these criteria to select chemicals for the PCCL for further consideration. The following sections summarize how EPA developed the screening criteria by evaluating the available data for chemicals in the Universe, using the framework (Exhibit 4) and the test chemicals. A more detailed discussion is provided in the support document entitled, "CCL 3 Chemicals: Screening to a PCCL" (USEPA, 2008 b).

Exhibit 4: Partition for Screening the Universe



a. Health Effects Data Elements

EPA evaluated the toxicity information and health effects data compiled from the data sources in the Universe and these data varied greatly. Some of these data are quantitative (e.g., RfD, LOAEL, NOAEL, LD_{50}) and some are descriptive (e.g., cancer classifications or predictions). EPA designed the screening process to accommodate both types of health effects data.

The quantitative toxicity elements and values available in the Universe included the following:

• RfDs and equivalent (RfD-eq): RfDs, Minimum Risk Levels (MRLs) from ATSDR, Tolerable Daily Intakes (TDIs) from the World Health Organization (WHO), and Public Health Goals (PHGs) from California EPA. A reference dose is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. There are slight differences among Agencies in the methodologies used for some of the RfD equivalents.

• NOAELs—No Observed Adverse Effect Levels. The NOAEL is the highest dose evaluated in a study or group of studies that does not have a biologically significant adverse effect on the species evaluated as compared to controls.

• LOAELS—Lowest Observed Adverse Effect Levels. The LOAEL is the lowest dose evaluated in a study or group of studies that has a biologically significant adverse effect on the species evaluated as compared to the controls.

• TD_{50}s—Tumorigenic dose 50. The dose-rate which if administered chronically for the standard life-span of the species will have a 50 percent probability of causing tumors at some point during that period.

• MRDD—Maximum Recommended Daily Dose. Recommendations for the maximum adult daily therapeutic doses for pharmaceuticals.

• LD_{50}s—Lethal dose 50; an estimate of a single dose that is expected to cause the death of 50 percent of the exposed animals; it is derived from experimental data.

EPA used descriptive cancer data to group data elements into toxicity categories that provide gradation based upon the strength of the data. Sources for the descriptive cancer data included:

• U.S. EPA Cancer Groupings.
• IARC Cancer Groupings.
• NTP weight-of-evidence findings from cancer bioassays.
• National Cancer Institute (NCI) weight-of-evidence findings from cancer bioassays.
• EPA Water Disinfection By-Products with Carcinogenicity Estimates (DBP-CAN) groupings based on carcinogenic potential derived from Quantitative Structure Activity Relationship (QSAR) projections.

EPA divided the chemicals in the Universe into five toxicity categories for screening based upon the distribution of the toxicity value for each type of quantitative data element and/or the qualitative information on cancer weight-of evidence. The five toxicity categories are designated 1 through 5, with Toxicity Category 1 containing chemicals in the most toxic grouping and Toxicity Category 5 the least toxic grouping.

Based upon the distribution of the chemicals for each quantitative data element, EPA selected ranges of toxicity values for each toxicity category that differed based upon the type of data element. For example, the range of toxicity values that place a LOAEL in Toxicity Category 1 differs from the values used for a LD_{50}. Exhibit 5 displays the ranges for each data element and their respective Toxicity Categories.

Additional information which describes how EPA performed the analyses to select the toxicity categories is described in the document entitled, "CCL 3 Chemicals: Screening to a PCCL" (USEPA, 2008 b).

EXHIBIT 5.—POTENCY MEASURES FOR UNIVERSE DATA ELEMENTS PARTITIONED BASED ON TOXICITY

[mg/kg/day or mg/kg]

	RfD	NOAEL	LOAEL	MRDD	LD_{50}
Toxicity Category 1	<0.0001	<0.01	<0.01	<0.01	<1
Toxicity Category 2	0.0001–<0.001	0.01–<1	0.01–<1	0.01–<1	1–<50
Toxicity Category 3	0.001–<0.05	1–<10	1–<10	1–<10	50–<500
Toxicity Category 4	0.05–<0.1	10–<1000	10–<1000	10–<1000	500–5000
Toxicity Category 5	>0.1	>1000	>1000	>1000	>5000

EPA partitioned the cancer-related data elements in the Universe into the Toxicity Categories as shown in Exhibit 6. The cancer data placed chemicals in only the three highest Toxicity Categories. EPA did not use quantitative measures of dose-response for carcinogenicity in the screening criteria because more chemicals have categorical data and can be analyzed using this descriptive data than by cancer slope factors. In addition, EPA did not use descriptors indicating lack of carcinogenic potential or insufficient data to determine carcinogenic potential in categorizing chemicals because those descriptors apply only to the cancer endpoint and do not consider noncancer effects associated with exposure to the chemical.

EXHIBIT 6.—PARTITIONING OF CANCER DATA BASED ON TD_{50} VALUES AND WEIGHT-OF-EVIDENCE DESCRIPTORS

	TD_{50}	EPA	IARC/HC	NTP	NCI	DSS-Tox
Toxicity Category 1**.	<0.1	Group A; Human Carcinogen.	Group 1	CE 2 species/2 sexes; or 2 species; or 2 sexes.	P 2 species/2 sexes; or 2 species; or 2 sexes.	H.
Toxicity Category 2	0.1–100	Groups B1 and B2; likely carcinogens.	Group 2A	Combinations of CE, SE, EE, and NE.	Combinations of P, E and N.	HM.
Toxicity Category 3	>100	Group C; Suggestive evidence of carcinogenicity.	Group 2B	Combinations of SE, EE, and NE.	Combinations of E and N.	M and LM.

** Cancer data placed chemicals in only the three highest Toxicity Categories.
CE = clear evidence, SE = some evidence, EE = equivocal evidence, NE = no evidence.
P = positive, N = Negative, E = equivocal.
H = high probability, HM = high to medium probability, M = medium probability, LM = medium to low probability.

EPA chose a conservative approach in the screening process to categorize each chemical's toxicity and evaluated all the available health effects dose-response and categorical data elements for a given chemical. Chemicals were assigned to the highest toxicity category indicated after an evaluation of all the available data. Accordingly, if a chemical had just one data element that places it in Toxicity Category 1, it was categorized as such even if some of the other data elements for that same chemical may place it in a lower toxicity category. For example, if a chemical is classified as a 2A carcinogen by IARC, it was placed in Toxicity Category 2 using the descriptive cancer data even if a quantified LOAEL from a different study places it in Toxicity Category 3.

b. Occurrence Data Elements

EPA evaluated the occurrence data elements for each chemical and placed them on the horizontal axis of the screening table. In assessing the data, EPA found that the data elements that represent a chemical's potential to occur in drinking water vary greatly. EPA's goal was to determine which data elements best represented the potential to occur in drinking water. EPA considered and evaluated data elements in the following categories:

• Finished Water—measures of concentration and frequency of detections.

• Ambient Water—measures of concentration and frequency of detections.

• Total Releases in the Environment—pounds per year and number of States.

• Pesticide Application Rates—pounds per year and number of States.

• Production volume—pounds per year.

In addition to evaluating quantitative data elements listed above, EPA also considered chemicals with descriptive data based upon their likelihood of occurring in drinking water. Examples of descriptive occurrence data elements include characterization as a disinfection byproduct or a drinking water treatment chemical.

EPA used the following hierarchal approach to select the occurrence data element used to screen a chemical: Finished Water or Ambient Water > Environmental Release Data > Production Data.

The highest data elements in the hierarchy are the finished and ambient water data; the lowest, the production data. Environmental release data from the Toxics Release Inventory (TRI) and pesticide application amounts occupy the middle position in the hierarchy.

EPA also decided that when multiple data values exist for the chemicals within a given component of the hierarchy, the most conservative data value is used. For example, in the case of a chemical that has finished water data and ambient water data, EPA selected the highest reported concentration as the occurrence value used in screening.

EPA obtained the finished water data elements from the National Contaminant Occurrence Database (NCOD), the Unregulated Contaminant Monitoring (UCM) Rounds 1 and 2, the National Inorganic Radionuclides Survey (NIRS), the Unregulated Contaminant Monitoring Regulation (UCMR) monitoring, the Information Collection Rule database for disinfection byproducts, the U.S. Department of Agriculture (USDA) Pesticide Data Program (PDP), and the U.S. Geological Survey (USGS) Pesticides Pilot Monitoring Program (PPMP). These sources included data elements such as percent samples with detections, percent drinking water systems with detections, mean and/or median detected concentrations, and highest observed concentrations.

EPA obtained ambient water values from the USGS National Water Quality Assessment Program (NAWQA), the USGS Toxics Substances Hydrology program's National Reconnaissance of Emerging Contaminants (NREC) and related studies, and the PPMP. These sources included data elements such as percent samples with detections, percent sites with detections, mean and/ or median detected concentrations, and highest observed concentrations.

The environmental release data are those reported for 2004 from the TRI and the National Pesticide Use Database, developed by the National Center for Food and Agricultural Policy (NCFAP). The available environmental release data elements include: total releases to the environment (lbs/yr), number of States with releases, pesticide total mass active ingredient applied nationally (lbs/yr), and number of States with pesticide application. EPA chose to use the pounds released per year into the environment for screening because the mass applied to the environment was more directly related to a potential concentration in water than the number of States where a chemical is released or applied.

EPA used the Toxic Substances Control Act (TSCA) chemical production volume ranges reported under the Chemical Update System/ Inventory Update Rule (CUS/IUR) to assess production volume. EPA selected the most recent year of data available for each particular chemical. CUS/IUR reports chemical production volume ranges rather than as exact values of release, and provides production data for all chemicals produced in volumes exceeding 10,000 lbs/yr. The production data are reported in 5 categories that range from less than 10,000 lbs/yr to greater than 1 billion lbs/yr. Therefore, EPA chose to use those ranges as the occurrence subdivisions for the production data.

The occurrence data were grouped by powers of 10 and arrayed from low to high across the horizontal axis of the screening table (Exhibit 4). The document entitled "CCL 3 Chemicals: Screening to a PCCL" (USEPA, 2008b) describes the analyses in greater detail.

In some cases, disinfection byproducts and water treatment chemicals lacked quantitative data elements in the Universe. However, both groups have a strong potential to be present in drinking water. EPA moved chemicals in these two categories forward to the PCCL for further evaluation even when limited health effects and/or occurrence information were available.

c. Selection of the PCCL

The last step in the screening process used the intersections between health effects and occurrence data elements in the screening table (Exhibit 4) to establish the PCCL selection line. As noted above, the health data elements were grouped by the 5 toxicity categories with the element showing the highest potency determining placement in the screening table. EPA selected the highest available data element in the occurrence hierarchy to determine placement of a chemical on the horizontal axis in the screening table. Because the chemicals were evaluated using a hierarchical approach for their occurrence elements, EPA developed separate criteria for each of the occurrence elements, and used the placement of a group of test chemicals that had all or nearly all of the occurrence data elements, to establish the position of the PCCL selection line. The test chemicals were selected from regulated and past CCL chemicals. Each had data to illustrate whether it was or was not of concern as a drinking water contaminant.

As a secondary analysis, EPA evaluated existing Drinking Water Equivalent Levels (DWELs) to confirm whether they would make the PCCL. The DWELS were derived from the lower RfD potency for each of the RfD Toxicity Categories. The DWEL (mg/L) is calculated from the RfD in mg/kg/day by multiplying the RfD by an adult body weight of 70 kg and dividing by a drinking water intake of 2 L/day (rounded to one significant figure).When comparing the position of the set of DWELs to the PCCL selection line, all four toxicity categories would be put on the PCCL. This analysis supports the position of the PCCL selection line for chemicals with finished or ambient water concentration data.

EPA also used the test chemicals to determine the PCCL selection line for the other occurrence data elements—total releases to the environment (i.e., TRI, pesticide application data) and production data. For example, the test chemicals were placed in Exhibit 4 based on their release data to guide the placement of the line that separated the "pass to the PCCL" chemicals from the "do not pass to the PCCL" chemicals. In general, the PCCL selection line was positioned so that regulated and most prior CCL chemicals would be selected for the PCCL.

EPA also analyzed the test chemicals with respect to occurrence, releases, and production data. The test data fit well for the former two categories. For the latter, the fit was not as good so EPA chose to set the PCCL selection line at the point where all chemicals produced at greater than 100 million pounds per year pass to the PCCL even if they fall in the lowest toxicity category.

The criteria for moving a chemical with finished or ambient water, environmental release, and production data to the PCCL are displayed in Exhibit 7.

EXHIBIT 7.—CRITERIA FOR A CHEMICAL TO PASS SCREENING TO THE PCCL

Health effects	Occurrence (by data type)		
	Finished/ambient water concentrations	Release amount (per year)	Production volume (per year)
Toxicity Category 1	All Concentrations	All Amounts	All Amounts.
Toxicity Category 2	≥1 µg/l	≥10,000 lbs/yr	≥500,000 lbs/yr.
Toxicity Category 3	≥10 µg/l	≥100,000 lbs/yr	≥10 M lbs/yr.
Toxicity Category 4	≥100 µg/l	≥1 M lbs/yr	≥50 M lbs/yr.
Toxicity Category 5	≥1000 µg/l	≥10 M lbs/yr	≥100 M lbs/yr.

EPA added DBPs and drinking water additives that lacked quantitative occurrence data but fell in the Toxicity Category 1 or Toxicity Category 2 groupings to the PCCL because of their high probability for being present in disinfected and treated drinking water.

The screening process provides a data-driven, objective, and transparent process for selecting the PCCL from the Universe. All Toxicity Category 1 chemicals (i.e., most toxic) were captured regardless of their occurrence category. The occurrence threshold required for the PCCL selection became less inclusive as the contaminant toxicity decreased. The screening of the CCL 3 Universe resulted in the selection of 532 chemical contaminants for the PCCL from the approximately 6,000 chemicals that were screened. The categorical summary of chemicals that passed the screening is illustrated in Exhibit 8. A complete chemical PCCL list can be found in Appendix B of the document entitled, "CCL 3 Chemicals: Screening to a PCCL" (USEPA, 2008b). The 532 PCCL chemicals were further scrutinized as part of the next key step in the process. Some of the contaminants on the PCCL had limited data available for the scoring protocols and could not be run through the models. The 32 contaminants that had limited data identified in the appendixes to the "Classification of the PCCL to the CCL" support document (EPA 2008c) and will remain on the PCCL until new data are identified for further evaluation.

EXHIBIT 8.—SUMMARY OF TOTAL CHEMICALS THAT PASSED SCREENING FOR PCCL BY SCREENING CATEGORIES

Toxicity categories	Finished or ambient water concentration	Pesticide app	Total releases	Production volume	Totals
Toxicity Category 1	29	4	56	38	127
Toxicity Category 2	33	26	32	61	152
Toxicity Category 3	36	31	21	66	154
Toxicity Category 4	5	4	10	63	82
Toxicity Category 5	0	0	0	17	17

3. Using Classification Models To Develop the CCL 3

The 532 PCCL chemicals were further scrutinized as part of this key step in the process by using classification models as tools to aid in the selection of the draft CCL 3. As experience is gained, the EPA expects to modify and improve the development of the classification process for future CCLs.

From the inception of the development of the CCL classification process, EPA intended to use classification models as a decision support tool. EPA envisioned that, after testing and evaluation, models would be used to process complex data in a consistent, objective, and reproducible manner and provide a prioritized listing of candidate contaminants for the last stage of the CCL process—an expert review and evaluation. Model application also would help EPA focus resources for the expert review and evaluation of the highest priority potential contaminants.

An overview of the classification model approach used to further evaluate chemicals on the PCCL is described in the following sections. A detailed discussion of the process is provided in a document entitled, "Contaminant Candidate List 3 Chemicals: Classification of the PCCL to the CCL" (USEPA, 2008c). The development of this classification process involves the following steps:

• Development of the Attribute Scoring Protocols.

• Development of the Training Data Set.

• Application of the Classification Models.

• Evaluation of Classification Model Output and Selection of the CCL.

To use models to evaluate and classify the PCCL contaminants for listing on the CCL, EPA needed to develop methods to interrelate the important measures (i.e., attributes) that represent a contaminant's health effects and potential for occurrence in drinking water. Four attributes were selected: Potency, severity, prevalence, and magnitude. Protocols were developed for scoring each attribute.

EPA also tested and evaluated the results of several classification models to determine which ones might provide the best decision support tools. To make this evaluation, EPA developed a chemical data set and used the data set to "train" the classification models. The selected models were utilized to process the data for the PCCL chemicals and provide a prioritized listing of candidate contaminants for the expert review and evaluation.

a. Development of the Attribute Scoring Protocols

EPA used attributes to characterize different chemicals on the basis of similar qualities or traits. These qualities or traits represent the likelihood of occurrence or potential for adverse health effects of each contaminant. Throughout the process of evaluating the attributes EPA recognized that a wide range of data elements would have to be used for each attribute to characterize chemicals on the PCCL. To evaluate PCCL chemicals with differing types of occurrence and health effects data as potential CCL contaminants, one must be able to establish consistent relationships among the different types of data that represent measures of the attributes. If the same data were available for all contaminants, the comparison and prioritization of candidates would be less complex. To consistently apply the best available data for PCCL chemicals, EPA normalized the different types of data into scales and scoring protocols that accept a variety of input data, apply a consistent framework, and compare different types of data. The following sections describe how EPA developed the scales and scoring protocols for the health effects and occurrence attributes.

i. Health Effects Attributes

Potency and severity are the attributes used to describe health effects. EPA defines potency as the lowest dose of a chemical that causes an adverse health effect and severity is based on the adverse health effect associated with the dose used to define the measure of potency. In other words, potency was scored on the dose that produced the adverse effect and severity was scored based on the health-related significance of the adverse effect (*e.g.*, from dermatitis to organ effects to cancer). These two attributes are interrelated, in that the severity is linked to the measure of potency.

The following toxicological parameters were used to evaluate potency:

• Reference Dose (RfD) or equivalent.

• Cancer potency (concentration in water for 10^{-4} cancer risk).

• No-Observed-Adverse-Effect Level (NOAEL).

• Lowest-Observed-Adverse-Effect Level (LOAEL).

• Rat oral median Lethal Dose (LD_{50}).

EPA developed a "learning set" of about two hundred chemicals to calibrate the potency scoring protocols. Once the data for the learning set of chemicals was collected, EPA arrayed and graphically displayed the data to analyze their range and distribution. EPA selected a distribution based on logarithms (base 10) of the toxicity parameters rounded to the nearest integer because it provided a spread of the chemical toxicity parameters across the range and the curve was roughly log-normal.

EPA used a log-based distribution to establish a potency scoring equation for each toxicity parameter. This was accomplished by assigning the most frequent (modal) value in each distribution a score of 5 on a 10 point scale. When the toxicity parameter was one log more toxic than the modal value, a score of 6 was assigned. Similarly, when the parameter was one log less toxic than the modal value a score of 4 was given, and so on. EPA developed an equation for each toxicity parameter that equated the modal value to a score of 5 and calculated the potency score. Because the modal rounded log differed for the different measures of toxicity, it was necessary to use a different equation for each to normalize the mode to a score of 5. The resultant equations are summarized in Exhibit 9.

EXHIBIT 9.—SCORING EQUATIONS FOR POTENCY

RfD Score = 10 − (Log_{10} of RfD + 7).
NOAEL Score = 10 − (Log_{10} of NOAEL + 4).
LOAEL Score = 10 − (Log_{10} of LOAEL + 4).
LD_{50} Score = 10 − (Log_{10} of LD_{50} + 2).
10^{-4} cancer risk Score = 10 − (Log_{10} of the 10^{-4} cancer risk + 6).

For distributions that spanned more than 5 orders of magnitude above or below the mode, scores for the tails of the distribution were truncated at 1 and 10. Conversely, for distributions that did not span 5 full orders of magnitude above and below the mode, not all scores between 1 and 10 were used. For example, the distribution of the 10^{-4} values for cancer risk was skewed, with values up to 5 orders of magnitude above the modal value (more potent carcinogens) but only 2 orders of magnitude below the mode (less potent carcinogens). This meant that the lowest potency score for this toxicity parameter was a "3."

EPA tested the scoring process by using a subset of contaminants with values from multiple data elements considered in the process. In the testing of the potency scoring process, EPA scored all of the chemicals in the learning set for each toxicity parameter to examine the consistency across scores for the non-cancer measures of potency. EPA evaluated the agreement of non-cancer scores across the RfD, NOAEL, LOAEL and LD_{50} inputs and found the scores for any given compound to be generally consistent across parameters. Because of the general consistency among scores, EPA determined that a hierarchy of RfD> NOAEL> LOAEL> LD_{50} would be used in the scoring of potency. This hierarchy gives preference to the potency value with the richest supporting data set (the RfD—or equivalent values) and gives the lowest ranking to the LD_{50} because it is a measure of acute rather than chronic toxicity. If data are available for both the cancer and noncancer endpoints, the higher of the cancer or noncancer potency is selected and the critical effect of the higher measure of potency is used to score the severity.

Severity refers to the relative impact of an adverse health affect. Just as toxicity increases with dose, the severity of the observed effect also increases. A low dose effect could be a simple increase in liver weight while the same chemical at a higher dose could cause cirrhosis of the liver. For consistency, the measure of severity that was used for scoring the PCCL chemicals was the effect or effects seen at the LOAEL. Restricting severity scores to the effects at the LOAEL ties them to the data used to derive the potency score.

The severity measures used to score the PCCL chemicals differ from those used for potency, prevalence, and magnitude because they are descriptive rather than quantitative. Accordingly, they are less amenable to automation and often require more scientific judgment in their application. To guide scoring for severity, EPA developed the nine-point scale displayed in Exhibit 10, and a compendium of nearly 250 descriptions of critical effects grouped by their severity scores (*e.g.*, "Chronic irritation without histopathology changes" equals a score of 3).

EXHIBIT 10.—FINAL NINE-POINT SCORING PROTOCOL FOR SEVERITY

Score	Critical effect	Interpretation
1	No adverse effect.	
2	Cosmetic effects	Considers those effects that alter the appearance of the body without affecting structure or functions.
3	Reversible effects; differences in organ weights, body weights or changes in biochemical parameters with minimal clinical significance.	Transient, adaptive effects.
4	Cellular/physiological changes that could lead to disorders (risk factors or precursor effects).	Considers cellular/physiological changes in the body that are used as indicators of disease susceptibility.
5	Significant functional changes that are reversible or permanent changes of minimal toxicological significance.	Considers those disorders in which the removal of chemical exposure will restore health back to prior condition.
6	Significant, irreversible, non-lethal conditions or disorders	Considers those disorders that persist for over a long period of time but do not lead to death.
7	Developmental or reproductive effects	Considers those chemicals that cause developmental effects or that impact the ability of a population to reproduce.
8	Tumors or disorders likely leading to death	Considers chemical exposures that result in a fatal disorder and all types of tumors.
9	Death.	

Severity scores 1 through 6 represent a progression in the severity of the observed effect. Severity score 7 is used for all studies where the effect observed is a reproductive and/or developmental effect allowing the Agency to track the chemicals that pose developmental or reproductive concerns consistent with the 1996 SDWA. A severity score of 8 was used to track all cases where cancer is the basis for the potency score.

ii. Occurrence Attributes

EPA used prevalence and magnitude to describe the potential to occur in drinking water. Prevalence measures how widespread the occurrence of the contaminant is in the environment or how widely the contaminant may be distributed. The prevalence measure indicates the percent of public water systems or monitoring sites across the nation with detections, number of States with releases, or the total pounds produced nationally. Magnitude relates to the quantity of a contaminant that may be found in the environment. The magnitude measures include the median concentration of detections in water or the total pounds of the chemical released into the environment. In most cases the same data element (*e.g.*, detections in drinking water or amount released into the environment) could be used to determine the prevalence, based on the spatial distribution and magnitude based on the amounts. However, where production data were used to determine prevalence, there was no corresponding direct measure of magnitude, so persistence and mobility data were used as surrogate indicators of potential magnitude.

Production/persistence and mobility data are assigned the lowest level in the hierarchy of data available for prevalence and magnitude. Persistence-mobility is determined by chemical properties that measure or estimate environmental fate characteristics of a contaminant and affect their likelihood to occur and persist in the water environment. Data sources that could provide occurrence data ranged from direct measure of concentrations in water to annual measures of environmental release or production. EPA compiled a second subset or learning set of 207 chemicals, with available data for all of the occurrence attribute data elements that measured prevalence and each of the data elements that measured magnitude, to calibrate protocols for prevalence and magnitude.

The data available for the prevalence attribute consisted of measurements of a contaminant's occurrence across the United States. The prevalence measures have finite ranges such as zero to 100 percent of samples/sites or 1 to 50 States depending on the reporting requirements of the available data source. Accordingly, the scaling of scores for prevalence focused on establishing appropriate groupings of the number of sites or States impacted across the 1 to 10 scoring scale.

The relationship between production or even environmental release data and the actual occurrence in drinking water is complex. Where actual water measurements are available, they are the preferred data element to score prevalence because they are the most direct measures of occurrence in drinking water. EPA selected the following hierarchy for scoring prevalence:

- Percent of PWSs with detections (national scale data).
- Percent of ambient water sites or samples with detections (national scale data).
- Number of States reporting application of the contaminant as a pesticide.
- Number of States reporting releases (total) of the chemical.
- Production volume in lbs/yr.

The production data provide the pounds produced annually of a chemical product in the United States. To some extent, this production rate represents the commercial importance of the chemical, so EPA interpreted the high production tonnage as a likely indication of wide use of a commodity chemical and used this information to score prevalence. For example, a chemical produced at a billion lbs/yr is more likely to be used and released more widely than a compound produced at only 10,000 lbs/yr.

Magnitude represents the quantity of a contaminant that may be in the environment. The data sources that provided the first four levels of the prevalence hierarchy provided direct measurements of water and environmental release that could be used to score magnitude. However, the production categories did not supply an appropriate measure for magnitude. EPA used the persistence and mobility for chemicals with only production data as the basis of the magnitude attribute.

To keep the process straightforward, EPA used one scale for all water concentration data. EPA distributed scores across the range of values so that organic contaminants could receive high scores as well as the inorganic contaminants (IOCs). Comparisons and adjustments were made until there was a reasonable distribution of the scores for organic and inorganic contaminants by using a semi-logarithmic scale. EPA selected the single scale approach and this is discussed in more detail in the report entitled "CCL 3 Chemicals: Classification of the PCCL to the CCL" (USEPA, 2008 c).

When developing the calibration scales for the release data, the ranges of data were similarly arrayed using a scale based on half-log units with a distribution of scores that reflected the distribution of the data in the learning set.

EPA based the persistence and mobility scores on chemical and physical properties combined with environmental fate parameters. Persistence and mobility act as measures of potential magnitude because both fate (i.e., persistence) and transport (i.e., mobility) affect the amount of a contaminant to be found in water. The length of time a chemical remains in the environment before it is degraded (persistence) affects its concentration in water. Similarly, the mobility of a chemical, or its ability to be transported to and in water, affects its potential to reach and dissolve in the source waters, and thus, the ultimate concentration of the chemical in the water.

EPA considered a number of data elements to measure the mobility of a chemical in the environment. The physical/chemical parameters that were chosen for the CCL process are:

- Organic Carbon Partition Coefficient (K_{oc})
- Octanol/Water Partition Coefficient (K_{ow})
- Soil/Water Distribution Coefficient (K_d)
- Henry's Law Coefficient (K_H)
- Solubility

The first 4 measures of mobility represent the equilibrium ratio for the partitioning of the contaminant from one medium to another: K_{oc} (soil/sediment organic carbon: water), K_{ow} (octanol: water), K_d (soil/sediment: water) and Henry's Law Coefficient (air: water). K_{oc}, K_{ow} and K_d are sometimes expressed as logs of the original measurements. The measures of persistence reflect the time the chemical will remain unchanged in the environment. Persistence is reflected in the following measures of environmental fate:

- Half-Life
- Measured Degradation Rate
- Modeled Degradation Rate

Each of the mobility and persistence data elements listed above are presented in hierarchical order, with the most desirable at the top (i.e., the first data to be used if available).

As was the case with prevalence, EPA used a hierarchy in scoring magnitude. The hierarchy uses finished water occurrence data if available, and if not, the highest available element in the hierarchy of finished water data > ambient water data > environmental release data > persistence and mobility data. The data elements used in scoring magnitude follow:

- Median value of detections from finished water systems (PWSs) (national scale data)
- Median value of detections from ambient water sites or samples (national scale data)
- Amount of pesticide applied (annual, in pounds)
- Amount of total releases (annual, in pounds)
- Persistence and mobility data

EPA developed attribute scoring protocols through a step-wise process of data selection, data analysis, calibration of scales, and evaluation of the functionality of the scores in PCCL to CCL decision-making. This is discussed in more detail in the report entitled "Contaminant Candidate List 3 Chemicals: Classification of the PCCL to the CCL" (USEPA, 2008 c). EPA used the attribute protocols to normalize the data for the PCCL chemicals and develop a set of scores for the four attributes that are the input into the models. By normalizing the data elements, EPA developed a process that can use different kinds of data and information (e.g., quantitative and descriptive) to develop input to the models and provide a relative score for potential contaminants using the attribute scores.

b. Training Data Set for the Classification Models

The training data set (TDS) for chemicals is the set of data used to train (or teach) the classification models to mimic EPA expert list-not list decisions for PCCL chemicals. EPA compiled this data set in addition to the two learning sets to represent the types of chemicals likely to move forward to the PCCL. This data set also represents the range of possible attribute scores and listing decisions needed to train and calibrate the classification models. The TDS used to train the models for CCL 3 was comprised of 202 discrete sets of attribute scores for chemicals and consensus list-not list decisions made by a team of EPA subject matter experts.

Classification models use statistical approaches for pattern recognition and derive mathematical relationships among input variables (e.g., measurements or descriptive data) and output from a TDS. EPA used classification models to develop a relationship between the contaminant attribute scores (input variables) and the classification of these contaminants into list-not list categories (output). EPA subject matter experts familiar with the technical aspects of the attribute data and the selection of drinking water contaminants for listing and regulation made the list-not list decisions for the TDS. EPA then applied the models to the PCCL to predict likely list-not list decisions.

EPA considered the following key factors in developing the training data set:

- Selection of contaminants representing a range of outcomes and decisions likely to be encountered in developing a CCL;
- A variety of input data ensuring adequate coverage of attribute scores and combinations of scores;
- Chemicals that, when present in drinking water, would present a meaningful opportunity for public health improvement if regulated; and
- Contaminants that would likely be selected for the PCCL.

The TDS used for training the classification models consisted of 202 combinations of attribute scores and the decisions made by EPA experts. The TDS included some of the contaminants from the learning sets used in developing the scoring protocols for toxicity and occurrence. It also included additional contaminants to meet the key factor requirements described above. The set of known chemicals chosen for the TDS was supplemented with a set of attribute scores and decisions that were selected to balance the range of scored attributes the classification model would need to evaluate as described further below.

Initially, EPA selected "data rich" contaminants from among regulated contaminants and previous CCLs because they had a range of readily available occurrence and health effects information. EPA drinking water subject matter experts and stakeholders reviewed the initial list of contaminants and identified additional candidates for the TDS. This initial selection process identified 51 chemical contaminants. Subsequently, EPA randomly chose 50 contaminants from chemicals in the CCL 3 Universe with high health effects potency values and accompanying occurrence data because they represented contaminants likely to make it to the PCCL. The addition of these 50 contaminants resulted in 101 contaminants with data to score attributes.

The performance of the classification models using the initial TDS gave an indication of gaps in the possible attribute space that the set of 101 TDS contaminants did not adequately cover. This led EPA to add the sets of possible attribute scores to the TDS based on Latin hypercube sampling (NIST, 2006; *http://www.itl.nist.gov/div898/handbook/glossary.htm#LHC*). Using this approach, EPA added 101 specific combinations of attribute scores to fill in gaps in the space defined by total possible attribute scores and improve the performance of the models. This set of 202 scores and decisions ensured good coverage of both "list" and "not list" outcomes and became the TDS. Models trained with the TDS with 202 decisions had greater agreement with EPA subject matter experts than those trained with the TDS of 101 contaminants.

List-not list decisions were a key component of the TDS. EPA subject matter experts made list-not list decisions as individuals and as a group, based on attribute scores and based on data that had not been converted to attribute scores (actual or raw data). The development of the list-not list decisions was an iterative process that incorporated revisions to the attribute scoring protocols as experience was gained by the EPA experts. EPA resolved differences between the decisions based on the scored attributes and the raw data by revising the scoring protocols based on the EPA experts' experience to improve the correlation of decisions based on scores to those based on raw data.

EPA subject matter experts reviewed and evaluated the health effects and occurrence data for each contaminant. Each individual reviewer made decisions about how to classify the contaminant and then met as a group to discuss their decisions. Early in the process the reviewers recognized that clear list or not-list decisions could easily be made for some contaminants, but not for other contaminants. For the chemicals where the decision whether to list contaminants was not clear, two categories were added to the analyses. The categories of List? (L?) or Not List? (NL?) allowed the group to identify chemicals that were close to the boundary for a List-Not List decision. That is L? signifies that the decision is leaning towards listing but with some uncertainty, and NL? signifies that the decision is leaning towards not listing but with some uncertainty. These additional two categories were incorporated into the evaluation and model training process.

The EPA subject matter experts also reached a consensus decision for each contaminant. This consensus decision was used to train the models. This is discussed in more detail in the report entitled "Contaminant Candidate List 3 Chemicals: Classification of the PCCL to the CCL" (USEPA, 2008c).

c. Evaluation of Classification Models

EPA identified several different models for possible use in selecting contaminants from the PCCL for the CCL: Artificial neural networks, classification decision trees, linear models, and multivariant adaptive regression splines. EPA evaluated the classification models in a two-step process. The first step was the evaluation and selection of models from within each of the model classes that best predicted the consensus decisions of the subject matter experts. The second step was the evaluation of the performance of the best models selected from each class (USEPA, 2008c).

EPA evaluated models based on the 4 attributes that the model was able to consider, the types of relationships or mathematical functions that the model utilized, and the model's ability to predict classifications of the TDS. The iterative training process minimized the model's predictive error, thereby reducing incorrect model predictions. EPA also evaluated the impact of the attributes used by the models and the effects of missing data on the performance of the models during the various stages of development.

EPA evaluated the performance of five models. Three models, Artificial Neural Network (ANN), Quick, Unbiased and Efficient Statistical Tree (QUEST), and Linear Regression demonstrated consistent performance when trained and evaluated with the TDS. The classification models were assessed and compared with respect to:

• The number of correct and incorrect classifications for the 202 TDS contaminants.
• The number of "large" misclassifications (off by more than one category).
• The weighted sum of TDS classification errors.
• Ability to identify intermediate classifications.
• Consistent behavior (e.g., no decreasing classification as attribute scores increase).

This is discussed in more detail in the report entitled "Contaminant Candidate List 3 Chemicals: Classification of the PCCL to the CCL" (USEPA, 2008c).

d. Application and Use of Model Results

From the inception of the development of the CCL classification process, EPA intended to use classification models as decision support tools. It was envisioned that the models would be used to process complex data in a consistent, objective, and reproducible manner and provide a prioritized listing of contaminants, allowing EPA to focus resources on the expert review and evaluation of the highest priority potential contaminants. The ANN, Linear, and QUEST models are three different classes of models, with three different mathematical approaches, yet they all provided similar results and logical determinations. EPA explored simple ways to combine the results of all three models, to capture both agreement among models and unique results. Both a straightforward, additive approach, and a collective, rank-order approach were utilized to provide a prioritized listing of contaminants to be considered further and evaluated for possible inclusion on the draft CCL 3.

e. Model Outcome and Expert Evaluation

In the last step of the process, the chemicals on the PCCL were scored for their attributes and evaluated by the three models. Some of the contaminants on the PCCL had limited data available for the scoring protocols and could not be run through the models. The 32 contaminants that had limited data are identified in the appendixes to the "Classification of the PCCL to the CCL" support document (EPA 2008c) and will remain on the PCCL until new data are identified for further evaluation. As part of the evaluation of model output, EPA formulated several post-model refinements that were added to the CCL selection process. Exhibit 11 illustrates the results of the model output for the PCCL contaminants. The PCCL consisted of chemicals with variable health effects data, ranging from reference doses (RfD) to Lethal Dose 50s (LD_{50}), and occurrence data ranging from measured water concentration data from Public Water Systems (PWS) to production volume data.

EXHIBIT 11.—MODEL RESULTS FOR THE PCCL CHEMICALS

3-Models decision	% of PCCL	Total # PCCL	Finished or ambient water	Release	Production
L	9	44	3	24	17
L–L?	12	58	9	29	20
L?	33	163	26	64	73
NL?–L?	6	30	6	11	13
NL?	28	139	29	28	82
NL?–NL	4	20	7	9	4
NL	9	46	21	7	18
N (all)	100	500	101	172	227

Four of the seven decision categories, L, L?, NL?, NL, in the first column of Exhibit 11 signify that all of the models were in unanimous agreement with the listing decision. The other categories (e.g., NL?–L?) represent varied agreement where one or two of the models chose one category and the other model(s) resulted in a different category. Note that none of the models placed a contaminant in a category more than one category higher or lower than the other models. That is, no contaminants were categorized as "L" by one model and as "NL?" by one of the other models, or visa versa. The models categorized approximately one-half of the chemicals on the PCCL as L? or above. When analyzed by data type, the majority of chemicals in the List category used LD_{50} data for health effects. This was a concern and became an important issue for consideration. The role LD_{50} played in the health effects scoring was discussed extensively during the post-model evaluation process.

As part of the last stage in the CCL classification process, the model output was reviewed by a group of internal EPA experts representing several offices. This step involved a detailed review of the data used for the models and the available supplemental data for the chemicals. The EPA experts also deliberated on the method of using the model data to produce a draft proposal for CCL 3. The function of this review was to critically compare the results from the model to the data for the chemicals for a cross section of the modeled contaminants.

Based upon issues identified by the evaluators, several post model refinements were added to the CCL process. Three major issues and refinements are described below.

The relationship between potency and concentration was important when deciding whether to list a chemical. However this ratio could only be developed when water concentration data were available. Accordingly, calculation of the ratio between the health-based value and the 90th percentile concentration in finished or ambient water was added as a post-model process. The potency/concentration ratio serves as a benchmark that suggests a greater concern for a contaminant if the ratio is low and a lesser concern when it is high.

The addition of modeled occurrence data for pesticides and estimated concentration in surface and ground water was obtained from the EPA Office of Pesticide Programs (OPP). The modeled estimates of concentration in water for pesticides are part of the EPA's pesticide registration and re-registration evaluations. Once the availability of the OPP data for some of the pesticides was confirmed, the data were extracted from OPP documents and used to generate a potency/concentration ratio similar to that used with the water concentration data.

Data certainty was factored into the decision process by characterizing health effect and occurrence data elements and their relative certainty based upon the type of data that was used to score the attribute for the model classification. This characterization tagged data elements with high certainty and low certainty. The combined certainty measure for a single contaminant (i.e., health effects and occurrence tags) was used to place contaminants in bins of high, medium and low certainty.

The high certainty bin consisted of chemicals with direct occurrence measured in water and well-studied data for health effects. Such contaminants are expected to be good candidates for regulatory determination because they provide information that can be considered in that process and have minimal research needs. Examples of the data used to characterize chemicals in the high certainty bin include chemicals with RfDs, LOAELs, and NOAELs, and water concentration data. The medium bin consists of chemicals that will need further occurrence and/or health effects research. For example, chemicals with well studied health effects that only have environmental release data are included in the medium bin. Chemicals that are released to the environment and need further health effects research are also included in the medium bin. The low certainty bin consists of chemicals that have limited data, yet these data suggest that further evaluation should be pursued. These chemicals may need extensive health effects and occurrence research that may require significant resources before regulatory determinations can be made. Examples include chemicals with only LD_{50} and/or production volume data. The CCL should consist both of chemicals that provide sufficient data to support regulatory determinations as well as chemicals that are of concern and need to be targeted for additional drinking water research. Contaminants from each bin were scrutinized separately in selecting which ones should be listed on the CCL 3.

4. Selection of the Draft CCL 3—Chemicals

The chemicals for the draft CCL 3 were selected from within the three certainty bins with the emphasis placed on the source of the occurrence data (e.g., measured concentrations, release, and production). Four groups of chemicals were placed on the CCL based on their modeled scores, the potency-concentration ratios, where available, and the estimate of data certainty. They included:

- 36 chemicals in the high certainty bin with finished or ambient water data and a potency/90th percentile concentration ratio ≤10.
- 24 pesticide chemicals in the medium certainty bin with modeled surface and/or ground water data that yielded a potency/concentration ratio ≤10.
- 27 chemicals in the medium certainty bin with release data that gave modeled L or L-L? rankings.
- 8 chemicals in the low certainty bin that were added to the CCL as recommended by the public in response to EPA's **Federal Register** notice (71 FR 60704, USEPA, 2006b). The notice requested that the public submit chemical and microbial contaminant nominations that should be considered for CCL 3. This process is discussed in section III.C.1.

The potency and concentration were compared to develop a ratio that was used to select contaminants for the draft CCL 3 from the high certainty bin. A ratio between the health-based value and the 90th percentile was taken for chemicals with measurements in finished and ambient water. Contaminants for this bin were selected for the draft CCL 3 when the ratio was ≤10, representing occurrence in water at a level of concern related to its health effects data.

The pesticides in the medium bin, where modeled data was obtained from OPP, were selected for the draft CCL 3 based on their potency/concentration ratios. Similar to the chemicals in the high certainty bin, pesticides were selected for the draft CCL 3 when the potency/concentration ratio was <10, representing potential occurrence in water at a level of concern related to its health effects data. The other chemicals in the medium bin were selected for the draft CCL 3 based on a review of their data and their prioritization from the classification models.

Chemicals in the low certainty bin were selected for the draft CCL 3 based on a review of their supplemental data and the data submitted through the nominations process. Some of the chemicals identified through the nominations process were already on the draft CCL 3 based on the data EPA collected for the universe. The supplemental data provided with the nominations were used to screen the nominated chemicals and score the attributes for those that passed the screen. The scored attributes were then processed through the models and the post-model evaluations. Those that were listed demonstrated adverse health effects and a potential to occur in PWSs. Chemicals not selected for the draft CCL 3 will remain on the PCCL until additional occurrence or health effects data become available to support their reevaluation.

B. Classification Approach for Microbial Contaminants

As discussed in CCL 2 (USEPA, 2005b), the Agency evaluated the NDWAC, NRC and other recommendations, and used the information to develop a pragmatic approach for classifying the microorganisms on the draft CCL 3. The CCL 3 approach for microbes, like the approach used for chemicals, uses the attributes of occurrence and health effects to select the microbial contaminants. EPA's objective is to target microorganisms with the highest potential for human exposure and the most serious adverse health effects. Parallel to the chemical selection process, the Agency considers a broad universe of microbial contaminants and systematically narrows that universe down to develop the draft CCL 3 in a transparent and scientifically sound CCL process. The first step of the CCL 3 approach for microbes identifies a universe of potential drinking water contaminants. The second step screens that universe of microbiological contaminants to a Preliminary Contaminant Candidate List (PCCL). Lastly, EPA selects the draft CCL 3 microbial list by ranking the PCCL contaminants based on occurrence in drinking water (including waterborne disease outbreaks) and human health effects.

1. Developing the Universe

EPA defined the microbial Universe for the draft CCL 3 as all known human pathogens. The Universe process began with the list of 1,415 recognized human pathogens compiled by Taylor *et al.* (2001). The Agency added organisms to the Universe and updated nomenclature in Taylor *et al.* (2001) to account for emerging pathogens and new taxonomy research.

As EPA reviewed Taylor *et al.* (2001), additional pathogens were also identified. EPA surveyed fungi in drinking water and identified six fungi reported to occur in drinking water distribution systems that did not appear on the Taylor list. The added fungi are shown in Exhibit 12. EPA also added reovirus to the Universe based on additional health effects information (Tyler, *et al.*, 2004).

In October 2006, EPA published a notice (71 FR 60704 (USEPA, 2006b)) requesting chemical and microbial contaminant nominations as part of the process to identify emerging contaminants that should be considered for the CCL. As a result of the nominations process, 24 microbial contaminants were nominated by the public. Twenty-two of the microbes were previously identified by Taylor *et al.* (2001) and are already in the Universe. The two additional pathogens nominated were *Methylobacterium* (with two species) and Mimivirus. These two bacterial species, two viral groups and six fungal species were added to the Microbial Universe which brings the Microbial Universe list to 1,425 pathogens. The full Universe list is available in the document, "Contaminant Candidate List 3 Microbes: Identifying the Universe" (USEPA, 2008d).

EXHIBIT 12.—FUNGI ADDED TO THE MICROBIAL UNIVERSE

Pathogen
Arthrographis kelrae
Chryosporium zontatum
Geotrichum candidum
Sporotrichum pruinosum
Stachybotrys chartarum
Stemphylium macrosporoideum

2. The Universe to PCCL

EPA developed screening criteria to reduce the Universe of all human pathogens to just those pathogens that could be transmitted through drinking water. For example, pathogens transmitted solely by animals, such as the virus that causes rabies, were screened out of the Universe and are not included on the PCCL. Screening is based on a pathogen's epidemiology, geographical distribution, and biological properties in their host and in the environment. EPA moved pathogens forward to the PCCL if there was any evidence linking a pathogen to a drinking water-related disease. The screening criteria restrict the microbial PCCL to human pathogens that may cause drinking water-related diseases resulting from ingestion of, inhalation of, or dermal contact with drinking water. EPA used 12 screening criteria (Exhibit 13) to reduce the pathogens in the microbial CCL universe to the PCCL.

EXHIBIT 13.—CCL SCREENING CRITERIA FOR PATHOGENS

1. All anaerobes.
2. Obligate intracellular fastidious pathogens.
3. Transmitted by contact with blood or body fluids.
4. Transmitted by vectors.
5. Indigenous to the gastrointestinal tract, skin and mucous membranes.
6. Transmitted solely by respiratory secretions.
7. Life cycle incompatible with drinking water transmission.
8. Drinking water-related transmission is not implicated.
9. Natural habitat is in the environment without epidemiological evidence of drinking water-related disease.
10. Not endemic to North America.
11. Represented by a pathogen for the entire genus or species (that are closely related).
12. Current taxonomy changed from taxonomy used in Universe.

Pathogens meeting any single criterion of the 12 criteria were removed from further consideration and not moved forward to the PCCL. Based upon this screening exercise, 1,396 of the 1,425 pathogens were excluded and 29 pathogens moved on to the PCCL. The results of the screening process are summarized in Exhibit 14. The screening criteria and results of the screening process are discussed in greater detail in the supporting document titled "Contaminant Candidate List 3 Microbes: Screening to the PCCL" (USEPA, 2008 e).

EXHIBIT 14.—APPLICATION OF TWELVE SCREENING CRITERIA TO PATHOGENS IN THE MICROBIAL CCL UNIVERSE

Pathogen class	Total	Screening Criteria												Pathogens screened out	On PCCL
		1	2	3	4	5	6	7	8	9	10	11	12		
Bacteria	540	125	14	10	37	117	7	0	29	154	2	28	5	528	12
Viruses	219	0	0	26	104	0	19	1	18	0	36	8	0	212	7
Protozoa	66	0	0	1	29	3	0	4	7	7	0	6	0	57	7*
Helminths	287	0	0	0	25	0	0	106	0	0	156	0	0	287	0
Fungi	313	0	0	0	0	12	1	0	0	297	0	0	0	310	3
Total	1,425	125	14	37	195	132	27	111	54	458	194	42	5	1,394	29*

* Two additional protozoa, *Cryptosporidium* and *Giardia* were not considered for CCL 3 and they are discussed in more detail later.

3. The PCCL to Draft CCL Process

Pathogens on the PCCL were scored for placement on the draft CCL. EPA devised a scoring system to assign a numerical value to each pathogen on the PCCL.

Each of the pathogens on the PCCL was scored using three scoring protocols, one protocol each for waterborne disease outbreaks (WBDO), occurrence in drinking water, and health effects. The higher of the WBDO score or the occurrence score is added to the normalized health effects score to produce a composite pathogen score. Pathogens receiving high scores were considered for placement on the CCL.

EPA normalized the health effects score so that occurrence and health effects have equal value in determining the ranking of the CCL. The equal weighting of occurrence and health effects information closely mirrors the risk estimate methods used by EPA during drinking water regulation development. This scoring system prioritizes and restricts the number of pathogens on the CCL to only those that have been strongly associated with drinking water-related disease. Pathogens that scored low will remain on the PCCL until additional occurrence data, epidemiological surveillance data, or health effects data become available to support their reevaluation. It is important to note that pathogens for which there are no data documenting a waterborne disease outbreak in drinking water earn a low score under the protocols. EPA believes that pathogens that have caused a WBDO and have health effects data should rank higher than pathogens that have only data on health effects but no evidence of a WBDO. The following sections describe the three protocols used to score the pathogens on the PCCL and the process by which the scores are combined.

a. Waterborne Disease Outbreak Protocol

The Centers for Disease Control and Prevention (CDC), EPA and the Council of State and Territorial Epidemiologists (CSTE) have maintained a collaborative surveillance system for collecting and periodically reporting data related to occurrences and causes of WBDOs since 1971. EPA used the CDC surveillance system as the primary source of data for the waterborne disease outbreaks protocol. Reports from the CDC system are published periodically in *Morbidity and Mortality Weekly Report* (MMWR).

For this protocol (Exhibit 15), a pathogen is scored as having a WBDO(s) in the U.S. if that pathogen is listed in a CDC waterborne disease drinking water surveillance summary (i.e., in the MMWR). A pathogen with multiple WBDOs listed by CDC is given the highest score under this protocol. EPA also scored non-CDC reported WBDOs and WBDOs outside the U.S. as well; however these were given lower scores. WBDOs outside the U.S. were scored when information was available from World Health Organization publications or other peer-reviewed publications.

In addition, CDC and EPA acknowledge that the WBDOs reported in the surveillance system represent only a portion of the burden of illness associated with drinking water exposure (CDC, 2004). The surveillance information does not include endemic waterborne disease risks, nor are reliable estimates available of the number of unrecognized WBDOs and associated cases of illness. Therefore, EPA also considered data as indicating a WBDO (even though CDC does not list a WBDO in their MMWR) if the non-CDC data showed a link between human illness defined by a common water source, a common time period of exposure and/or similar symptoms. EPA also considered the use of molecular typing methods to link patients and environmental isolates.

Only two pathogens were given a WBDO score on this basis, *Mycobacterium avium* and *Arcobacter butzlerei*. They are discussed in greater detail in the "Contaminant Candidate List 3 Microbes: PCCL to CCL Process" (USEPA, 2008 f).

EXHIBIT 15.—WATERBORNE DISEASE OUTBREAK SCORING PROTOCOL

Category	Score
Has caused multiple (2 or more) documented WBDOs in the U.S. since CDC surveillance initiated in 1973	5
Has caused at least one documented WBDO in the U.S. since CDC surveillance initiated in 1973	4
Has caused documented WBDOs at any time in the U.S.	3
Has caused documented WBDOs in countries other than the U.S.	2
Has never caused WBDOs in any country, but has been epidemiologically associated with water-related disease	1

b. Occurrence Protocol

The second attribute of the scoring process evaluates the occurrence of a pathogen in drinking water. Because water-related illness may also occur in the absence of recognized outbreaks, EPA scored the occurrence (direct detection) of microbes using cultural, immunochemical, or molecular detection of pathogens in drinking water under the Occurrence Protocol (Exhibit 16). Occurrence characterizes pathogen introduction, survival, and distribution in the environment. Occurrence implies that pathogens are present in water and that they may be capable of surviving and moving through water to produce illness in persons exposed to drinking water by ingestion, inhalation, or dermal contact.

Pathogen occurrence is considered broadly to include treated drinking water, and all waters using a drinking water source for recreational purposes. This attribute does not characterize the extent to which a pathogen's occurrence poses a public health threat from drinking water exposure. Because viability and infectivity cannot be determined by non-cultural methods, the public health significance of non-cultural detections is unknown.

EXHIBIT 16.—OCCURRENCE SCORING PROTOCOL FOR PATHOGENS

Category	Score
Detected in drinking water in the U.S.	3
Detected in source water in the U.S.	2
Not detected in the U.S.	1

c. Health Effects Protocol

EPA's health effects protocol evaluates the extent or severity of human illness produced by a pathogen across a range of potential endpoints. The seven-level hierarchy developed for this protocol (Exhibit 17) begins with mild, self-limiting illness and progresses to death.

The final outcome of a host-pathogen relationship resulting from drinking water exposure is a function of viability, infectivity, and pathogenicity of the microbe to which the host is exposed and the host's susceptibility and immune response. SDWA directs EPA to consider subgroups of the population at greater risk of adverse health effects (i.e., sensitive populations) in the selection of unregulated contaminants for the CCL. Sensitive populations may have increased susceptibility and may experience increased severity of symptoms, compared to the general population. SDWA refers to several categories of sensitive populations including the following: children and infants, elderly, pregnant women, and persons with a history of serious illness.

Health effects for individuals with marked immunosuppression (e.g., primary or acquired severe immunodeficiency, transplant recipients, individuals undergoing potent cytoreductive treatments) are not included in this health effects scoring. While such populations are considered sensitive subpopulations, immunosuppressed individuals often have a higher standard of ongoing health care and protection required than the other sensitive populations under medical care. More importantly, nearly all pathogens have very high health effect scores for the markedly immunosuppressed individuals; therefore there is little differentiation between pathogens based on health effects for the immunosuppressed subpopulation.

This protocol scores the representative or common clinical presentation for the specific pathogen for the population category under consideration. EPA used recently published clinical microbiology manuals as the primary data source for the common clinical presentation. These manuals take a broad epidemiological view of health effects rather than focusing on narrow research investigations. The one exception to this approach was EPA's scoring of health effects for *Helicobacter pylori*. *H. pylori* is discussed in greater detail in section IV.C as well as in the support document, "CCL 3 Microbes: PCCL to CCL Process" (USEPA, 2008 f).

To obtain a representative characterization of health effects in all populations, EPA evaluated separately the general population and these four sensitive populations as to the common clinical presentation of illness for that population. EPA added the general population score to the highest score among the four sensitive subpopulations for an overall health effects score. The resulting score acknowledges that sensitive populations have increased risk for waterborne diseases.

EXHIBIT 17.—HEALTH EFFECTS SCORING PROTOCOL FOR PATHOGENS

Outcome category	Score	Manifestation in population class				
		General population	Children/ infants	Elderly	Pregnant women	Chronic disease
Does the organism cause significant mortality (> 1/1,000 cases)?.	7					
Does the organism cause pneumonia, meningitis, hepatitis, encephalitis, endocarditis, cancer, or other severe manifestations of illness necessitating long term hospitalization (> week)?.	6					
Does the illness result in long term or permanent dysfunction or disability (e.g., sequelae)?.	5					
Does the illness require short term hospitalization? (< week)?	4					
Does the illness require physician intervention?	3					
Is the illness self-limiting within 72 hours (without requiring medical intervention)?.	2					
Does the illness result in mild symptoms with minimal or no impact on daily activities?.	1					

d. Combining Protocol Scores to Rank Pathogens

EPA scored and ranked the PCCL using the three attribute scoring protocols, occurrence, waterborne disease outbreaks, and health effects. These protocols are designed in a hierarchical manner so that each pathogen is evaluated using the same criteria and the criteria range for each protocol varies from high significance to low significance. The three attribute scores are then combined into a total score.

EPA scored pathogens first using the WBDO and occurrence protocols, and then selected the highest score. Selection of the higher score from the WBDO or occurrence protocol elevates pathogens that have been detected in drinking water or source water in the U.S. (occurrence score of 2 or 3) above pathogens that have caused WBDOs in other countries but not in the U.S. (WBDO score of 2).

The CCL selection process considered pathogens causing recent waterborne outbreaks more important than pathogens detected in drinking water without documented disease from that exposure. Direct detection of pathogens indicates the potential for waterborne transmission of disease. Documented waterborne disease outbreaks provide an additional weight of evidence that illness was transmitted and that there was a waterborne route of exposure. EPA developed protocols to define a hierarchy of the relevance that each of these types of data provide in evaluating microbes for the CCL. Combining these two sources of occurrence information enabled EPA to consider both emerging pathogens, which are detected in water and should be considered, yet are not tracked by public health surveillance programs, and those pathogens with WBDO data. This hierarchy also acknowledges that organisms identified as agents in WBDO are a higher priority for the CCL.

Next, pathogens were scored using the Health Effects Protocol. All five population categories were scored for each pathogen using the most common clinical presentation for the specific pathogen for the population category under consideration. Because it is recognized that pathogens may produce a range of illness from asymptomatic infection to fulminate illness progressing rapidly to death, scoring decisions are based upon the more common clinical presentation and clinical course for the population under consideration, rather than the extremes. The pathogen's score for the general population is added to the highest score among the four sensitive populations to produce a sum score between 2 and 14.

Finally, EPA normalizes the Health Effects and WBDO/Occurrence score because the Agency believes they are of equal importance. The highest possible score for WBDO/Occurrence is 5 and the highest possible Health Effect score is 14. To equalize this imbalance, the Agency multiplies the health effects score by $5/14$. Combining health effects data with the WBDO/occurrence data by adding the scores from these protocols provides a system that evaluates both the severity of potential disease and the potential magnitude of exposure through drinking water.

Exhibit 18 presents the scores for all the PCCL pathogens with the exception of *Giardia* and *Cryptosporidium*. These two protozoan pathogens made it through the screening protocol, however, EPA chose not to score or include them on the PCCL because EPA has recently published a national primary drinking water regulation that specifically addresses these pathogens (January 4, 2006, 71 FR 388 (USEPA, 2006 a) and is discussed in more detail later.

EXHIBIT 18.—PATHOGENS ON THE PCCL

Pathogen	WBDO	Occurrence	Normalized health score	Total[1] score
Naegleria fowleri	4	3	5.0	9.0
Legionella pneumophila	5	3	3.6	8.6
Escherichia coli (0157)	5	3	3.2	8.2

EXHIBIT 18.—PATHOGENS ON THE PCCL—Continued

Pathogen	WBDO	Occurrence	Normalized health score	Total[1] score
Hepatitis A virus	5	2	3.2	8.2
Shigella sonnei	5	3	3.2	8.2
Helicobacter pylori	1	3	5.0	8.0
Campylobacter jejuni	5	3	2.5	7.5
Salmonella enterica	5	3	2.5	7.5
Caliciviruses	5	3	2.1	7.1
Entamoeba histolytica	5	3	2.1	7.1
Vibrio cholerae	5	3	2.1	7.1
Adenovirus	2	3	3.6	6.6
Enterovirus	2	3	3.6	6.6
Cyclospora cayetanensis	4	1	2.5	6.5
Mycobacterium avium	4	3	2.5	6.5
Rotavirus	4	2	2.5	6.5
Yersinia enterocolitica	5	3	1.4	6.4
Arcobacter butzleri	4	3	2.1	6.1
Fusarium solani	1	3	2.9	5.9
Plesiomonas shigelloides	4	3	1.8	5.8
Hepatitis E virus	2	1	3.6	5.6
Toxoplasma gondii	2	1	3.2	5.2
Aspergillus fumigatus group	1	3	2.1	5.1
Exophiala jeanselmei	1	3	2.1	5.1
Aeromonas hydrophila	1	3	1.8	4.8
Astrovirus	2	2	1.4	3.4
Microsporidia	1	2	1.4	3.4
Isospora belli	2	0	1.1	3.1
Blastocystis hominis	1	0	0.7	1.7

1. Total Score = Normalized Health Score + the higher of WBDO or Occurrence scores.

e. Other Criteria Considered for Listing and Scoring Microbes on the Draft CCL 3

i. Organisms Covered by Existing Regulations

EPA considered an additional screening criterion based upon contaminants that might be controlled through drinking water monitoring requirements under the Total Coliform Rule (TCR) (54 FR 27544, June 29, 1989 (USEPA, 1989b)). Many of the bacteria in the CCL Universe, including the *Enterobacteriaceae* and members of the genera *Campylobacter* and *Vibrio,* are associated with fecal contamination and as such their presence could be signaled by the total coliform monitoring requirements under current drinking water regulations. In the TCR, EPA chose to require monitoring for *Escherichia coli* or fecal coliform (and total coliforms) in finished drinking water because it provides a broad indication of the potential presence of fecal pathogens in drinking water, though more so for bacteria than for viruses and protozoa.

EPA chose not to exclude common enteric bacterial pathogens from the PCCL even though they may be indicated by the TCR. Numerous waterborne disease outbreaks have occurred in systems that were in compliance with drinking water monitoring requirements under the TCR. EPA recognizes the frequency of total coliform monitoring under the TCR may be limited, especially for smaller systems, thus transitory fecal contamination could go undetected. The recognition of these bacterial pathogens on the CCL list will provide additional understanding of the risks posed by distribution systems.

The Agency is currently revising the TCR and considering distribution water quality issues (because of the pathways of potential fecal contamination). Including these pathogens on the CCL emphasizes their importance in protecting public health. EPA believes that enteric pathogens should be included for further specific regulatory consideration in the CCL.

ii. Organisms Covered by Treatment Technique Regulations

According to SDWA (section 1412(b)(1), as amended in 1996), EPA must select CCL contaminants that "at the time of publication, are not subject to any proposed or promulgated national primary drinking water regulation * * *." In promulgating regulations for contaminants in drinking water, EPA can set either a legal limit (MCL) and require monitoring for the contaminant in drinking water or, for those contaminants that are difficult to measure, EPA can establish a treatment technique requirement. The Surface Water Treatment Rule (SWTR) (54 FR 27486, June 29, 1989 (USEPA, 1989a)) included MCLGs for *Legionella, Giardia,* and viruses at zero because any amount of exposure to these contaminants represents some public health risk. Since measuring disease-causing microbes in drinking water is not considered to be feasible, EPA established treatment technique requirements for these contaminants. The purpose of subsequent treatment technique requirements (Interim Enhanced Surface Water Treatment Rule (63 FR 69478; USEPA 1998a), Long Term Surface Water Treatment Rule 1 (67 FR 1813; USEPA, 2002a) and the Long Term Surface Water Treatment Rule 2 (71 FR 654; USEPA, 2006a)) which included an MCLG of zero for *Cryptosporidium,* is to reduce disease incidence associated with *Cryptosporidium* and other pathogenic microorganisms in drinking water. These rules apply to all public water systems that use surface water or ground water under the direct influence of surface water.

The Ground Water Rule (71 FR 65573, (USEPA, 2006c)) set treatment technique requirements to control for viruses (and pathogenic bacteria) because it was not feasible to monitor for viruses (or pathogenic bacteria) in drinking water. Under the GWR, if systems detect total coliforms in the distribution system, they are required to monitor for a fecal indicator (*E. coli,* coliphage, or enterococci) in the source water. If fecal contamination is found in the source water, the system must take remedial action to address contamination.

While *Cryptosporidium* and *Giardia* have been implicated in WBDOs, there is a substantial amount of research regarding health effects and sensitivity to various treatment control measures. More importantly, as noted above, EPA has recently published a National Primary Drinking Water Regulation, The Long Term 2 Surface Water Treatment Rule that specifically addresses these pathogens (71 FR 654 (USEPA, 2006a)). Therefore, they are excluded from the CCL.

EPA did not exclude specific viruses and *Legionella* from consideration for the CCL even though they have broad category MCLGs and treatment technique requirements. Viruses include a wide range of taxa. The treatment and health effects information for different viral taxa was very limited when setting the treatment technique requirements for surface water and ground water systems. Also, different viral taxa have been implicated in various waterborne disease outbreaks for which EPA did not have dose response or treatment data when promulgating its treatment technique requirements. *Legionella* has recently been identified in numerous WBDOs (e.g., CDC *MMWR* reports, 2006). Additionally EPA received additional information on the occurrence of *Legionella* in distribution systems as part of the nominations process (USEPA 2008g). Therefore EPA included viruses and *Legionella* on the draft CCL 3.

iii. Applying Genomic and Proteomic Data to Microbes

The Agency and NDWAC workgroup evaluated the possibility of using genomics and proteomics as data to identify emerging waterborne pathogens, opportunistic microorganisms, and other newly identified microorganisms. While the application of these data in identifying genetic properties that may be pathogenic is a powerful tool for the elucidation of pathogenic mechanisms, the technology is yet largely unproven and the Agency has decided at this time not to use these techniques for CCL application. However, the Agency is monitoring the progress of these technologies and as the data improve and genomics progresses the Agency may consider them for future CCL development.

4. Selection of the Draft CCL 3 Microbes From the PCCL

The 29 PCCL pathogens in Exhibit 18 are ranked according to an equal weighting of their summed scores for normalized health effects and the higher of the individual scores for WBDO and occurrence in drinking water. EPA believes this ranking indicates the most important pathogens to consider for the draft CCL 3. To determine which of the 29 PCCL pathogens should be the highest priority for EPA's drinking water program and included on the draft CCL 3, the Agency considered both scientific and policy factors. The factors included the PCCL scores for WBDO, occurrence, and health effects; comments and recommendations from the various expert panels; the specific intent of SDWA; and the need to focus Agency resources on pathogens to provide the most effective opportunities to advance public health protection. After consideration of these factors, EPA has determined that the draft CCL 3 will include the 11 highest ranked pathogens shown in Exhibit 18.

Additionally, the Agency notes that, and as can be observed in Exhibit 18, there are a few "natural" break points in the ranked scores for the 29 pathogens, with the top 11 forming the highest ranked group of pathogens. EPA does believe that the overall rankings strongly reflect the best available scientific data and high quality expert input employed in the CCL selection process, and therefore should be important factors in helping to identify the top priority pathogens for the draft CCL 3.

C. Public Input

1. Nominations and Surveillance

On October 16, 2006, EPA published a **Federal Register** notice (71 FR 60704 (USEPA, 2006 b)) requesting the public to submit chemical and microbial contaminant nominations that should be considered for CCL 3. EPA evaluated nominated contaminants to identify the data supporting their nomination. This section describes EPA's request for contaminants and summarizes the nominations received by EPA. A more detailed discussion of the contaminants, including a list of the specific contaminants nominated, can be found in the CCL 3 Nominations Summary in EPA's Water Docket (USEPA, 2008 g).

The Agency sought CCL nominations for contaminants by framing the SDWA requirements in a series of questions to document the anticipated or known occurrence in PWS(s) and adverse health effects of potential contaminants. The Agency requested that the public respond to these questions and provide the documentation and rationale for including a contaminant for consideration in the CCL process. The questions posed to the public were:

—What are the contaminant's name, CAS number, and/or common synonym (if applicable)?

—What factors make this contaminant a priority for the CCL 3 process (e.g., widespread occurrence; anticipated toxicity to humans; potentially harmful effects to susceptible populations (e.g., children, elderly and immunocompromised); potentially contaminated source water (surface or ground water), and/or finished water; releases to air, land, and/or water; contaminants manufactured in large quantities with a potential to occur in source waters)?

—What are the significant health effects and occurrence data available, which you believe supports the CCL requirement(s) that a contaminant may have an adverse effect on the health of persons and is known or anticipated to occur in public water systems?

The Agency compiled the information from the nominations process to identify the contaminants nominated and the rationale for the nomination and to compare the supporting data to information already gathered by EPA.

The nominations process identified 150 chemical and 24 microbial contaminants from 11 organizations and individuals. The organizations that nominated contaminants are:

—American Society of Microbiology (ASM),

—American Water Works Association (AWWA),

—Association of Metropolitan Water Agencies (AMWA),

—Association of State Drinking Water Administrators (ASDWA),

—Mothers Against *Acanthamoeba* Disease,

—Natural Resources Defense Council, (NRDC),

—Riverkeepers,

—State of New Jersey Department of Environmental Protection,

—State of New York Department of Health, and

—State of Texas Commission on Environmental Quality.

Exhibit 19 summarizes the types of nominated contaminants and who nominated them. The complete list of chemical and microbial contaminants nominated can be found in EPA's Water Docket. Some of the nominations identified categories of contaminants that the Agency should consider for the CCL. There were 23 chemical groups identified from the 150 chemical contaminants that were nominated. For example, several organizations identified pesticides that are not currently regulated under the SDWA as candidates for consideration. Other groups identified by the public are listed in Exhibit 19.

EXHIBIT 19.—SUMMARY OF CCL 3 NOMINATIONS

Nominator	Number of individual contaminants or specific examples from nominated groups	Types and groups of contaminants
ASM	2	Mimivirus, *Naegleria fowleri*.
AMWA	3	Nitrosoamines and other DBPs.
ASDWA	14	Disinfection byproducts (DBPs), unregulated pesticides, solvents, total petroleum hydrocarbons, cyanotoxins, 3 perfluorinated contaminants (PFCs), viruses, phthalates, nitrite, nitrate; endocrine disruptors.
AWWA	38	DBPs, pesticides, 16 specific microbes, cyanotoxins, radium, 1,4-dioxane.
Mothers Against *Acanthamoeba* Disease	1	*Acanthamoeba*.
New Jersey DEP	4	PFOS, PFOA, trichloropropane, tertiary butyl alcohol.
New York DOH	24	Pharmaceuticals, personal care products, DBPs, fuel oxygenates, 1,4-dioxane, herbicides, bio-monitoring data.
NRDC	26	Alkylphenolpolyethoxylates (APEs that may be endocrine disrupter compounds (EDC)), all unregulated pesticides, perchlorate, Mycobacterium avium complex (MAC), phthalates, managanese, bisphenol A.
Riverkeeper	52	Pharmaceuticals, sodium, chloride.
Texas DEQ	3	Viruses, nitrite, nitrate.

The Agency evaluated the nominations to identify contaminants not previously considered for the CCL and new pertinent information provided by the public. Nominated contaminants were evaluated to identify and compare supporting information provided to that used in the CCL process. Of the 174 chemical and microbial contaminants nominated, 152 contaminants were already being considered by the Agency. Seven of the nominated contaminants are currently regulated in PWSs and will not be included in the CCL 3 process. Most of the data sources cited in the nominations process were already identified for the CCL 3 process. The nominations process did identify recently published specialized studies from scientific literature that were subsequently incorporated in the CCL 3 evaluation process.

Where new supplemental data was provided for contaminants that had not been identified for the draft CCL 3, EPA used the supplemental data to screen the nominated chemicals and score the attributes for those that passed the screen. EPA then processed the nominated contaminants through the models and the post-model evaluations. Twenty of the contaminants identified in the nominations process are on the draft CCL 3.

2. External Expert Review and Input

EPA actively sought external advice and expert input for the draft CCL 3. In addition to their own recommendations, the NRC and NDWAC recommended that the Agency seek opportunities to incorporate additional expert input in the development of the draft CCL 3. EPA convened several external expert panels at integral stages during the development of the draft CCL 3. EPA incorporated expert judgment and input from the scientific community into the CCL process for both chemicals and microbes. The Agency has requested a consultation with the Science Advisory Board that will take place in 2008.

For each expert panel, EPA sought panel members that provided a variety of disciplines and expertise. Panel members were encouraged to provide comments as individuals based upon their expertise and background, not as representatives of their respective organizational affiliations. Expert panel members were also encouraged to present individual comments if consensus comments were not developed. Separate panels were convened to review the draft chemical and microbial CCL 3 lists and the processes used to develop them. A more detailed discussion of the chemical and microbial expert review and input is provided in the support documents in the EPA Water Docket. A brief overview of the chemical and microbial expert review and stakeholder involvement follows.

a. Chemical Expert Input Panels

In September of 2006, EPA formed two external expert panels to provide specific input into the chemical CCL 3 process. In the first panel, experts reviewed the data sources and the process used to identify the chemical universe. EPA convened the second panel for a 3-day workshop to review the data and information used to develop screening criteria, the data and methodology for the classification approach, and to provide overall input into the CCL process. In summary, the panels recommended that EPA consider additional data sources in the process. They also commented on ways to improve and clarify the presentation of EPA efforts, thereby ensuring that the CCL 3 process for chemicals is more transparent. The expert panel reviewing the classification approach identified additional analyses and approaches to train and validate the models. The panel specifically commented on the varied nature of data elements and sources considered in the classification process. The panel recommended that to account for these varied data sources, contaminants be flagged based upon data certainty, and that uncertainty be considered in making a listing decision. The Agency applied their recommendations in the development of the draft CCL 3. In addition, the expert panels acknowledged the Agency's efforts to transparently present a complex process and noted that many of the questions posed by the panels were previously considered by EPA. They recommended that additional discussion and information in the support documents would add to the clarity of the process.

In March 2007, EPA convened a panel to review the preliminary draft CCL 3 list for the chemical contaminants in a two-day workshop. Panelists provided comments on a preliminary draft list of contaminants after receiving supporting materials and presentations from EPA staff. The panel's review focused mainly on the chemicals on the draft CCL 3. They provided comments on contaminants considered for the draft CCL 3 and commented on the supporting data and methods EPA used to identify the contaminants selected. They also provided general comments on the classification model output and the processes used to select chemical contaminants for CCL 3. In addition, they recommended EPA consider a strong outreach process to highlight the significant modeling and decision making processes used in its development.

The panel recognized the level of effort and detail that went into the development of the modeling process used to create the draft list and complimented EPA on these efforts. Comments from all the panels were considered by EPA and appropriate changes were incorporated into the process/protocols to formulate the draft CCL 3. (Specific recommendations and comments are further described in USEPA, 2008h.)

b. Microbial Expert Input Panels

EPA convened three workshops to review, discuss, and comment on the microbes considered and selected for the draft CCL 3. In December 2005, a group of expert microbiologists reviewed and commented on the universe of human pathogens and the screening criteria used to develop the PCCL. This panel agreed that focusing on human pathogens is a reasonable and pragmatic way to identify potential drinking water contaminants. While the panel suggested that animal pathogens may develop the ability to infect humans, they noted that these emerging contaminants should not be listed on the CCL based on the theoretical potential to become zoonotic pathogens. They also identified additional criteria and methods to apply those criteria to the Microbial Universe, which EPA incorporated into the CCL process.

In June 2006, a panel of experts met for three days to review EPA's implementation of recommendations by NRC and NDWAC to select microbes for the CCL. EPA implemented the NDWAC recommendation to develop a process that paralleled the chemical process yet still accounted for the different types of data and information that are uniquely available for microbial contaminants. Panel members agreed that health effects and occurrence of microbes should be evaluated to identify pathogens of the greatest health importance. The panel recommended that EPA use a decision tree approach for microbes rather than the classification approach suggested by NRC and NDWAC.

The panel further recommended that the Agency consider a different selection process than the one used for chemical contaminants, related to the different information available for microbes. Based on this recommendation, the Agency evaluated options to consolidate the potency and severity attributes for microbes into a single health effect attribute, developed a waterborne disease outbreak protocol, and considered occurrence as a single attribute. The Agency considered these and other recommendations as it developed the current three attribute selection process discussed in Section III.B. The panel also recommended that the Agency consider drinking water treatment and removing microbes from further consideration if conventional drinking water treatment protects public health. The Agency's considerations of these and other recommendations are discussed in the Microbial Expert Review support document (USEPA, 2008i).

In March 2007, EPA convened a third workshop to review the preliminary draft CCL 3 list of microbial contaminants. EPA provided the panel with background materials and staff presentations. The panel's review focused mainly on the draft CCL 3 for microbes. The panel also provided comments on the processes used to select the microbial contaminants. Panel members commented on specific microbes considered for the draft CCL 3 and commented on the data and processes EPA used to identify the contaminants selected. The panel noted that the Agency considered a comprehensive list of microbes and thought the draft CCL 3 was reasonable. The panel also recommended that the Agency consider adding a frequency of disease parameter to the health effects scoring protocol for future CCLs. For example, while the panel agreed with EPA that the health effects for *Naegleria fowleri* are severe, the health effects scoring protocol should consider the limited occurrence of disease. The panel also noted that this would help balance the consideration of less severe adverse health effects such as gastrointestinal illness that are more prevalent with consideration of more severe responses that are less prevalent, such as *N. fowleri*. The panel recommended that EPA provide further discussion of the rationale to evaluate waterborne disease and health effects equally in the protocol. The discussion of the Agency's rationale is included in Section III.B and addresses the importance of documented waterborne disease outbreaks to identify potential microbial contaminants for the CCL. (A more detailed summary of the expert comments is provided in USEPA, 2008 i.)

3. How are the CCL and UCMR Interrelated for Specific Chemicals and Groups?

EPA promulgated UCMR 2 on January 4, 2007 (72 FR 367 (USEPA, 2007 a; see also USEPA, 2007 b and c)). The UCMR program was developed in coordination with the CCL. Both programs consider the adverse health effects a contaminant may pose through drinking water exposures. Sixteen contaminants on the UCMR 2 monitoring list are also on the draft CCL 3. The draft CCL 3 includes acetochlor and its degradates, alachlor degradates, dimethoate, 1,3-dinitrobenzene, metolachlor and its degradates, RDX, terbufos sulfone, and four of the nitrosamines. In addition to the health effects data and potential occurrence, the UCMR 2 also considers analytical methods, availability of analytical standards, and laboratory capacity to conduct a nationwide monitoring program in selecting contaminants. The UCMR 2 includes nine contaminants that are not on draft CCL 3. The five polybrominated flame retardants can be measured by the same analytical method used for terbufos sulfone. The polybrominated flame retardants lacked sufficient occurrence information to be listed on draft CCL 3 (USEPA 2008 b). The polybrominated flame retardants are listed on UCMR2 because of recent concern that these have become more widespread environmental contaminants (e.g., Darnerud *et al.*, 2001) and this monitoring data will provide information for future CCLs. Similarly, 2,4,6-trinitrotoluene (TNT) and two of the nitrosamines also use an analytical method in the UCMR 2. The Agency will also use the results from UCMR 2 as a source of occurrence information during the selection of CCL 4, as well as for CCL 3 regulatory determinations. Alachor was listed on UCMR 2, but was removed from consideration for CCL 3 because there is an existing MCL.

IV. Request for Comment

The purpose of this notice is to present the draft CCL 3 and seek comment on various aspects of its development. The Agency requests comment on the approach used to develop the draft CCL 3 and also requests comments on the contaminants selected, including any supporting data that can be utilized in developing the final CCL 3. A number of contaminants considered for the draft CCL 3 may be of particular current interest. The following sections provide information for a few of the contaminants that are of most interest. Data obtained and evaluated for developing the draft CCL 3 and referred to in the following sections may be found in the docket for this notice. Specifically, the Agency is also asking for public comments on pharmaceuticals and perfluorinated compounds to identify any additional data and information on their concentrations in finished or ambient water and requests comment on how they have been considered in the CCL 3 process. The Agency is also seeking additional data and information on the occurrence and health effects of *H. pylori* and how this pathogen was considered in the CCL 3 process. Information and comments submitted will be considered in determining the final CCL 3, as well as in the development of future CCLs and in the Agency's efforts to set drinking water priorities in the future.

A. Pharmaceuticals

The Agency evaluated data sources to identify pharmaceuticals and personal care products that have the potential to occur in PWSs. The primary source of health effects information on pharmaceuticals in the universe was the Food and Drug Administration Database on Maximum Recommended Daily Doses (MRDD). This database includes the recommended adult doses for over 1,200 pharmaceutical agents. Occurrence information from USGS Toxics Substances Hydrology program's National Reconnaissance of Emerging Contaminants, and related efforts, provided ambient water concentration data for 123 contaminants, which include pharmaceuticals. Other data sources included TRI and high production volume chemical data. From this analysis, EPA included 287 pharmaceuticals in the Chemical Universe. These pharmaceuticals had maximum recommended daily dose information that EPA used to evaluate adverse health effects. EPA considered those pharmaceuticals for which MRDD values and occurrence information were available and pharmaceuticals that were in Toxicity Category 1, using the same criteria discussed in Section III.A.2.a. EPA found that less than two percent of the pharmaceuticals included in the MRDD database fell into this category.

EPA applied the LOAEL screening protocols to contaminants with MRDD values. The LOAEL protocol was used because pharmaceutical agents, although used for their beneficial effects, have associated side-effects that may be adverse. Chemicals evaluated with these data had similar modal values and distributions to the toxicity values from IRIS. The range of toxicity values in this database covered 9 orders of magnitude when evaluated based on their rounded logs. They had the same modal value as the LOAELs from IRIS and a very similar distribution. Thirty-five percent of the IRIS LOAELS and 38 percent of the MRDDs had the modal rounded log. Thirty-three percent of the LOAELs and 19 percent MRDDs had rounded logs that were lower than the mode, while 31 percent of the LOAELs and 44% of the MRDDs had rounded logs that were above the modal log value.

The screening process moved approximately 10 percent of the pharmaceuticals in the Universe to the PCCL. All toxicity data on those chemicals were included in the screening with the most serious qualitative or quantitative measure of toxicity determining placement in a toxicity category. Only one of the PCCL chemicals (diazinon, a veterinary product as well as a pesticide) had water concentration data. Two other pharmaceuticals: phenytoin (an anticonvulsant) and nitroglycerin (treatment of angina), had release data. The remainder were scored for occurrence based on production information, which meant that they fell into the low certainty bin for their occurrence parameters. Nitroglycerin is the only pharmaceutical that is included on the draft CCL 3. EPA is aware of concerns regarding the potential presence of pharmaceuticals in water supplies. The Agency is seeking additional data and information on the concentrations of pharmaceuticals in finished or ambient water and requests comment on how pharmaceuticals have been considered in the CCL 3 process.

B. Perfluorooctanoic Acid and Perfluorooctane Sulfonic Acid

EPA evaluated perfluorinated compounds in the CCL 3 process and requests comment on its decisions to include perfluorooctanoic acid (PFOA) and not to include perfluorooctane sulfonic acid (PFOS) on the draft CCL 3. EPA identified potential health effects and occurrence information for these compounds from the data sources discussed in Section III. The data used for these compounds are discussed in the support documents in more detail. Available analytic methods for these chemicals limited the occurrence data for these compounds. The Agency identified data on the annual production from CUS/IUR indicating limited production and possible release to the environment. Several organizations nominated PFOS and PFOA for consideration in the CCL process. The nominations noted that these chemicals are persistent in the environment and have been detected at varying levels in drinking water and ambient water in smaller specialized studies. EPA collected the information cited in the nominations and evaluated each of these chemicals. The Agency included PFOA on the draft CCL 3 because it met the criteria for inclusion on draft CCL 3 based on drinking water occurrence studies in Ohio and West Virginia (Emmett, *et al.*, 2006) and on health effects data indicated through animal studies (USEPA, 2005 a).

The Agency did not include PFOS on the draft CCL 3. Occurrence data for PFOS characterized detections in several States (Boulanger, *et al.*, 2004, Hansen, *et al.*, 2002, Goeden and Kelly, 2006). These data showed that levels of detection for PFOS in ambient water ranged from 20 to approximately 100 parts per trillion. Data identified in the nominations process detected PFOS at higher concentrations in areas surrounding landfills known to be contaminated with industrial waste containing PFOS. The CCL process did not consider occurrence data from targeted studies of contaminated waste sites, however. Such studies are usually developed to identify and characterize hazardous waste cleanup efforts and may not be representative of occurrence in drinking water not in close proximity to the study site. PFOS was phased out of production in the U.S. between 2000 and 2002, and regulation limits its importation to a very small number of controlled, very low release uses, (67 FR 72854; December 9, 2002 (USEPA, 2002 c)). Based on the general absence of occurrence data, combined with the phase out, effectively eliminating most future releases, PFOS did not meet the criteria for CCL 3.

The Agency is evaluating data related to PFOA in a formal risk assessment process under the Toxic Substance Control Act. EPA's Science Advisory Board (SAB) completed a review of a draft risk assessment in 2006 and SAB made recommendations for the further development of the risk assessment. A final risk assessment may not be completed for several years, as a number of important studies are underway. The Agency is also participating in additional research regarding the toxicity and persistence of related perfluorochemicals, as well as research to help identify where these chemicals are coming from and how people may be exposed to them.

C. Helicobacter pylori

Helicobacter pylori is a pathogen that causes gastric cancer in addition to acute gastric ulcers. EPA placed this pathogen on the draft CCL. However, the analysis for *H. pylori* differs from the other pathogens due to the long term and/or chronic nature of its health effects rather than the more common acute effects of most waterborne pathogens. This organism is an emerging pathogen whose impact has only recently begun to be understood. Given the slow development of adverse health effects due to infection by *H. pylori*, it is more difficult to link contamination of drinking water and show a waterborne disease outbreak. Therefore, given the long timeframe of cancer and ulcer development (as opposed to the commonly acute gastrointestinal illness of nearly all the other pathogens on the PCCL) as well as the ongoing nature of the research, EPA used peer-reviewed scientific papers to score the health effects of *Helicobacter pylori*. EPA request comment on the process of selection of microbial contaminants that cause chronic rather than acute health effects.

V. EPA's Next Steps

Between now and the publication of the final CCL, the Agency will evaluate comments received during the comment period for this notice, consult with the SAB, and re-evaluate the criteria used to develop the draft CCL and revise the CCL, as appropriate.

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Dated: February 6, 2008.

Benjamin H. Grumbles,

Assistant Administrator, Office of Water.

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APPENDIX F
Schnabel:
Installed Monitoring Wells
(MW-1 &MW-2) Report

Monitoring Well Installation & Residential Well Sampling Battlefield Golf Club Water Project Centerville Turnpike South Murray Drive & Whittamore Road Chesapeake, Virginia

Project 08330106
February 3, 2009

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February 3, 2009

Mr. Robert Sciacchitano, P.E.
URS Corporation
277 Bendix Road, Suite 500
Virginia Beach, Virginia 23452

Subject: 08330106, Monitoring Well Installation and Residential Well Sampling, Battlefield Golf Club Water Project, Centerville Turnpike South, Murray Drive and Whittamore Road, Chesapeake, Virginia

Dear Robert:

Schnabel Engineering, LLC is pleased to submit this report concerning monitoring well installation and residential well sampling at the Battlefield Golf Club Water Project.

PROJECT DESCRIPTION

Two test wells were installed and water samples were obtained from two residential wells as part of this study.

FIELD ACTIVITIES

Fishburne Drilling, Inc., Chesapeake, Virginia installed two monitoring wells (MW-1 and MW-2) on November 24, 25 and 26, 2008. The two-inch diameter monitoring wells were installed to depths of 45 and 90 feet below ground surface. Monitoring Well MW-1 was installed to 90 feet and MW-2 was installed to 45 feet. MW-1 was constructed as a Type III monitoring well. The monitoring wells were installed within an easement along the east side of Bonney Road in a grassy area near the northern terminus of Bonney Road. A permit was granted by the City of Chesapeake prior to drilling activities. The drilling and well construction activities were performed under the observation of Schnabel personnel. The test boring locations are shown on

Figure 1 in Appendix A. Monitoring well construction details and protocol for installing monitoring wells in test borings are also included in Appendix A.

Test borings were advanced with a 2.9375-inch O.D. tri-cone roller bit, 4.25-inch and 8.25-inch I.D. hollow stem augers. Soil samples were collected in MW-1 at a minimum of every five feet from 18 to 90 feet in the test boring. We collected two undisturbed samples from the MW-1 test boring. The undisturbed samples were collected from depths of 55 to 57 feet and 60 to 62 feet below ground surface. Boring logs are included in Appendix A.

The wells were developed using a submersible pump. Several groundwater measurements were obtained in MW-1 and MW-2. Measurements were referenced to the ground surface (the rim of protective manhole cover) at each well location. The groundwater measurements obtained from MW-1 and MW-2 are indicated in the table below.

Well Number	Date	Water Level (ft)	Time
MW-1	12-10-08	21.53	7:24 AM
MW-1	12-17-08	15.33	6:55 AM
MW-1	12-19-08	11.82	6:45 AM
MW-1	12-22-08	9.52	5:35 PM
MW-1	12-23-08	8.03	7:16 AM
MW-1	12-24-08	7.01	6:25 AM
MW-1	1-5-09	6.28	7:44 AM
MW-1	1-15-09	5.61	2:51 PM
MW-2	12-10-08	4.08	7:09 AM
MW-2	12-17-08	3.07	6:58 AM
MW-2	12-19-08	3.35	6:43 AM
MW-2	12-22-08	3.06	5:39 PM
MW-2	12-23-08	3.17	7:20 AM
MW-2	12-24-08	3.17	6:28 AM
MW-2	1-5-09	4.03	7:46 AM
MW-2	1-15-09	3.87	2:53 PM

Field sampling of two residential wells was conducted on December 22, 2008. The residential well samples were collected from 1204 and 1208 Murray Drive. The well samples were collected from exterior spigots at the rear of each residence. A field blank sample was also collected on December 22, 2008. The samples were submitted to REIC Consultants, Inc., Beaver, West Virginia for laboratory analysis. The water samples were analyzed according to the Well Specification – Water Analysis Parameters from URS dated September 17, 2008. Modifications to the Water Analysis Parameters provided by URS included the exemption of E. Coli, Color and Asbestos and the addition of Total Organic Carbon (TOC). Certificates of Analysis and Chains of Custody are included in Appendix B.

SOIL LABORATORY TESTING

Permeability tests were performed on the undisturbed samples in our geotechnical laboratory. The summary of soil laboratory test results and laboratory test curves are included in Appendix C.

This letter report summarizes our activities to date for the Battlefield Golf Club Water Project. We have endeavored to complete the services identified herein in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality and under similar conditions as this project. No other representation, express or implied, is included or intended, and no warranty or guarantee is included or intended in this report, or any other instrument of service.

We appreciate the opportunity to be of service and look forward to a continued cordial working relationship on this project. If you have any questions, please do not hesitate to contact us.

Very truly yours,
SCHNABEL ENGINEERING, LLC

Russell Rountree (dah)

Russell W. Rountree
Senior Staff Scientist

COMMONWEALTH OF VIRGINIA
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Gilbert T. Seese, P.E.
Principal

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Appendices:

Appendix A – Subsurface Exploration Data

Appendix B – Laboratory Analytical Chemical Data

Appendix C – Soil Laboratory Test Data

APPENDIX A

Subsurface Exploration Data

Protocol for Installing Monitoring Wells within Test Borings (2 Sheets)
Location Plan (Figure 1)
General Notes for Subsurface Exploration Logs
Identification of Soils
Test Boring Logs (MW-1 and MW-2)
Monitoring Well Construction Details (2 Sheets)

PROTOCOL FOR INSTALLING
MONITORING WELLS IN TEST BORINGS

I. DRILLING METHODS AND PROCEDURE

Drilling and sampling was performed using a 2-15/16 inch, tri-cone roller bit, a 5-7/8 inch, tri-cone roller bit, 8-1/4 inch I.D., hollow-stem auger and 4-1/4 inch I.D., hollow-stem auger drill and split-barrel (spoon) soil sampling device.

A. Monitoring well locations were staked by Schnabel Engineering. A permit was obtained from the City of Chesapeake prior to drilling at the monitoring well locations.

B. The Unified Soil Classification System, ASTM D 2487-83, with additional descriptive terms was used for visual sample classifications.

C. Elevations at the top of the wells was provided by URS Corporation.

II. MONITORING WELL MW-1

A. The following procedure was followed to develop and finish the borehole as a monitoring well.

1. Upon encountering the clay layer at a depth of approximately 52 feet, a six-inch diameter PVC casing was installed to depth of 53 feet. The six-inch casing was then grouted with a slurry mixture of bentonite cement and allowed to cure for a minimum of 24 hours.

2. Upon curing of the grout, drilling and sampling were resumed through the six-inch casing to a depth of 90 feet. Upon completion of drilling, 2-inch diameter Schedule 40 PVC pipe was installed at the desired depth of the borehole. The monitoring well was furnished with 10 feet of No. 10 slot, 2-inch diameter Schedule 40 PVC, screen flush jointed to permanent casing. No organic solvents were used during well construction.

3. The monitoring well screen was surrounded with a filter pack compatible with surrounding medium consisting of graded washed filter sand placed above the top of the screen. A minimum two-foot thick bentonite clay seal

was placed above the filter pack. A slurry mixture of bentonite and cement was used to grout the annulus above the bentonite seal in the well.

4. The permanent monitoring well casing was finished flush with the ground surface. The well head was finished with a cap, and an outer (surface) protective steel casing with a locking cap. The protective casing was set into a thick concrete collar at grade.

5. Well development consisted of purging the well using a 12-volt submersible pump. Development was complete when a significant drop in the turbidity of the water was observed.

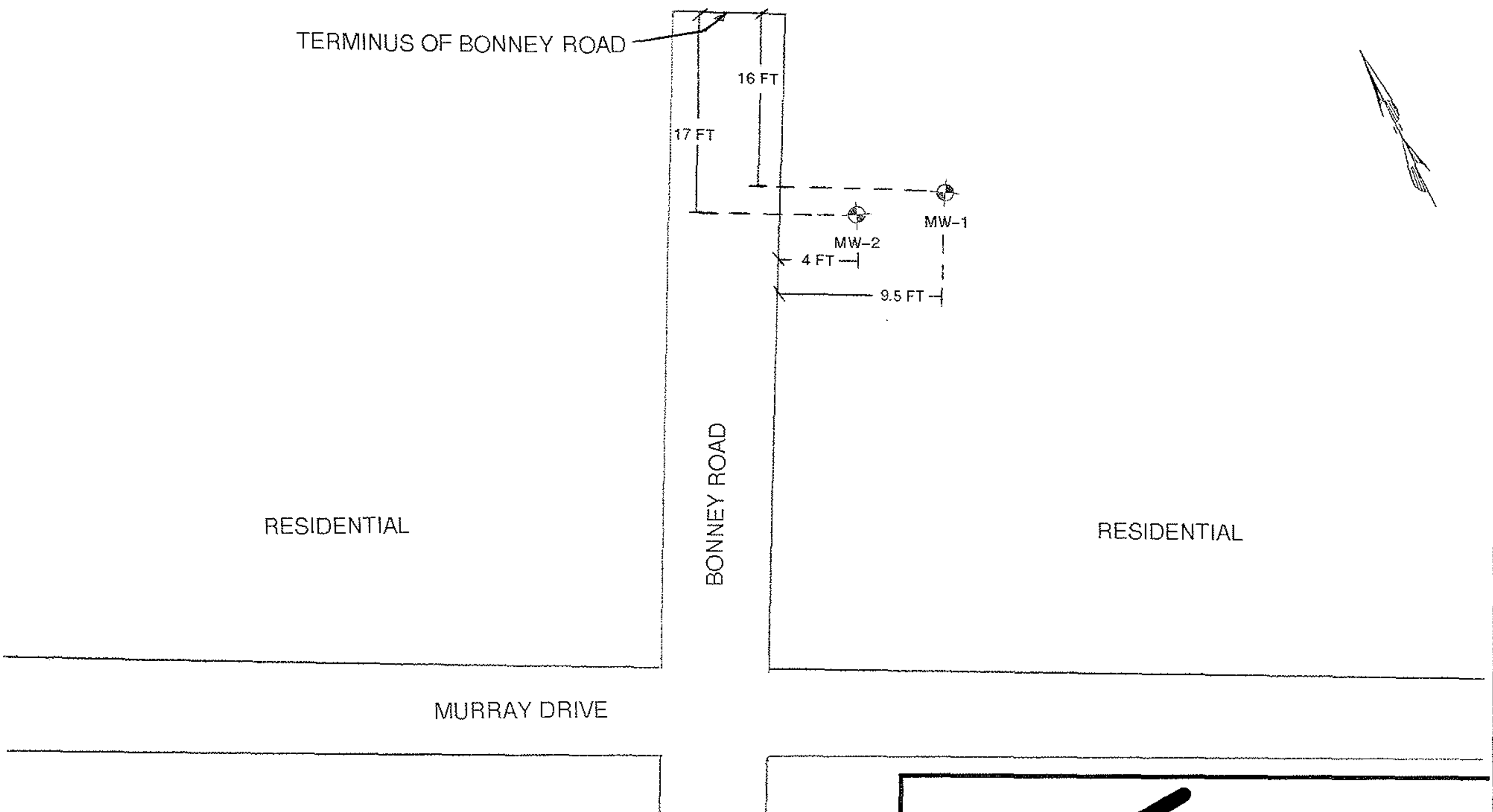
III. <u>MONITORING WELL MW-2</u>

1. Upon completion of drilling, 2-inch diameter Schedule 40 PVC pipe was installed at the desired depth of the borehole. The monitoring well was furnished with 10 feet of No. 10 slot, 2-inch diameter Schedule 40 PVC, screen flush jointed to permanent casing. No organic solvents were used during well construction.

2. The monitoring well screen was surrounded with a filter pack compatible with surrounding medium consisting of graded washed filter sand placed above the top of the screen. A minimum two-foot thick bentonite clay seal was placed above the filter pack. A slurry mixture of bentonite and cement was used to grout the annulus above the bentonite seal in the wells.

3. The permanent monitoring well casing was finished flush with the ground surface. The well head was finished with a cap, and an outer (surface) protective steel casing with a locking cap. The protective casing was set into a thick concrete collar at grade.

4. Well development consisted of purging the well using a 12-volt submersible pump. Development was complete when a significant drop in the turbidity of the water was observed.



LEGEND:

MW-2 **APPROXIMATE MONITORING WELL LOCATION**

Schnabel

Schnabel Engineering

BATTLEFIELD GOLF CLUB WATER PROJECT, MONITORING WELL INSTALLATION

BONNEY ROAD AND MURRAY DRIVE, CHESAPEAKE, VIRGINIA

LOCATION PLAN	**SCALE:** NTS	**DATE:** 1/09	**PROJECT NO.:** 08330106
	DRAWN BY: RR	**CHECK BY:** GS	**FIGURE:** 1

SCHNABEL ENGINEERING
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 general 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.

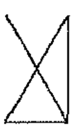
3. Estimated ground water levels indicated on the logs are only estimates from available data and may vary with precipitation, porosity of the soil, site topography, and other factors.

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

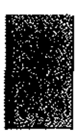
5. The logs and related information depict subsurface conditions only at the specific locations and at the particular time when drilled or excavated. Soil conditions at other locations may differ from conditions occurring at these locations. Also, the passage of time may result in a change in the subsurface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

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:



S-1, SPT - Sample No., Standard Penetration Test
5+10+1 - Number of blows in each 6-in increment



UD-1, UNDIST - Sample No., 2" or 3" Undisturbed Tube Sample
REC=24", 100% - Recovery in inches, Percent Recovery

C-1, CORE - Core No., Rock Core
Run = 5.0 ft - Run Length in feet
REC = 60" 100% - Recovery in inches, Percent Recovery
RQD = 60" 100% - RQD in inches, Percent RQD

MC - Moisture Content

PP - Pocket Penetrometer Reading (tsf)

FID - Flame Ionization Detector Reading (ppm)

PID - Photoionization Detector Reading (ppm)

GP - Geostick Penetration Reading (inches)

LL - Liquid Limit

PL - Plastic Limit

TPH - Total Petroleum Hydrocarbons

SCHNABEL ENGINEERING
IDENTIFICATION OF SOILS

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

			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. 10 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 SOIL COMPONENT PROPORTIONS (ASTM D-2487)

			Examples
Adjective Form	GRAVELLY SANDY	>30% to <50% coarse grained component in a fine-grained soil	GRAVELLY LEAN CLAY
	CLAYEY SILTY	>12% to <50% fine grained component in a coarse-grained soil	SILTY SAND
"With"	WITH GRAVEL WITH SAND	>15% to <30% coarse grained component in a fine-grained soil	FAT CLAY WITH GRAVEL
	WITH GRAVEL WITH SAND	>15% to <50% coarse grained component in a coarse-grained soil	POORLY GRADED GRAVEL WITH SAND
	WITH SILT WITH CLAY	>5% to <12% fine grained component in a coarse-grained soil	POORLY GRADED SAND WITH SILT

III. GLOSSARY OF MISCELLANEOUS TERMS

SYMBOLS .... Unified Soil Classification Symbols are shown above as group symbols. A dual symbol "-" indicates the soil belongs to two groups. A borderline symbol "/" indicates the soil belongs to two possible groups.

FILL .... Man-made deposit containing soil, rock and often foreign matter.

PROBABLE FILL .... Soils which contain no visually detected foreign matter but which are suspect with regard to origin.

DISINTEGRATED ROCK (DR) .... Residual 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.

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

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

LENSES .... 0 to ½ inch seam within a material in a test pit.

LAYERS .... ½ to 12 inch seam within a material in a test pit.

POCKET .... Discontinuous body within a material in a test pit.

MOISTURE CONDITIONS .... Wet, moist or dry to indicate visual appearance of specimen.

COLOR .... Overall color, with modifiers such as light to dark or variation in coloration.

Schnabel Engineering	TEST BORING LOG	Project: Battlefield Golf Club Water Project Bonney Road and Murray Drive Chesapeake, Virginia	Boring Number: **MW-1** Contract Number: 08330106 Sheet: 1 of 3

Contractor: Fishburne Drilling
Chesapeake, Virginia

Contractor Foreman: T. Donahue

Schnabel Representative: R. Rountree

Equipment: CME-550X

Method: 2-15/16" O.D. Tri-cone Roller Bit

Hammer Type: Auto Hammer (140 lb)

Dates Started: 11/24/08 **Finished:** 11/26/08

Ground Surface Elevation: 9.1 (ft) **Total Depth:** 90.0 ft

Groundwater Observations	Date	Time	Depth	Casing	Caved
Encountered ∇	11/24	11:10 AM	18.0'	---	---
Completion	11/26	3:07 PM	---	---	---
Casing Pulled	11/26	3:15 PM	---	---	---

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
								Mud rotary probe to 18 feet.
					5			
					10			
					15			
	∇ POORLY GRADED SAND WITH SILT, fine to medium grained sand, wet, dark gray	SP-SM				S-1, SPT 7+9+9+9 REC=24", 100%		NORFOLK FORMATION
				B1	20			
22.0	POORLY GRADED SAND, fine to medium grained sand, wet, gray, estimated <5% silt	SP	-12.9			S-2, SPT 5+5+5+11 REC=24", 100%		

(continued)

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	POORLY GRADED SAND, fine to medium grained sand, wet, gray, estimated <5% silt *(continued)*	SP		B1				NORFOLK FORMATION *(continued)*
					30	S-3, SPT 6+7+8+14 REC=24", 100%		
					35	S-4, SPT 14+20+24+22 REC=24", 100%		
37.0	SILTY SAND, fine to medium grained sand, wet, gray	SM	-27.9					
					40	S-5, SPT 4+6+6+6 REC=24", 100%		
					45	S-6, SPT 3+3+2+3 REC=24", 100%		
47.0	CLAYEY SAND, fine to medium grained sand, wet, dark gray	SC	-37.9					
					50	S-7, SPT 2+3+3+4 REC=24", 100%		
52.0	LEAN CLAY WITH SAND, moist, dark gray, contains mica	CL	-42.9	B2				
					55	S-8, SPT 2+2+2+2 REC=24", 100%	PP =0.50 tsf	2 15/16" tri-cone roller bit used during sampling to 55 feet.
						UD-1 REC=16", 67%	PP =1.25 tsf	8 1/4" I.D. hollow stem augers used to set the 6" casing to 53 feet.
						S-9, SPT	PP =0.25 tsf	5 7/8" tri-cone roller bit used during sampling

(continued)

Schnabel Engineering	TEST BORING LOG	Project: Battlefield Golf Club Water Project, Bonney Road and Murray Drive, Chesapeake, Virginia	Boring Number: MW-1
			Contract Number: 08330106
			Sheet: 3 of 3

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	LEAN CLAY WITH SAND, moist, dark gray, contains mica *(continued)*	CL		B2	60	1+2+2+2 REC=24", 100%; UD-2 REC=15", 63%	PP =0.25 tsf	from 55 to 90 feet and to set 2" well. NORFOLK FORMATION *(continued)*
62.0	SILTY SAND, fine to medium grained sand, wet, greenish gray, estimated 5 - 10% shells Changes to contains lean clay layers, estimated <5% shells	SM	-52.9	C1	65, 70, 75	S-10, SPT 4+8+5+7 REC=24", 100%; S-11, SPT 6+11+12+10 REC=24", 100%; S-12, SPT 3+8+10+12 REC=24", 100%		Two-inch monitoring well installed to 90.45 feet upon completion. YORKTOWN FORMATION
77.0	LEAN CLAY WITH SAND, wet, gray, contains silty sand lenses	CL	-67.9	C2	80	S-13, SPT 3+6+6+11 REC=24", 100%	PP =1.25 tsf	
82.0	CLAYEY SAND, fine to medium grained sand, wet, greenish gray, estimated 5 - 10% shells	SC	-72.9	C1	85	S-14, SPT 6+12+14+14 REC=24", 100%		
87.0	SILTY SAND, fine to medium grained sand, wet, greenish gray, estimated <5% shells	SM	-77.9			S-15, SPT 6+14+18+22 REC=24", 100%		
90.0			-80.9		90			

Bottom of Boring at 90.0 ft.
Observation well installed upon completion.

Schnabel Engineering — TEST BORING LOG	Project: Battlefield Golf Club Water Project Bonney Road and Murray Drive Chesapeake, Virginia	Boring Number: **MW-2** Contract Number: 08330106 Sheet: 1 of 2

Contractor: Fishburne Drilling
Chesapeake, Virginia

Contractor Foreman: T. Donahue

Schnabel Representative: R. Rountree

Equipment: CME-550X

Method: 4-1/4" I.D. Hollow Stem Auger

Hammer Type: Auto Hammer (140 lb)

Dates Started: 11/25/08 **Finished:** 11/25/08

Ground Surface Elevation: 9.0 (ft) **Total Depth:** 45.0 ft

Groundwater Observations

	Date	Time	Depth	Casing	Caved
Encountered ∇	11/25	11:31 AM	5.0'	---	---
Completion	11/26	3:42 PM	---	---	---
Casing Pulled	11/26	4:21 PM	---	---	---

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
								Elevation referenced to top of concrete curb (assumed 100.0).
								Auger probe to 45.5 feet; see Boring Log MW-1 for strata descriptions.
5	∇							
10								Two-inch monitoring well installed to 45.04 feet upon completion.
15								
20								

(continued)

TEST BORING LOG REVISED MW BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_07_06.GDT 2/2/09

Schnabel Engineering	TEST BORING LOG	Project:	Battlefield Golf Club Water Project Bonney Road and Murray Drive Chesapeake, Virginia	Boring Number: MW-2 Contract Number: 08330106 Sheet: 2 of 2

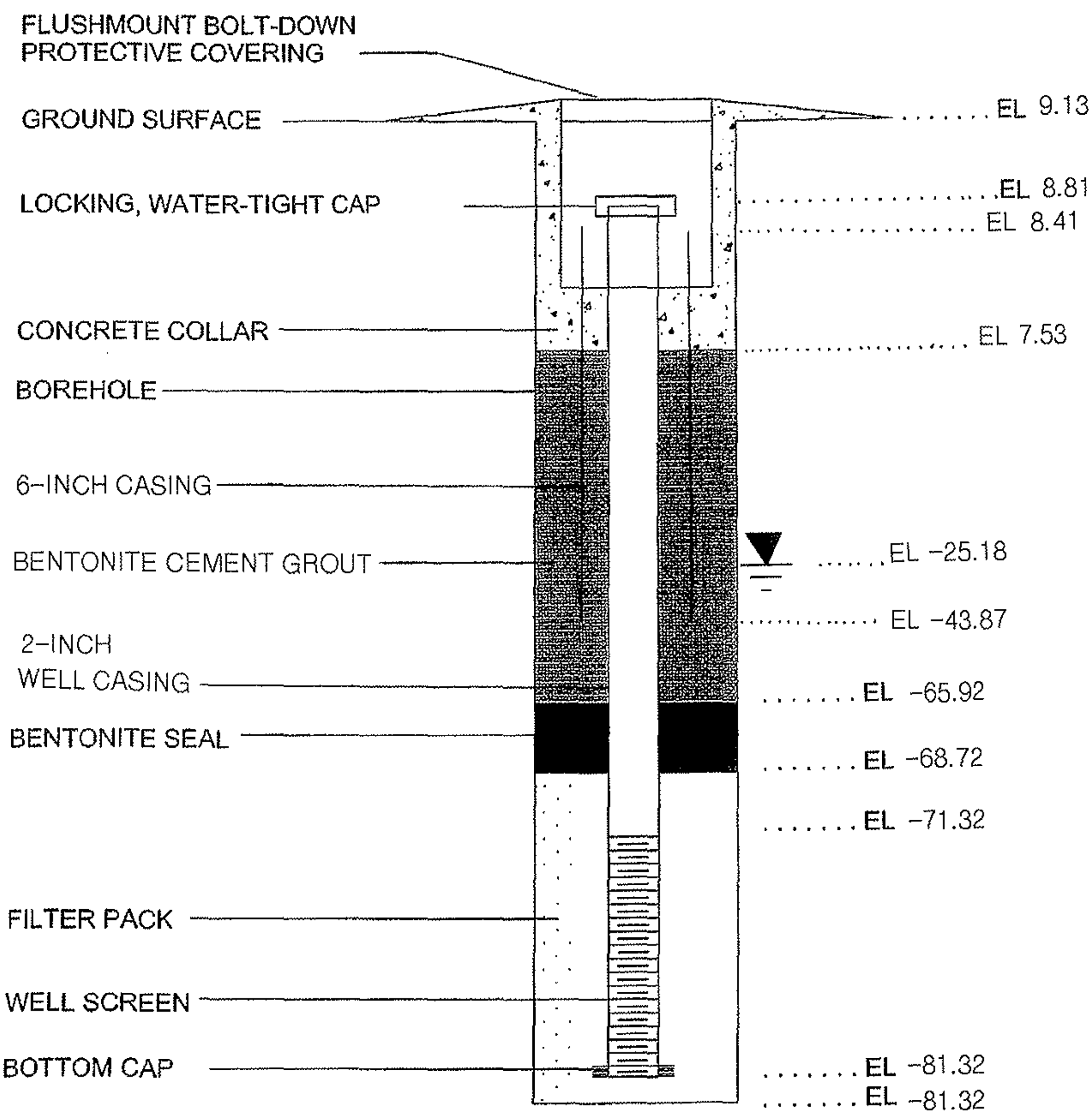
DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
					30			
					35			
					40			
					45			

Bottom of Boring at 45.0 ft.
Observation well installed upon completion.

CONSTRUCTION DETAILS FOR MONITORING WELL MW-1

BORING NUMBER: MW-1
SCREEN SIZE AND TYPE: 10 FT, NO. 10 SLOT PVC
CASING SIZE AND TYPE: 2 IN. SCH. 40 PVC FLUSH JOINT
FILTER PACK MATERIAL: NO. 2 FILTER SAND
DEVELOPMENT: SUBMERSIBLE PUMP

CONTRACT NO.: 08330106
DATE WATER LEVEL OBTAINED: 12-1-08
DATE INSTALLED: 11-26-08
DATE DEVELOPED: 12-1-08



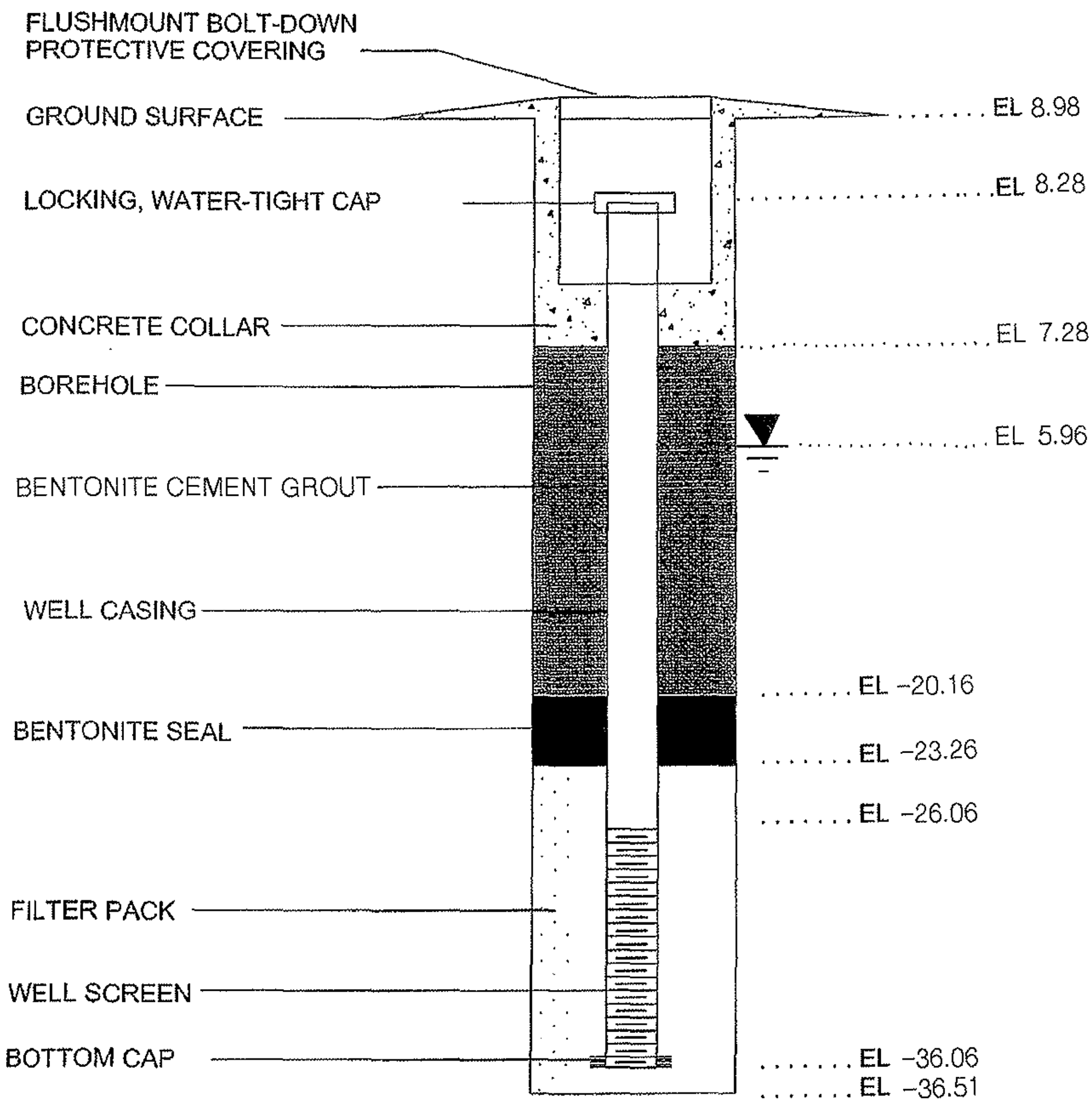
Schnabel Engineering

NOT TO SCALE

CONSTRUCTION DETAILS FOR MONITORING WELL MW-2

BORING NUMBER: MW-2
SCREEN SIZE AND TYPE: 10 FT, NO. 10 SLOT PVC
CASING SIZE AND TYPE: 2 IN. SCH. 40 PVC FLUSH JOINT
FILTER PACK MATERIAL: NO. 2 FILTER SAND
DEVELOPMENT: SUBMERSIBLE PUMP

CONTRACT NO.: 08330106
DATE WATER LEVEL OBTAINED: 12-1-08
DATE INSTALLED: 11-25 & 26-08
DATE DEVELOPED: 12-1-08



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APPENDIX B

Laboratory Analytical Chemical Data

Certificates of Analysis and Chains of Custody

1204 MURRAY DRIVE

225 Industrial Park Drive
Beaver, WV 25813
TEL: 304.255.2500
FAX: 304.255.2572
Website: www.reiclabs.com

Improving the environment, one client at a time...

January 22, 2009

Mr. Russell Rountree
SCHNABEL ENGINEERING SOUTH LLC
300 ED WRIGHT LN SUITE 1
NEWPORT NEWS VA 23606

TEL: (757) 947-1220
FAX (757) 947-1220

RE: 08330106

Order No.: 0812H90

Dear Mr. Russell Rountree:

REI Consultants, Inc. received 1 sample(s) on 12/23/2008 for the analyses presented in the following report.

Please note two changes you may see on your report.

- Results for "Dissolved" parameters will be shown under a separate sample ID, rather than as a separate analysis under the same sample ID. The sample ID for "Dissolved" parameters will include "Field Filtered" or "Lab Filtered", as appropriate.
- Metals results will no longer be identified as "Total" or "Total Recoverable". The methods have not been changed, only their appearance on the report.

If you have any questions regarding these results, please do not hesitate to call.

Sincerely,

Scott Gross
Project Manager

ACCREDITED IN ACCORDANCE WITH nelac

225 Industrial Park Drive
Beaver, WV 25813
TEL: 304.255.2500
FAX: 304.255.2572
Website: www.reiclabs.com

Improving the environment, one client at a time...

Report Narrative

Project Manager:: **Scott Gross**

WO#: **0812H90**
Date: **1/22/2009**

CLIENT: SCHNABEL ENGINEERING SOUTH LL
Project: 08330106

All analyses were performed using documented laboratory SOPs that incorporate appropriate quality control procedures as described in the applicable methods. REI Consultants, Inc. (REIC) technical managers have verified compliance of reported results with the REIC's Quality Program and SOPs, except as noted in this case narrative. Any deviation from compliance is explained below and/or identified within the body of this report by a qualifier footnote which is defined at the bottom of each page.

All samples were analyzed using the methods stated in the analytical report without modification, unless otherwise noted.

All sample results are reported on an "as-received" wet weight basis unless otherwise noted.

Results reported for sums of individual parameters, such as Total Trihalomethanes (TTHM) and Total Haloacetic Acids (HAA5), may vary slightly from the sum of the individual parameter results. This apparent anomaly is caused by rounding individual results and summations at reporting, as required by EPA.

Following standard laboratory protocol, sample preservation, such as pH, is verified at time of extraction or analysis based on client requested parameters. Improper preservation is noted on the analytical bench sheet, extraction log, or preservation log and client is notified by close of following business day. All results are reported using preservation compliant samples unless otherwise noted in the analytical report.

The test results in this report meet all NELAP requirements for parameters for which accreditations are required or available. Any exceptions are noted in this report. This report may not be reproduced, except in full, without the written approval of REIC.

In compliance with federal guidelines and standard operating procedures, all reports, including raw data and supporting quality control, will be disposed of after five years unless otherwise arranged by the client via written notification or contract requirement.

If you have any questions please contact the project manager whose name is listed above.

REI Consultants, Inc. **Analytical Results** Date: *02-Feb-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812H90 **Lab ID** 0812H90-01A
Client Sample ID:	1204 MURRAY DRIVE	**DateReceived**	12/23/2008
Project:	08330106	**Collection Date:**	12/22/2008 4:45:00 PM
Site ID:	BATTLEFIELD GOLF CLUB	**Matrix:**	DRINKING WATER

Analyses	Result	Units	Qual	PQL	MCL	Prep Date	Date Analyzed
METALS BY ICP			**E200.7**			Analyst: **BP**	
Aluminum	0.188	mg/L		0.100	0.200	12/24/08 12:16 PM	12/31/08 12:27 AM
Boron	0.163	mg/L		0.100	NA	12/24/08 12:16 PM	12/31/08 12:27 AM
Iron	0.184	mg/L		0.100	0.300	12/24/08 12:16 PM	12/31/08 12:27 AM
Magnesium	18.8	mg/L		0.500	NA	12/24/08 12:16 PM	12/31/08 12:27 AM
Manganese	ND	mg/L		0.050	0.050	12/24/08 12:16 PM	12/31/08 12:27 AM
Silica (as SiO2)	19.2	mg/L		0.210	NA	12/24/08 12:16 PM	12/29/08 2:46 PM
Sodium	106	mg/L		0.500	NA	12/24/08 12:16 PM	12/31/08 12:27 AM
METALS BY ICP-MS			**E200.8**			Analyst: **BM**	
Antimony	ND	mg/L		0.0010	0.0060	12/24/08 12:16 PM	12/29/08 4:01 PM
Arsenic	ND	mg/L		0.0050	0.0100	12/24/08 12:16 PM	12/29/08 4:01 PM
Barium	ND	mg/L		0.100	2.00	12/24/08 12:16 PM	12/29/08 4:01 PM
Beryllium	ND	mg/L		0.0020	0.0040	12/24/08 12:16 PM	12/29/08 4:01 PM
Cadmium	ND	mg/L		0.0010	0.0050	12/24/08 12:16 PM	12/29/08 4:01 PM
Chromium	0.0052	mg/L		0.0050	0.100	12/24/08 12:16 PM	12/29/08 4:01 PM
Cobalt	ND	mg/L		0.100	NA	12/24/08 12:16 PM	12/29/08 4:01 PM
Copper	ND	mg/L		0.0500	1.30	12/24/08 12:16 PM	12/29/08 4:01 PM
Lead	ND	mg/L		0.0050	0.0150	12/24/08 12:16 PM	12/29/08 4:01 PM
Molybdenum	ND	mg/L		0.100	NA	12/24/08 12:16 PM	12/29/08 4:01 PM
Nickel	ND	mg/L		0.0100	0.100	12/24/08 12:16 PM	12/29/08 4:01 PM
Selenium	ND	mg/L		0.0050	0.0500	12/24/08 12:16 PM	12/29/08 4:01 PM
Silver	ND	mg/L		0.0500	NA	12/24/08 12:16 PM	12/29/08 4:01 PM
Thallium	ND	mg/L		0.0010	0.0020	12/24/08 12:16 PM	12/29/08 4:01 PM
Vanadium	ND	mg/L		0.0500	NA	12/24/08 12:16 PM	12/29/08 4:01 PM
Zinc	0.0151	mg/L		0.0100	5.00	12/24/08 12:16 PM	12/29/08 4:01 PM
HARDNESS, CALCIUM			**SM2340 B**			Analyst: **BP**	
Hardness, Calcium (As CaCO3)	67.4	mg/L		1.00	NA		12/31/08 12:27 AM
HARDNESS			**SM2340 B**			Analyst: **BP**	
Hardness, Total (As CaCO3)	145	mg/L		1.00	NA	12/24/08 12:16 PM	12/31/08 12:27 AM
MERCURY, TOTAL			**E245.1**			Analyst: **CGW**	
Mercury	ND	mg/L		0.0010	0.0020	12/24/08 12:08 PM	12/30/08 10:49 AM
PCB			**E505**			Analyst: **Sub**	
Aroclor 1016	See Attached			NA	NA		
Aroclor 1221	See Attached			NA	NA		
Aroclor 1232	See Attached			NA	NA		
Aroclor 1242	See Attached			NA	NA		
Aroclor 1248	See Attached			NA	NA		

Key: MCL	Maximum Contaminant Level	**Qualifiers:**	B	Analyte detected in the associated Method Blank
MDL	Minimum Detection Limit		E	Estimated Value above quantitation range
NA	Not Applicable		H	Holding times for preparation or analysis exceeded
ND	Not Detected at the PQL or MDL		S	Spike/Surrogate Recovery outside accepted recovery limit
PQL	Practical Quantitation Limit		*	Value exceeds Maximum Contaminant Level
TIC	Tentatively Identified Compound, Estimated Concentrati			

REI Consultants, Inc. Analytical Results

Date: *02-Feb-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812H90 **Lab ID** 0812H90-01A
Client Sample ID:	1204 MURRAY DRIVE	**DateReceived**	12/23/2008
Project:	08330106	**Collection Date:**	12/22/2008 4:45:00 PM
Site ID:	BATTLEFIELD GOLF CLUB	**Matrix:**	DRINKING WATER

Analyses	Result	Units	Qual	PQL	MCL	Prep Date	Date Analyzed
PCB			**E505**			Analyst: **Sub**	
Aroclor 1254	See Attached			NA	NA		
Aroclor 1260	See Attached			NA	NA		
Chlordane	See Attached			NA	NA		
Toxaphene	See Attached			NA	NA		
SEMIVOLATILE ORGANIC COMPOUNDS			**E525.2**			Analyst: **Sub**	
Alachlor	See Attached			NA	NA		
Atrazine	See Attached			NA	NA		
Benzo(a)pyrene	See Attached			NA	NA		
Di(2-ethylhexyl)adipate	See Attached			NA	NA		
Di(2-ethylhexyl)phthalate	See Attached			NA	NA		
Endrin	See Attached			NA	NA		
gamma-BHC	See Attached			NA	NA		
Heptachlor	See Attached			NA	NA		
Heptachlor epoxide	See Attached			NA	NA		
Hexachlorobenzene	See Attached			NA	NA		
Hexachlorocyclopentadiene	See Attached			NA	NA		
Methoxychlor	See Attached			NA	NA		
Simazine	See Attached			NA	NA		
CARBAMATES 531.1			**E531.1**			Analyst: **Sub**	
Aldicarb	See Attached			NA	NA		
Aldicarb sulfone	See Attached			NA	NA		
Aldicarb sulfoxide	See Attached			NA	NA		
Carbofuran	See Attached			NA	NA		
Oxamyl	See Attached			NA	NA		
GLYPHOSATE 547			**E547**			Analyst: **Sub**	
Glyphosate	See Attached			NA	NA		
ENDOTHALL 548.1			**E548.1**			Analyst: **Sub**	
Endothall	See Attached			NA	NA		
DIQUAT 549.2			**E549.2**			Analyst: **Sub**	
Diquat	See Attached			NA	NA		
DIOXIN			**SW8280**			Analyst: **Sub**	
2,3,7,8-TCDD	See Attached			NA	NA		
SEMIVOLATILE ORGANIC COMPOUNDS BY EPA			**E504.1**			Analyst: **JG**	
1,2-Dibromo-3-chloropropane	ND	mg/L		0.000020	0.000200	01/02/09 1:30 PM	01/02/09 5:53 PM

Key:

MCL	Maximum Contaminant Level	**Qualifiers:**	B	Analyte detected in the associated Method Blank
MDL	Minimum Detection Limit		E	Estimated Value above quantitation range
NA	Not Applicable		H	Holding times for preparation or analysis exceeded
ND	Not Detected at the PQL or MDL		S	Spike/Surrogate Recovery outside accepted recovery limit
PQL	Practical Quantitation Limit		*	Value exceeds Maximum Contaminant Level
TIC	Tentatively Identified Compound, Estimated Concentrati			

REI Consultants, Inc. **Analytical Results** **Date:** *02-Feb-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812H90 **Lab ID** 0812H90-01A
Client Sample ID:	1204 MURRAY DRIVE	**DateReceived**	12/23/2008
Project:	08330106	**Collection Date:**	12/22/2008 4:45:00 PM
Site ID:	BATTLEFIELD GOLF CLUB	**Matrix:**	DRINKING WATER

Analyses	Result	Units	Qual	PQL	MCL	Prep Date	Date Analyzed
SEMIVOLATILE ORGANIC COMPOUNDS BY EPA			**E504.1**			Analyst: **JG**	
1,2-Dibromoethane	ND	mg/L		0.000020	0.000050	01/02/09 1:30 PM	01/02/09 5:53 PM
SEMIVOLATILE ORGANIC COMPOUNDS			**E515.1**			Analyst: **JG**	
2,4,5-TP (Silvex)	ND	mg/L		0.000608	0.0500	12/23/08 2:00 PM	12/30/08 12:00 AM
2,4-D	ND	mg/L		0.000122	0.0700	12/23/08 2:00 PM	12/30/08 12:00 AM
Dalapon	ND	mg/L		0.00790	0.200	12/23/08 2:00 PM	12/30/08 12:00 AM
Dinoseb	ND	mg/L		0.000122	0.00700	12/23/08 2:00 PM	12/30/08 12:00 AM
Pentachlorophenol	ND	mg/L		0.000608	0.00100	12/23/08 2:00 PM	12/30/08 12:00 AM
Picloram	ND	mg/L		0.000608	0.500	12/23/08 2:00 PM	12/30/08 12:00 AM
VOLATILE ORGANIC COMPOUNDS			**E524.2**			Analyst: **SDG**	
Benzene	ND	µg/L		1.0	5.0		12/30/08 1:37 PM
Carbon tetrachloride	ND	µg/L		1.0	5.0		12/30/08 1:37 PM
1,2-Dichlorobenzene	ND	µg/L		1.0	600		12/30/08 1:37 PM
1,4-Dichlorobenzene	ND	µg/L		1.0	75.0		12/30/08 1:37 PM
1,2-Dichloroethane	ND	µg/L		1.0	5.0		12/30/08 1:37 PM
1,1-Dichloroethene	ND	µg/L		1.0	7.0		12/30/08 1:37 PM
cis-1,2-Dichloroethene	ND	µg/L		1.0	70.0		12/30/08 1:37 PM
trans-1,2-Dichloroethene	ND	µg/L		1.0	100		12/30/08 1:37 PM
1,2-Dichloropropane	ND	µg/L		1.0	5.0		12/30/08 1:37 PM
Ethylbenzene	ND	µg/L		1.0	700		12/30/08 1:37 PM
Methylene chloride	ND	µg/L		1.0	5.0		12/30/08 1:37 PM
Styrene	ND	µg/L		1.0	100		12/30/08 1:37 PM
Tetrachloroethene	ND	µg/L		1.0	5.0		12/30/08 1:37 PM
Surr: 1,2-Dichlorobenzene-d4	80.1	%REC		75-125	NA		12/30/08 1:37 PM
Surr: 4-Bromofluorobenzene	85.0	%REC		75-125	NA		12/30/08 1:37 PM
RESIDUAL CHLORINE - LAB TEST, HOLD TIME E			**SM4500-CL-G**			Analyst: **CC**	
Chlorine, Total Residual	ND	µg/L		100	NA		12/24/08 10:00 AM
TURBIDITY			**SM2130 B**			Analyst: **CC**	
Turbidity	0.65	NTU	*	0.50	0.50		12/24/08 9:30 AM
COLIFORM BY P/A			**SM9223 B**			Analyst: **CC**	
Fecal Coliform	ABSENT	NA		NA	NA	12/23/08 2:15 PM	12/24/08 2:15 PM
Total Coliform	ABSENT	NA		NA	NA	12/23/08 2:15 PM	12/24/08 2:15 PM
CYANIDE			**E335.4**			Analyst: **BA**	
Cyanide, Total	ND	mg/L		0.020	NA		12/24/08 9:00 AM

Key:
- MCL Maximum Contaminant Level
- MDL Minimum Detection Limit
- NA Not Applicable
- ND Not Detected at the PQL or MDL
- PQL Practical Quantitation Limit
- TIC Tentatively Identified Compound, Estimated Concentrati

Qualifiers:
- B Analyte detected in the associated Method Blank
- E Estimated Value above quantitation range
- H Holding times for preparation or analysis exceeded
- S Spike/Surrogate Recovery outside accepted recovery limit
- * Value exceeds Maximum Contaminant Level

REI Consultants, Inc. **Analytical Results** **Date:** *02-Feb-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812H90 **Lab ID** 0812H90-01A
Client Sample ID:	1204 MURRAY DRIVE	**DateReceived**	12/23/2008
Project:	08330106	**Collection Date:**	12/22/2008 4:45:00 PM
Site ID:	BATTLEFIELD GOLF CLUB	**Matrix:**	DRINKING WATER

Analyses	Result Units	Qual	PQL	MCL	Prep Date	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY		**E300.0**			Analyst: **CW**	
Chloride	136 mg/L		10.0	250		12/29/08 6:39 PM
Fluoride	0.46 mg/L		0.20	4.00		12/29/08 6:39 PM
Sulfate	13.9 mg/L		5.00	250		12/29/08 6:39 PM
ANIONS BY ION CHROMATOGRAPHY		**E300.0**			Analyst: **CW**	
Nitrogen, Nitrate-Nitrite	ND mg/L		0.10	10.0		01/01/09 8:42 AM
TOTAL DISSOLVED SOLIDS		**SM2540 C**			Analyst: **DSA**	
Total Dissolved Solids	401 mg/L		1	500		12/23/08 6:05 PM
ALKALINITY		**SM2320 B**			Analyst: **DSA**	
Alkalinity, Total (As CaCO3)	162 mg/L		1.0	NA		12/23/08 3:06 PM
CORROSIVITY, LANGELIER INDEX		**SM2330 B**			Analyst: **IL**	
Langelier Index	0.14 at 20 °C		NA	NA		01/05/09 12:00 AM
PH - LAB TEST, HOLD TIME EXPIRED		**SM4500-H+-B**			Analyst: **DSA**	
pH	8.07 SU		NA	NA		12/23/08 3:06 PM
ORGANIC CARBON, TOTAL		**SM5310 C**			Analyst: **DSA**	
Total Organic Carbon	1.45 mg/L		1.00	NA		12/24/08 7:12 AM

Key:

MCL	Maximum Contaminant Level	**Qualifiers:** B	Analyte detected in the associated Method Blank
MDL	Minimum Detection Limit	E	Estimated Value above quantitation range
NA	Not Applicable	H	Holding times for preparation or analysis exceeded
ND	Not Detected at the PQL or MDL	S	Spike/Surrogate Recovery outside accepted recovery limit
PQL	Practical Quantitation Limit	*	Value exceeds Maximum Contaminant Level
TIC	Tentatively Identified Compound, Estimated Concentrati		

REIC

CHAIN OF CUSTODY RECORD NO. 263754

REI Consultants, Inc.
225 Industrial Park Rd.
P.O. Box 286, Beaver, WV 25813
Phone: 304-255-2500 or 800-999-0105
FAX: 304-255-2572
e-mail: rlabs@reiclabs.com

CLIENT: Schnabel Engineering
ADDRESS: 300 Ed Wright Lane, Suite E
CITY/STATE/ZIP: Newport News, VA 23606
BILL TO: Same
CITY/STATE/ZIP:
PURCHASE ORDER #
QUOTE #

CONTACT PERSON: Russell Rountree
TELEPHONE #: (757)947-1220
FAX #: (757)947-1225
E-MAIL ADDRESS: rrountree@schnabel-eng.com
SITE ID & STATE: Battlefield Golf Club Water Project
PROJECT ID: 08330106
SAMPLER: Russell Rountree

SAMPLE LOG AND ANALYSIS REQUEST

TURNAROUND TIME REQUIREMENTS
REGULAR: ___
*RUSH: ___ 5-Day ___ 3-Day ___ 2-Day ___ 1-Day
*Rush work needs prior Laboratory approval and will include surcharges

PRESERVATIVES
0 No Preservative
1 Hydrochloric Acid
2 Nitric Acid
3 Sulfuric Acid
4 Sodium Thiosulfate
5 Sodium Hydroxide
6 Zinc Acetate
7 EDTA

NOTE PRESERVATIVES →
PRESERVATIVE CODES

ANALYSIS REQUESTED & METHOD:
- Routine Chemical Analyses *
- Full Chemical Analysis *
- Synthetic Organic Compounds *
- Trace Metals and other *
- Asbestos

SAMPLE ID	NO. & TYPE OF CONTAINERS	SAMPLING DATE / TIME	MATRIX	SAMPLE COMP / GRAB	Routine Chemical Analyses	Full Chemical Analysis	Synthetic Organic Compounds	Trace Metals and other	Asbestos	COMMENTS
1204 Murray Drive	20	12-22-08 4:45	W	G	/	/	/	/	/	

* See attached analysis parameters summary

NO Asbestos per Client. 12/23/08

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
[signature]	12/22/08 7:00	[signature]	12-23-08				

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Temperature Upon Arrival °C	
				1.5	☐ FAX Results ☒ Email Results

Fed Ex

Pace Analytical™

www.pacelabs.com

Pace Analytical Services, Inc.
1700 Elm Street
Minneapolis, MN 55414
Phone: 612.607.1700
Fax: 612.607.6444

Report Prepared for:

Scott Gross
REI Consultants, Inc.
225 Industrial Park Dr.
Beaver WV 25813

Report Information:

Pace Project #: 1087001
Sample Receipt Date: 12/30/2008
Client Project #: 0812H90
Client Sub PO #: N/A
State Cert #: 9952C

REPORT OF LABORATORY ANALYSIS FOR 2,3,7,8-TCDD

Invoicing & Reporting Options:

The report provided has been invoiced as a Level 2 Drinking Water Report. If an upgrade of this report package is requested, an additional charge may be applied.

Please review the attached invoice for accuracy and forward any questions to Nate Habte, your Pace Project Manager.

Report Summary:

Enclosed are analytical results of one drinking water sample analyzed for 2,3,7,8-TCDD content. This sample was analyzed according to Method 1613B by High Resolution Gas Chromatography/High Resolution Mass Spectrometry.

The results reported for this sample and the associated quality control samples were all within the criteria described in Method 1613B; with the exception of a blank internal standard recovery below the target range for the method. If you have any questions or concerns regarding these results, please contact Nate Habte, your Pace Project Manager.

This report has been reviewed and prepared by:

For Nate Habte
Nate Habte, Project Manager
(612) 607-6407
(612) 607-6444 (fax)
natnael.habte@pacelabs.com

ACCREDITED IN ACCORDANCE WITH nelac

Report of Laboratory Analysis

Report Prepared Date:

January 12, 2009

Report No.....1087001_1613DW

1130

REI Consultants, Inc.
225 Industrial Park Drive
Beaver, WV 25813
TEL: *304.255.2500* FAX: *304.255.2572*

CHAIN-OF-CUSTODY RECORD

1087001

Subcontractor:

PACE ANALYTICAL SERVICES INC.
1700 Elm St. Suite 200
Minneapolis, MN 55414

TEL: (919) 596-1935
FAX:
Acct #:

23-Dec-08

Sample ID	Matrix	Date Collected	Bottle Type	Requested Tests: SW8280	1					
0812H90-01A	Drinking Water	12/22/2008 4:45:00 PM	ALS, PLASTIC, GLA	1						001

2378. TCDD

GeneralComments:

State Code: VA
After analysis, the samples do not need to be returned and can be disposed per your standard laboratory practices.

1 Method 1613 per Scott G. @ 12/30/08

		Date/Time			Date/Time
Relinquished by:	[signature]	12/22/08 e 1600	Received by:	[signature]	9:45
Relinquished by:			Received by:	[signature] Pace	12/30/08

T=3.0

Sample Condition Upon Receipt

Pace Analytical

Client Name: REI Project # 1087001

Courier: ☐ Fed Ex ☑ UPS ☐ USPS ☐ Client ☐ Commercial ☐ Pace Other ______

Tracking #: 12 26X 7131 36 62 0327

Optional
Proj. Due Date:
Proj. Name:

Custody Seal on Cooler/Box Present: ☐ yes ☑ no   Seals intact: ☐ yes ☑ no

Packing Material: ☐ Bubble Wrap ☐ Bubble Bags ☐ None ☐ Other ______ Temp Blank: Yes ____ No ____

Thermometer Used 80344042, 179425   Type of Ice: Wet Blue None   ☐ Samples on ice, cooling process has begun

Cooler Temperature 3.0   Biological Tissue is Frozen: Yes No

Temp should be above freezing to 6°C

Date and Initials of person examining contents: 12/30/08 SK

		Comments:
Chain of Custody Present:	☑Yes ☐No ☐N/A	1.
Chain of Custody Filled Out:	☑Yes ☐No ☐N/A	2.
Chain of Custody Relinquished:	☑Yes ☐No ☐N/A	3.
Sampler Name & Signature on COC:	☐Yes ☑No ☐N/A	4.
Samples Arrived within Hold Time:	☑Yes ☐No ☐N/A	5.
Short Hold Time Analysis (<72hr):	☐Yes ☑No ☐N/A	6.
Rush Turn Around Time Requested:	☐Yes ☑No ☐N/A	7.
Sufficient Volume:	☑Yes ☐No ☐N/A	8.
Correct Containers Used:	☑Yes ☐No ☐N/A	9.
-Pace Containers Used:	☐Yes ☑No ☐N/A	
Containers Intact:	☑Yes ☐No ☐N/A	10.
Filtered volume received for Dissolved tests	☐Yes ☑No ☐N/A	11.
Sample Labels match COC:	☑Yes ☐No ☐N/A	12.
-Includes date/time/ID/Analysis Matrix: WT		
All containers needing acid/base preservation have been checked. Noncompliance are noted in 13.	☐Yes ☑No ☐N/A	13.
All containers needing preservation are found to be in compliance with EPA recommendation.	☐Yes ☑No ☐N/A	
Exceptions: VOA, Coliform, TOC, Oil and Grease, WI-DRO (water)	☐Yes ☑No	Initial when completed / Lot # of added preservative
Samples checked for dechlorination:	☐Yes ☑No ☐N/A	14.
Headspace in VOA Vials (>6mm):	☐Yes ☑No ☐N/A	15.
Trip Blank Present:	☐Yes ☑No ☐N/A	16.
Trip Blank Custody Seals Present	☐Yes ☐No ☑N/A	
Pace Trip Blank Lot # (if purchased):		

Client Notification/ Resolution: Field Data Required? Y / N

Person Contacted: ______ Date/Time: ______

Comments/ Resolution: ______

12-30-08

Project Manager Review: (U)   Date: 12/30/08

Note: Whenever there is a discrepancy affecting North Carolina compliance samples, a copy of this form will be sent to the North Carolina DEHNR Certification Office (i.e. out of hold, incorrect preservative, out of temp, incorrect containers)

Pace Analytical™

Pace AnalyticalServices, Inc.
1700 Elm Street - Suite 200
Minneapolis, MN 55414

Tel: 612-607-1700
Fax: 612-607-6444

Drinking Water Analysis Results
2,3,7,8-TCDD -- USEPA Method 1613B

Sample ID..........0812H90-01A
Client..................REI Consultants, Inc.
Lab Sample ID.....1087001001

Date Collected.....12/22/2008
Date Received......12/30/2008
Date Extracted.....01/05/2009

	Sample 0812H90-01A	Method Blank	Lab Spike	Lab Spike Dup
[2,3,7,8-TCDD]	**ND**	ND	--	--
RL	5 pg/L	5 pg/L	--	--
2,3,7,8-TCDD Recovery	--	--	99%	102%
Spike Recovery Limit	--	--	73-146%	73-146%
RPD			2.8%	
IS Recovery	**70%**	30% !	75%	64%
IS Recovery Limits	31-137%	31-137%	25-141%	25-141%
CS Recovery	**85%**	77%	96%	83%
CS Recovery Limits	42-164%	42-164%	37-158%	37-158%
Filename	R90106A17	R90106A05	R90106A03	R90106A04
Analysis Date	01/06/2009	01/06/2009	01/06/2009	01/06/2009
Analysis Time	16:06	10:24	09:27	09:53
Analyst	SMT	SMT	SMT	SMT
Volume	0.963L	0.900L	0.907L	0.913L
Dilution	NA	NA	NA	NA
ICAL Date	12/31/2008	12/31/2008	12/31/2008	12/31/2008
CCAL Filename	R90106A02	R90106A02	R90106A02	R90106A02

! = Outside the Control Limits
ND = Not Detected
RL = Reporting Limit
Limits = Control Limits from Method 1613 (10/94 Revision), Tables 6A and 7A
RPD = Relative Percent Difference of Lab Spike Recoveries
IS = Internal Standard [2,3,7,8-TCDD-$^{13}C_{12}$]
CS = Cleanup Standard [2,3,7,8-TCDD-$^{37}Cl_4$]

Analyst: [signature]

Project No.............1087001

the standard in safety

Underwriters
Laboratories

LABORATORY REPORT

This report contains 4 pages.
(including the cover page)

If you have any questions concerning this report, please do not hesitate to call us at (800) 332-4345 or (574) 233-4777.

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Underwriters Laboratories Inc.
110 S. Hill Street, South Bend, IN 46617-2702 USA
T.: 800 332.4345 / F.: 574.233.8207 / W.: ul.com

the standard in safety

Underwriters Laboratories

Laboratory Report

Client: REIC

Attn: Joy Mullins
225 Airport Industrial Park Road
P.O. Box 286
Beaver, WV 25813

Copies to: None

Report: 218270
Priority: Standard Written
Status: Final
PWS ID: Not Supplied

Sample Information

UL ID #	Client ID	Method	Collected Date / Time	Collected By:	Received Date / Time
1998296	0812H90-01A	505	12/22/08 16:45	Client	12/30/08 09:30
1998297	0812H90-01A	525.2	12/22/08 16:45	Client	12/30/08 09:30
1998298	0812H90-01A	531.1	12/22/08 16:45	Client	12/30/08 09:30
1998299	0812H90-01A	547	12/22/08 16:45	Client	12/30/08 09:30
1998300	0812H90-01A	548.1	12/22/08 16:45	Client	12/30/08 09:30
1998301	0812H90-01A	549.2	12/22/08 16:45	Client	12/30/08 09:30

Report Summary

Note: Sample containers, except for Method 549.2, were provided by the client.

Note: The samples submitted for Methods 548.1 and 549.2 analysis were received outside the seven day hold time. The client was notified of the situation and analysis was authorized by Scott Gross of REIC.

Note: In the Method 549.2 analysis, the diquat recovery in the MS (33%) was outside the acceptance limits of 63-97%.

Note: In the Method 525.2 analysis, the di(2-ethylhexyl)phthalate recovery in the LFB (142%) was outside the acceptance limits of 70-130%.

Note: In the Method 525.2 analysis, the di(2-ethylhexyl)phthalate recovery in the FBL (206%) was outside the acceptance limits of 50-200%.

Note: In the Method 525.2 analysis, heptachlor epoxide is not reportable in the sample submitted due to matrix interference.

Detailed quantitative results are presented on the following pages.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call Traci Chlebowski at (574) 233-4777.

Note: This report may not be reproduced, except in full, without written approval from Underwriters Laboratories (UL).

Traci Chlebowski — Authorized Signature
Project Manager — Title
1/20/09 — Date

Client Name: REIC
Report #: 218270

Underwriters Laboratories Inc.
110 S. Hill Street, South Bend, IN 46617-2702 USA
T:: 800.332.4345 / F:: 574.233.8207 / W:: ul.com

Client Name: REIC

Report #: 218270

Sampling Point: 0812H90-01A

PWS ID: Not Supplied

Semi-volatile Organic Chemicals									
Analyte ID #	Analyte	Method	Reg Limit	MRL†	Result	Units	Preparation Date	Analyzed	UL ID #
12674-11-2	Aroclor 1016	505	---	0.08	< 0.08	ug/L	12/31/08 13:50	12/31/08 22:07	1998296
11104-28-2	Aroclor 1221	505	---	0.19	< 0.19	ug/L	12/31/08 13:50	12/31/08 22:07	1998296
11141-16-5	Aroclor 1232	505	---	0.23	< 0.23	ug/L	12/31/08 13:50	12/31/08 22:07	1998296
53469-21-9	Aroclor 1242	505	---	0.26	< 0.26	ug/L	12/31/08 13:50	12/31/08 22:07	1998296
12672-29-6	Aroclor 1248	505	---	0.1	< 0.1	ug/L	12/31/08 13:50	12/31/08 22:07	1998296
11097-69-1	Aroclor 1254	505	---	0.1	< 0.1	ug/L	12/31/08 13:50	12/31/08 22:07	1998296
11096-82-5	Aroclor 1260	505	---	0.2	< 0.2	ug/L	12/31/08 13:50	12/31/08 22:07	1998296
57-74-9	Chlordane	505	2 *	0.1	< 0.1	ug/L	12/31/08 13:50	12/31/08 22:07	1998296
8001-35-2	Toxaphene	505	3 *	1.0	< 1.0	ug/L	12/31/08 13:50	12/31/08 22:07	1998296
15972-60-8	Alachlor	525.2	2 *	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
309-00-2	Aldrin	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
1912-24-9	Atrazine	525.2	3 *	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
50-32-8	Benzo[a]pyrene	525.2	0.2 *	0.02	< 0.02	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
58-89-9	gamma-BHC (Lindane)	525.2	0.2 *	0.02	< 0.02	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
23184-66-9	Butachlor	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
60-57-1	Dieldrin	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
103-23-1	Di(2-ethylhexyl)adipate	525.2	400 *	0.6	< 0.6	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
117-81-7	Di(2-ethylhexyl)phthalate	525.2	6 *	0.6	**0.8**	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
72-20-8	Endrin	525.2	2 *	0.01	< 0.01	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
76-44-8	Heptachlor	525.2	0.4 *	0.04	< 0.04	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
118-74-1	Hexachlorobenzene	525.2	1 *	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
77-47-4	Hexachlorocyclopentadiene	525.2	50 *	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
72-43-5	Methoxychlor	525.2	40 *	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
51218-45-2	Metolachlor	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
21087-64-9	Metribuzin	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
1918-16-7	Propachlor	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
122-34-9	Simazine	525.2	4 *	0.07	< 0.07	ug/L	12/31/08 09:30	12/31/08 21:08	1998297
116-06-3	Aldicarb	531.1	---	0.5	< 0.5	ug/L	12/31/08 08:20	12/31/08 18:34	1998298
1646-88-4	Aldicarb sulfone	531.1	---	0.7	< 0.7	ug/L	12/31/08 08:20	12/31/08 18:34	1998298
1646-87-3	Aldicarb sulfoxide	531.1	---	0.5	< 0.5	ug/L	12/31/08 08:20	12/31/08 18:34	1998298
63-25-2	Carbaryl	531.1	---	0.5	< 0.5	ug/L	12/31/08 08:20	12/31/08 18:34	1998298
1563-66-2	Carbofuran	531.1	40 *	0.9	< 0.9	ug/L	12/31/08 08:20	12/31/08 18:34	1998298
16655-82-6	3-Hydroxycarbofuran	531.1	---	0.5	< 0.5	ug/L	12/31/08 08:20	12/31/08 18:34	1998298
16752-77-5	Methomyl	531.1	---	0.5	< 0.5	ug/L	12/31/08 08:20	12/31/08 18:34	1998298
23135-22-0	Oxamyl	531.1	200 *	1.0	< 1.0	ug/L	12/31/08 08:20	12/31/08 18:34	1998298
1071-83-6	Glyphosate	547	700 *	6.0	< 6.0	ug/L	12/31/08 13:00	01/02/09 18:55	1998299
145-73-3	Endothall	548.1	100 *	9.0	< 9.0	ug/L	12/31/08 08:05	01/02/09 16:15	1998300
85-00-7	Diquat	549.2	20 *	0.4	< 0.4	ug/L	12/31/08 08:20	12/31/08 13:08	1998301

Any positive Aroclor result would require analysis for total PCB as decachlorobiphenyl by method 508A (MCL = 0.5 ug/L)

† UL has demonstrated it can achieve these report limits in reagent water, but can not document them in all sample matrices.

Reg Limit Type:	MCL	SMCL	AL
Symbol:	*	^	!

170173035

REI Consultants, Inc.
225 Industrial Park Drive
Beaver, WV 25813
TEL: *304.255.2500* FAX: *304.255.2572*

CHAIN-OF-CUSTODY RECORD

Subcontractor:

UNDERWRITERS LABORATORIES
110 SOUTH HILL STREET
SOUTH BEND, IN 46617

TEL: (574) 233-4777
FAX:
Acct #:

218270

1998296 1998297 1998298 1998299 1998300 1998301

23-Dec-08

Sample ID	Matrix	Date Collected	Bottle Type	Requested Tests						
				E505	E525.2	E531.1	E547	E548.1	E549.2	
0812H90-01A	Drinking Water	12/22/2008 4:45:00 PM	ALS, PLASTIC, GLA	1	1	1	1	1	1	

> all but 549.2

548 + 549
rcvd out of HT pm 123008

2.8°C wet

General Comments:

State Code: VA
After analysis, the samples do not need to be returned and can be disposed per your standard laboratory practices.

		Date/Time			Date/Time
Relinquished by:	[signature]	12/25/08 @ 1600	Received by:	UPS	
Relinquished by:			Received by:	[signature]	123008 0930

1208 MURRAY DRIVE

REIC

Improving the environment, one client at a time...

225 Industrial Park Drive
Beaver, WV 25813
TEL: 304.255.2500
FAX: 304.255.2572
Website: www.reiclabs.com

January 22, 2009

Mr. Russell Rountree
SCHNABEL ENGINEERING SOUTH LLC
300 ED WRIGHT LN SUITE 1
NEWPORT NEWS VA 23606

TEL: (757) 947-1220
FAX (757) 947-1220

RE: 08330106

Order No.: 0812H94

Dear Mr. Russell Rountree:

REI Consultants, Inc. received 1 sample(s) on 12/23/2008 for the analyses presented in the following report.

Please note two changes you may see on your report.

- Results for "Dissolved" parameters will be shown under a separate sample ID, rather than as a separate analysis under the same sample ID. The sample ID for "Dissolved" parameters will include "Field Filtered" or "Lab Filtered", as appropriate.
- Metals results will no longer be identified as "Total" or "Total Recoverable". The methods have not been changed, only their appearance on the report.

If you have any questions regarding these results, please do not hesitate to call.

Sincerely,

Scott Gross
Project Manager

REIC
225 Industrial Park Drive
Beaver, WV 25813
TEL: 304.255.2500
FAX: 304.255.2572
Website: www.reiclabs.com

Improving the environment, one client at a time...

Report Narrative

Project Manager:: **Scott Gross**

WO#: **0812H94**
Date: **1/22/2009**

CLIENT: SCHNABEL ENGINEERING SOUTH LL
Project: 08330106

All analyses were performed using documented laboratory SOPs that incorporate appropriate quality control procedures as described in the applicable methods. REI Consultants, Inc. (REIC) technical managers have verified compliance of reported results with the REIC's Quality Program and SOPs, except as noted in this case narrative. Any deviation from compliance is explained below and/or identified within the body of this report by a qualifier footnote which is defined at the bottom of each page.

All samples were analyzed using the methods stated in the analytical report without modification, unless otherwise noted.

All sample results are reported on an "as-received" wet weight basis unless otherwise noted.

Results reported for sums of individual parameters, such as Total Trihalomethanes (TTHM) and Total Haloacetic Acids (HAA5), may vary slightly from the sum of the individual parameter results. This apparent anomaly is caused by rounding individual results and summations at reporting, as required by EPA.

Following standard laboratory protocol, sample preservation, such as pH, is verified at time of extraction or analysis based on client requested parameters. Improper preservation is noted on the analytical bench sheet, extraction log, or preservation log and client is notified by close of following business day. All results are reported using preservation compliant samples unless otherwise noted in the analytical report.

The test results in this report meet all NELAP requirements for parameters for which accreditations are required or available. Any exceptions are noted in this report. This report may not be reproduced, except in full, without the written approval of REIC.

In compliance with federal guidelines and standard operating procedures, all reports, including raw data and supporting quality control, will be disposed of after five years unless otherwise arranged by the client via written notification or contract requirement.

If you have any questions please contact the project manager whose name is listed above.

REI Consultants, Inc. **Analytical Results** **Date:** *02-Feb-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812H94 **Lab ID** 0812H94-01A
Client Sample ID:	1208 MURRAY DRIVE	**DateReceived**	12/23/2008
Project:	08330106	**Collection Date:**	12/22/2008 4:25:00 PM
Site ID:	BATTLEFIELD GOLF CLUB	**Matrix:**	DRINKING WATER

Analyses	Result	Units	Qual	PQL	MCL	Prep Date	Date Analyzed
METALS BY ICP			**E200.7**			Analyst: **BP**	
Aluminum	0.267	mg/L	*	0.100	0.200	12/24/08 12:16 PM	12/31/08 12:32 AM
Boron	0.111	mg/L		0.100	NA	12/24/08 12:16 PM	12/31/08 12:32 AM
Iron	1.79	mg/L	*	0.100	0.300	12/24/08 12:16 PM	12/31/08 12:32 AM
Magnesium	18.9	mg/L		0.500	NA	12/24/08 12:16 PM	12/31/08 12:32 AM
Manganese	0.186	mg/L	*	0.050	0.050	12/24/08 12:16 PM	12/31/08 12:32 AM
Silica (as SiO2)	27.6	mg/L		0.210	NA	12/24/08 12:16 PM	12/29/08 2:52 PM
Sodium	81.1	mg/L		0.500	NA	12/24/08 12:16 PM	12/31/08 12:32 AM
METALS BY ICP-MS			**E200.8**			Analyst: **BM**	
Antimony	ND	mg/L		0.0010	0.0060	12/24/08 12:16 PM	12/29/08 4:19 PM
Arsenic	ND	mg/L		0.0050	0.0100	12/24/08 12:16 PM	12/29/08 4:19 PM
Barium	ND	mg/L		0.100	2.00	12/24/08 12:16 PM	12/29/08 4:19 PM
Beryllium	ND	mg/L		0.0020	0.0040	12/24/08 12:16 PM	12/29/08 4:19 PM
Cadmium	ND	mg/L		0.0010	0.0050	12/24/08 12:16 PM	12/29/08 4:19 PM
Chromium	0.0071	mg/L		0.0050	0.100	12/24/08 12:16 PM	12/29/08 4:19 PM
Cobalt	ND	mg/L		0.100	NA	12/24/08 12:16 PM	12/29/08 4:19 PM
Copper	ND	mg/L		0.0500	1.30	12/24/08 12:16 PM	12/29/08 4:19 PM
Lead	ND	mg/L		0.0050	0.0150	12/24/08 12:16 PM	12/29/08 4:19 PM
Molybdenum	ND	mg/L		0.100	NA	12/24/08 12:16 PM	12/29/08 4:19 PM
Nickel	ND	mg/L		0.0100	0.100	12/24/08 12:16 PM	12/29/08 4:19 PM
Selenium	ND	mg/L		0.0050	0.0500	12/24/08 12:16 PM	12/29/08 4:19 PM
Silver	ND	mg/L		0.0500	NA	12/24/08 12:16 PM	12/29/08 4:19 PM
Thallium	ND	mg/L		0.0010	0.0020	12/24/08 12:16 PM	12/29/08 4:19 PM
Vanadium	ND	mg/L		0.0500	NA	12/24/08 12:16 PM	12/29/08 4:19 PM
Zinc	0.0218	mg/L		0.0100	5.00	12/24/08 12:16 PM	12/29/08 4:19 PM
HARDNESS, CALCIUM			**SM2340 B**			Analyst: **BP**	
Hardness, Calcium (As CaCO3)	104	mg/L		1.00	NA		12/31/08 12:32 AM
HARDNESS			**SM2340 B**			Analyst: **BP**	
Hardness, Total (As CaCO3)	182	mg/L		1.00	NA	12/24/08 12:16 PM	12/31/08 12:32 AM
MERCURY, TOTAL			**E245.1**			Analyst: **CGW**	
Mercury	ND	mg/L		0.0010	0.0020	12/24/08 12:08 PM	12/30/08 10:50 AM
PCB			**E505**			Analyst: **Sub**	
Aroclor 1016	See Attached			NA	NA		
Aroclor 1221	See Attached			NA	NA		
Aroclor 1232	See Attached			NA	NA		
Aroclor 1242	See Attached			NA	NA		
Aroclor 1248	See Attached			NA	NA		

Key:
- MCL Maximum Contaminant Level
- MDL Minimum Detection Limit
- NA Not Applicable
- ND Not Detected at the PQL or MDL
- PQL Practical Quantitation Limit
- TIC Tentatively Identified Compound, Estimated Concentrati

Qualifiers:
- B Analyte detected in the associated Method Blank
- E Estimated Value above quantitation range
- H Holding times for preparation or analysis exceeded
- S Spike/Surrogate Recovery outside accepted recovery limit
- * Value exceeds Maximum Contaminant Level

REI Consultants, Inc. **Analytical Results** Date: *02-Feb-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812H94	**Lab ID**	0812H94-01A
Client Sample ID:	1208 MURRAY DRIVE	**DateReceived**	12/23/2008		
Project:	08330106	**Collection Date:**	12/22/2008 4:25:00 PM		
Site ID:	BATTLEFIELD GOLF CLUB	**Matrix:**	DRINKING WATER		

Analyses	Result	Units	Qual	PQL	MCL	Prep Date	Date Analyzed
PCB			**E505**			Analyst: **Sub**	
Aroclor 1254	See Attached			NA	NA		
Aroclor 1260	See Attached			NA	NA		
Chlordane	See Attached			NA	NA		
Toxaphene	See Attached			NA	NA		
SEMIVOLATILE ORGANIC COMPOUNDS			**E525.2**			Analyst: **Sub**	
Alachlor	See Attached			NA	NA		
Atrazine	See Attached			NA	NA		
Benzo(a)pyrene	See Attached			NA	NA		
Di(2-ethylhexyl)adipate	See Attached			NA	NA		
Di(2-ethylhexyl)phthalate	See Attached			NA	NA		
Endrin	See Attached			NA	NA		
gamma-BHC	See Attached			NA	NA		
Heptachlor	See Attached			NA	NA		
Heptachlor epoxide	See Attached			NA	NA		
Hexachlorobenzene	See Attached			NA	NA		
Hexachlorocyclopentadiene	See Attached			NA	NA		
Methoxychlor	See Attached			NA	NA		
Simazine	See Attached			NA	NA		
CARBAMATES 531.1			**E531.1**			Analyst: **Sub**	
Aldicarb	See Attached			NA	NA		
Aldicarb sulfone	See Attached			NA	NA		
Aldicarb sulfoxide	See Attached			NA	NA		
Carbofuran	See Attached			NA	NA		
Oxamyl	See Attached			NA	NA		
GLYPHOSATE 547			**E547**			Analyst: **Sub**	
Glyphosate	See Attached			NA	NA		
ENDOTHALL 548.1			**E548.1**			Analyst: **Sub**	
Endothall	See Attached			NA	NA		
DIQUAT 549.2			**E549.2**			Analyst: **Sub**	
Diquat	See Attached			NA	NA		
DIOXIN			**SW8280**			Analyst: **Sub**	
2,3,7,8-TCDD	See Attached			NA	NA		
SEMIVOLATILE ORGANIC COMPOUNDS BY EPA			**E504.1**			Analyst: **JG**	
1,2-Dibromo-3-chloropropane	ND	mg/L		0.000020	0.000200	01/02/09 1:30 PM	01/02/09 6:07 PM

Key:			Qualifiers:	
	MCL	Maximum Contaminant Level	B	Analyte detected in the associated Method Blank
	MDL	Minimum Detection Limit	E	Estimated Value above quantitation range
	NA	Not Applicable	H	Holding times for preparation or analysis exceeded
	ND	Not Detected at the PQL or MDL	S	Spike/Surrogate Recovery outside accepted recovery limit
	PQL	Practical Quantitation Limit	*	Value exceeds Maximum Contaminant Level
	TIC	Tentatively Identified Compound, Estimated Concentrati		

REI Consultants, Inc. **Analytical Results** **Date:** *02-Feb-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812H94 **Lab ID** 0812H94-01A
Client Sample ID:	1208 MURRAY DRIVE	**DateReceived**	12/23/2008
Project:	08330106	**Collection Date:**	12/22/2008 4:25:00 PM
Site ID:	BATTLEFIELD GOLF CLUB	**Matrix:**	DRINKING WATER

Analyses	Result	Units	Qual	PQL	MCL	Prep Date	Date Analyzed
SEMIVOLATILE ORGANIC COMPOUNDS BY EPA			**E504.1**			Analyst: **JG**	
1,2-Dibromoethane	ND	mg/L		0.000020	0.000050	01/02/09 1:30 PM	01/02/09 6:07 PM
SEMIVOLATILE ORGANIC COMPOUNDS			**E515.1**			Analyst: **JG**	
2,4,5-TP (Silvex)	ND	mg/L		0.000607	0.0500	12/23/08 2:00 PM	12/30/08 12:00 AM
2,4-D	ND	mg/L		0.000121	0.0700	12/23/08 2:00 PM	12/30/08 12:00 AM
Dalapon	ND	mg/L		0.00789	0.200	12/23/08 2:00 PM	12/30/08 12:00 AM
Dinoseb	ND	mg/L		0.000121	0.00700	12/23/08 2:00 PM	12/30/08 12:00 AM
Pentachlorophenol	ND	mg/L		0.000607	0.00100	12/23/08 2:00 PM	12/30/08 12:00 AM
Picloram	ND	mg/L		0.000607	0.500	12/23/08 2:00 PM	12/30/08 12:00 AM
VOLATILE ORGANIC COMPOUNDS			**E524.2**			Analyst: **SDG**	
Benzene	ND	µg/L		1.0	5.0		12/29/08 10:46 AM
Carbon tetrachloride	ND	µg/L		1.0	5.0		12/29/08 10:46 AM
1,2-Dichlorobenzene	ND	µg/L		1.0	600		12/29/08 10:46 AM
1,4-Dichlorobenzene	ND	µg/L		1.0	75.0		12/29/08 10:46 AM
1,2-Dichloroethane	ND	µg/L		1.0	5.0		12/29/08 10:46 AM
1,1-Dichloroethene	ND	µg/L		1.0	7.0		12/29/08 10:46 AM
cis-1,2-Dichloroethene	ND	µg/L		1.0	70.0		12/29/08 10:46 AM
trans-1,2-Dichloroethene	ND	µg/L		1.0	100		12/29/08 10:46 AM
1,2-Dichloropropane	ND	µg/L		1.0	5.0		12/29/08 10:46 AM
Ethylbenzene	ND	µg/L		1.0	700		12/29/08 10:46 AM
Methylene chloride	ND	µg/L		1.0	5.0		12/29/08 10:46 AM
Styrene	ND	µg/L		1.0	100		12/29/08 10:46 AM
Tetrachloroethene	ND	µg/L		1.0	5.0		12/29/08 10:46 AM
Surr: 1,2-Dichlorobenzene-d4	88.2	%REC		75-125	NA		12/29/08 10:46 AM
Surr: 4-Bromofluorobenzene	94.5	%REC		75-125	NA		12/29/08 10:46 AM
RESIDUAL CHLORINE - LAB TEST, HOLD TIME E			**SM4500-CL-G**			Analyst: **CC**	
Chlorine, Total Residual	ND	µg/L		100	NA		12/24/08 11:30 AM
TURBIDITY			**SM2130 B**			Analyst: **CC**	
Turbidity	2.87	NTU	*	0.50	0.50		12/24/08 9:30 AM
COLIFORM BY P/A			**SM9223 B**			Analyst: **CC**	
Fecal Coliform	ABSENT	NA		NA	NA	12/23/08 2:57 PM	12/24/08 2:57 PM
Total Coliform	ABSENT	NA		NA	NA	12/23/08 2:57 PM	12/24/08 2:57 PM
CYANIDE			**E335.4**			Analyst: **BA**	
Cyanide, Total	ND	mg/L		0.020	NA		12/24/08 9:00 AM

Key:
- MCL Maximum Contaminant Level
- MDL Minimum Detection Limit
- NA Not Applicable
- ND Not Detected at the PQL or MDL
- PQL Practical Quantitation Limit
- TIC Tentatively Identified Compound, Estimated Concentrati

Qualifiers:
- B Analyte detected in the associated Method Blank
- E Estimated Value above quantitation range
- H Holding times for preparation or analysis exceeded
- S Spike/Surrogate Recovery outside accepted recovery limit
- * Value exceeds Maximum Contaminant Level

REI Consultants, Inc. **Analytical Results** **Date:** *02-Feb-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812H94	**Lab ID**	0812H94-01A
Client Sample ID:	1208 MURRAY DRIVE	**DateReceived**	12/23/2008		
Project:	08330106	**Collection Date:**	12/22/2008 4:25:00 PM		
Site ID:	BATTLEFIELD GOLF CLUB	**Matrix:**	DRINKING WATER		

Analyses	Result	Units	Qual	PQL	MCL	Prep Date	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**E300.0**			Analyst: **CW**	
Chloride	124	mg/L		5.00	250		12/30/08 11:04 PM
Fluoride	0.33	mg/L		0.20	4.00		12/30/08 11:04 PM
Sulfate	24.2	mg/L		5.00	250		12/30/08 11:04 PM
ANIONS BY ION CHROMATOGRAPHY			**E300.0**			Analyst: **CW**	
Nitrogen, Nitrate-Nitrite	ND	mg/L		0.10	10.0		01/01/09 9:01 AM
TOTAL DISSOLVED SOLIDS			**SM2540 C**			Analyst: **DSA**	
Total Dissolved Solids	377	mg/L		1	500		12/23/08 6:05 PM
ALKALINITY			**SM2320 B**			Analyst: **DSA**	
Alkalinity, Total (As CaCO3)	156	mg/L		1.0	NA		12/24/08 7:45 AM
CORROSIVITY, LANGELIER INDEX			**SM2330 B**			Analyst: **IL**	
Langelier Index	-0.77	at 20 °C		NA	NA		01/05/09 12:00 AM
PH - LAB TEST, HOLD TIME EXPIRED			**SM4500-H+-B**			Analyst: **DSA**	
pH	6.98	SU		NA	NA		12/24/08 7:45 AM
ORGANIC CARBON, TOTAL			**SM5310 C**			Analyst: **DSA**	
Total Organic Carbon	2.01	mg/L		1.00	NA		12/24/08 7:12 AM

Key:

MCL	Maximum Contaminant Level	**Qualifiers:**	B	Analyte detected in the associated Method Blank
MDL	Minimum Detection Limit		E	Estimated Value above quantitation range
NA	Not Applicable		H	Holding times for preparation or analysis exceeded
ND	Not Detected at the PQL or MDL		S	Spike/Surrogate Recovery outside accepted recovery limit
PQL	Practical Quantitation Limit		*	Value exceeds Maximum Contaminant Level
TIC	Tentatively Identified Compound, Estimated Concentrati			

REIC

CHAIN OF CUSTODY RECORD NO.

REI Consultants, Inc.
225 Industrial Park Rd.
P.O. Box 286, Beaver, WV 25813
Phone: 304-255-2500 or 800-999-0105
FAX: 304-255-2572
e-mail: rlabs@reiclabs.com

CLIENT: Schnabel Engineering
ADDRESS: 300 E Wright Lane Suite I
CITY/STATE/ZIP: Newport News, VA 23606
BILL TO: Same
CITY/STATE/ZIP:
PURCHASE ORDER #
QUOTE #

CONTACT PERSON: Russell Romance
TELEPHONE #: 757-947-1220
FAX #: 757 947-1225
E-MAIL ADDRESS: rromance@schnabel-eng.com
SITE ID & STATE: Battlefield Golf Club Water Project
PROJECT ID: 08330106
SAMPLER: Russell Romance

SAMPLE LOG AND ANALYSIS REQUEST

TURNAROUND TIME REQUIREMENTS
REGULAR: ___
*RUSH: ___ 5-Day ___ 3-Day ___ 2-Day ___ 1-Day
*Rush work needs prior Laboratory approval and will include surcharges

PRESERVATIVES
0 No Preservative
1 Hydrochloric Acid
2 Nitric Acid
3 Sulfuric Acid
4 Sodium Thiosulfate
5 Sodium Hydroxide
6 Zinc Acetate
7 EDTA

NOTE PRESERVATIVES →
PRESERVATIVE CODES

ANALYSIS REQUESTED & METHOD: Routine Chemical Analysis *; Full Chemical Analysis *; Synthetic Organic Compounds *; Trace Metals and Other *; Asbestos

SAMPLE ID	NO. & TYPE OF CONTAINERS	SAMPLING DATE / TIME	MATRIX	SAMPLE COMP / GRAB	Routine Chemical Analysis	Full Chemical Analysis	Synthetic Organic Compounds	Trace Metals and Other	Asbestos	COMMENTS
1209 Murray Drive	20	12-22-08 1425	W	G	/	/	/	/	/	

* See attached analysis parameters summary

→ NO Asbestos per client. SG 12/23/08

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
[signature]	12-22-08 7:00	[signature]	12-23-08 1515				
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Temperature Upon Arrival 1.5 °C		☐ FAX Results	☒ Email Results

Fed Ex

Pace Analytical™

www.pacelabs.com

Pace Analytical Services, Inc.
1700 Elm Street
Minneapolis, MN 55414
Phone: 612.607.1700
Fax: 612.607.6444

Report Prepared for:

Scott Gross
REI Consultants, Inc.
225 Industrial Park Dr.
Beaver WV 25813

REPORT OF LABORATORY ANALYSIS FOR 2,3,7,8-TCDD

Report Summary:

This report contains results of one drinking water sample analyzed to determine 2,3,7,8-TCDD content. This sample was analyzed according to Method 1613 by High Resolution Gas Chromatography/High Resolution Mass Spectrometry.

Report Prepared Date:

January 8, 2009

Report Information:

Pace Project #: 1086999
Sample Receipt Date: 12/30/2008
Client Project #: 0812H94
Client Sub PO #: N/A
State Cert #: 9952C

Invoicing & Reporting Options:

The report provided has been invoiced as a Level 2 Drinking Water Report. If an upgrade of this report package is requested, an additional charge may be applied.

Please review the attached invoice for accuracy and forward any questions to Nate Habte, your Pace Project Manager.

This report has been reviewed and prepared by:

For Nate Habte
Nate Habte, Project Manager
(612) 607-6407
(612) 607-6444 (fax)
natnael.habte@pacelabs.com

ACCREDITED IN ACCORDANCE WITH nelac

Report of Laboratory Analysis

REI Consultants, Inc.
225 Industrial Park Drive
Beaver, WV 25813
TEL: *304.255.2500* FAX: *304.255.2572*

1130

CHAIN-OF-CUSTODY RECORD

1086999

Subcontractor:

PACE ANALYTICAL SERVICES INC.
1700 Elm St. Suite 200
Minneapolis, MN 55414

TEL: (919) 596-1935
FAX:
Acct #:

23-Dec-08

Sample ID	Matrix	Date Collected	Bottle Type	Requested Tests						
				SW8280	①					
0812H94-01A	Drinking Water	12/23/2008 2:20:22 PM	ALS, PLASTIC, GLA	1						C001

2378 - TCDD

General Comments:

State Code: VA
After analysis, the samples do not need to be returned and can be disposed per your standard laboratory practices.
① Method 1613 per Scott G. @ 12/30/08

		Date/Time			Date/Time
Relinquished by:	[signature]	12/25/08 @ 1600	Received by:	UPS	
Relinquished by:			Received by:	[signature] / Pace	12/30/08 9:45

T= 3.0

Report No....1086999_1613DW

Sample Condition Upon Receipt

Pace Analytical

Client Name: REI Project # 1086999

Courier: ☐ Fed Ex ☑ UPS ☐ USPS ☐ Client ☐ Commercial ☐ Pace Other

Tracking #: 12 26X 713 136 162 0327

Optional
Proj. Due Date:
Proj. Name:

Custody Seal on Cooler/Box Present: ☐ yes ☑ no Seals intact: ☐ yes ☑ no

Packing Material: ☐ Bubble Wrap ☐ Bubble Bags ☐ None ☐ Other Temp Blank: Yes No ✓

Thermometer Used 80344042, 179425 Type of Ice: Wet Blue None ☐ Samples on ice, cooling process has begun

Cooler Temperature 3.0 Biological Tissue is Frozen: Yes No

Temp should be above freezing to 6°C

Date and Initials of person examining contents: 12/30/08 SL

Comments:

Chain of Custody Present:	☑Yes	☐No	☐N/A	1.
Chain of Custody Filled Out:	☑Yes	☐No	☐N/A	2.
Chain of Custody Relinquished:	☑Yes	☐No	☐N/A	3.
Sampler Name & Signature on COC:	☐Yes	☑No	☐N/A	4.
Samples Arrived within Hold Time:	☑Yes	☐No	☐N/A	5.
Short Hold Time Analysis (<72hr):	☐Yes	☑No	☐N/A	6.
Rush Turn Around Time Requested:	☐Yes	☑No	☐N/A	7.
Sufficient Volume:	☑Yes	☐No	☐N/A	8.
Correct Containers Used:	☑Yes	☐No	☐N/A	9.
-Pace Containers Used:	☐Yes	☑No	☐N/A	
Containers Intact:	☑Yes	☐No	☐N/A	10.
Filtered volume received for Dissolved tests	☐Yes	☑No	☐N/A	11.
Sample Labels match COC:	☑Yes	☐No	☐N/A	12.
-Includes date/time/ID/Analysis Matrix: WT				
All containers needing acid/base preservation have been checked. Noncompliance are noted in 13.	☐Yes	☑No	☐N/A	13.
All containers needing preservation are found to be in compliance with EPA recommendation.	☐Yes	☑No	☐N/A	
Exceptions: VOA,Coliform, TOC, Oil and Grease, WI-DRO (water)	☐Yes	☑No		Initial when completed / Lot # of added preservative
Samples checked for dechlorination:	☐Yes	☑No	☐N/A	14.
Headspace in VOA Vials (>6mm):	☐Yes	☑No	☐N/A	15.
Trip Blank Present:	☐Yes	☑No	☐N/A	16.
Trip Blank Custody Seals Present	☐Yes	☐No	☑N/A	
Pace Trip Blank Lot # (if purchased):				

Client Notification/ Resolution: Field Data Required? Y / N

Person Contacted: ______ Date/Time: ______

Comments/ Resolution: ______

SL 12-30-08

Project Manager Review: [signature] Date: 12/30/08

Note: Whenever there is a discrepancy affecting North Carolina compliance samples, a copy of this form will be sent to the North Carolina DEHNR Certification Office (i.e. out of hold, incorrect preservative, out of temp, incorrect containers)

Pace Analytical™

Pace AnalyticalServices, Inc.
1700 Elm Street - Suite 200
Minneapolis, MN 55414

Tel: 612-607-1700
Fax: 612-607-6444

Drinking Water Analysis Results
2,3,7,8-TCDD -- USEPA Method 1613B

Sample ID..........0812H94-01A
Client..................REI Consultants, Inc.
Lab Sample ID.....1086999001

Date Collected.....12/23/2008
Date Received......12/30/2008
Date Extracted.....01/06/2009

	Sample 0812H94-01A	Method Blank	Lab Spike	Lab Spike Dup
[2,3,7,8-TCDD]	**ND**	ND	--	--
RL	5 pg/L	5 pg/L	--	--
2,3,7,8-TCDD Recovery	--	--	104%	105%
Spike Recovery Limit	--	--	73-146%	73-146%
RPD			0.5%	
IS Recovery	**53%**	52%	68%	48%
IS Recovery Limits	31-137%	31-137%	25-141%	25-141%
CS Recovery	**84%**	86%	85%	75%
CS Recovery Limits	42-164%	42-164%	37-158%	37-158%
Filename	R90106B06	R90106B05	R90106B03	R90106B04
Analysis Date	01/06/2009	01/06/2009	01/06/2009	01/06/2009
Analysis Time	22:45	22:16	21:19	21:48
Analyst	SMT	SMT	SMT	SMT
Volume	0.962L	0.934L	0.935L	0.913L
Dilution	NA	NA	NA	NA
ICAL Date	12/31/2008	12/31/2008	12/31/2008	12/31/2008
CCAL Filename	R90106B02	R90106B02	R90106B02	R90106B02

! = Outside the Control Limits
ND = Not Detected
RL = Reporting Limit
Limits = Control Limits from Method 1613 (10/94 Revision), Tables 6A and 7A
RPD = Relative Percent Difference of Lab Spike Recoveries
IS = Internal Standard [2,3,7,8-TCDD-$^{13}C_{12}$]
CS = Cleanup Standard [2,3,7,8-TCDD-$^{37}Cl_4$]

Analyst:

Project No.............1086999

the standard in safety

Underwriters
Laboratories

LABORATORY REPORT

This report contains 4 pages.
(including the cover page)

If you have any questions concerning this report, please do not hesitate to call us at (800) 332-4345 or (574) 233-4777.

Underwriters Laboratories Inc.
110 S. Hill Street, South Bend, IN 46617-2702 USA
T:: 800.332.4345 / F:: 574.233.8207 / W:: ul.com

the standard in safety

Underwriters
Laboratories

Laboratory Report

Client: REIC

Attn: Joy Mullins
225 Airport Industrial Park Road
P.O. Box 286
Beaver, WV 25813

Copies to: None

Report: 218268
Priority: Standard Written
Status: Final
PWS ID: Not Supplied

Sample Information

UL ID #	Client ID	Method	Collected Date / Time	Collected By:	Received Date / Time
1998288	0812H94-01A	505	12/23/08 14:20	Client	12/30/08 09:30
1998289	0812H94-01A	525.2	12/23/08 14:20	Client	12/30/08 09:30
1998290	0812H94-01A	531.1	12/23/08 14:20	Client	12/30/08 09:30
1998291	0812H94-01A	548.1	12/23/08 14:20	Client	12/30/08 09:30
1998292	0812H94-01A	547	12/23/08 14:20	Client	12/30/08 09:30
1998293	0812H94-01A	549.2	12/23/08 14:20	Client	12/30/08 09:30

Report Summary

Note: Sample containers, except for Method 549.2, were provided by the client.

Note: The samples submitted for Methods 549.2 and 548.1 were analyzed outside the seven day hold time. The client was notified of the situation and analysis was authorized by Scott Gross of REIC.

Note: In the Method 525.2 analysis, heptachlor epoxide is not reportable in the sample submitted due to matrix interference.

Detailed quantitative results are presented on the following pages.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call Traci Chlebowski at (574) 233-4777.

Note: This report may not be reproduced, except in full, without written approval from Underwriters Laboratories (UL).

Traci Chlebowski
Authorized Signature

Project Manager
Title

1/20/09
Date

Client Name: REIC
Report #: 218268

Underwriters Laboratories Inc.
110 S. Hill Street, South Bend, IN 46617-2702 USA
T:: 800.332.4345 / F:: 574.233.8207 / W:: ul.com

Client Name: REIC

Report #: 218268

Sampling Point: 0812H94-01A

PWS ID: Not Supplied

Semi-volatile Organic Chemicals

Analyte ID #	Analyte	Method	Reg Limit	MRL†	Result	Units	Preparation Date	Analyzed	UL ID #
12674-11-2	Aroclor 1016	505	---	0.08	< 0.08	ug/L	12/31/08 13:50	12/31/08 21:20	1998288
11104-28-2	Aroclor 1221	505	---	0.19	< 0.19	ug/L	12/31/08 13:50	12/31/08 21:20	1998288
11141-16-5	Aroclor 1232	505	---	0.23	< 0.23	ug/L	12/31/08 13:50	12/31/08 21:20	1998288
53469-21-9	Aroclor 1242	505	---	0.26	< 0.26	ug/L	12/31/08 13:50	12/31/08 21:20	1998288
12672-29-6	Aroclor 1248	505	---	0.1	< 0.1	ug/L	12/31/08 13:50	12/31/08 21:20	1998288
11097-69-1	Aroclor 1254	505	---	0.1	< 0.1	ug/L	12/31/08 13:50	12/31/08 21:20	1998288
11096-82-5	Aroclor 1260	505	---	0.2	< 0.2	ug/L	12/31/08 13:50	12/31/08 21:20	1998288
57-74-9	Chlordane	505	2 *	0.1	< 0.1	ug/L	12/31/08 13:50	12/31/08 21:20	1998288
8001-35-2	Toxaphene	505	3 *	1.0	< 1.0	ug/L	12/31/08 13:50	12/31/08 21:20	1998288
15972-60-8	Alachlor	525.2	2 *	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
309-00-2	Aldrin	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
1912-24-9	Atrazine	525.2	3 *	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
50-32-8	Benzo[a]pyrene	525.2	0.2 *	0.02	< 0.02	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
58-89-9	gamma-BHC (Lindane)	525.2	0.2 *	0.02	< 0.02	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
23184-66-9	Butachlor	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
60-57-1	Dieldrin	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
103-23-1	Di(2-ethylhexyl)adipate	525.2	400 *	0.6	< 0.6	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
117-81-7	Di(2-ethylhexyl)phthalate	525.2	6 *	0.6	< 0.6	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
72-20-8	Endrin	525.2	2 *	0.01	< 0.01	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
76-44-8	Heptachlor	525.2	0.4 *	0.04	< 0.04	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
118-74-1	Hexachlorobenzene	525.2	1 *	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
77-47-4	Hexachlorocyclopentadiene	525.2	50 *	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
72-43-5	Methoxychlor	525.2	40 *	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
51218-45-2	Metolachlor	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
21087-64-9	Metribuzin	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
1918-16-7	Propachlor	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
122-34-9	Simazine	525.2	4 *	0.07	< 0.07	ug/L	12/31/08 09:30	12/31/08 20:29	1998289
116-06-3	Aldicarb	531.1	---	0.5	< 0.5	ug/L	12/31/08 08:20	12/31/08 17:58	1998290
1646-88-4	Aldicarb sulfone	531.1	---	0.7	< 0.7	ug/L	12/31/08 08:20	12/31/08 17:58	1998290
1646-87-3	Aldicarb sulfoxide	531.1	---	0.5	< 0.5	ug/L	12/31/08 08:20	12/31/08 17:58	1998290
63-25-2	Carbaryl	531.1	---	0.5	< 0.5	ug/L	12/31/08 08:20	12/31/08 17:58	1998290
1563-66-2	Carbofuran	531.1	40 *	0.9	< 0.9	ug/L	12/31/08 08:20	12/31/08 17:58	1998290
16655-82-6	3-Hydroxycarbofuran	531.1	---	0.5	< 0.5	ug/L	12/31/08 08:20	12/31/08 17:58	1998290
16752-77-5	Methomyl	531.1	---	0.5	< 0.5	ug/L	12/31/08 08:20	12/31/08 17:58	1998290
23135-22-0	Oxamyl	531.1	200 *	1.0	< 1.0	ug/L	12/31/08 08:20	12/31/08 17:58	1998290
1071-83-6	Glyphosate	547	700 *	6.0	< 6.0	ug/L	12/31/08 13:00	01/02/09 18:29	1998292
145-73-3	Endothall	548.1	100 *	9.0	< 9.0	ug/L	12/31/08 08:05	01/02/09 15:59	1998291
85-00-7	Diquat	549.2	20 *	0.4	< 0.4	ug/L	12/31/08 08:20	12/31/08 12:53	1998293

Any positive Aroclor result would require analysis for total PCB as decachlorobiphenyl by method 508A (MCL = 0.5 ug/L)

† UL has demonstrated it can achieve these report limits in reagent water, but can not document them in all sample matrices.

Reg Limit Type:	MCL	SMCL	AL
Symbol:	*	^	!

173034

REI Consultants, Inc.
225 Industrial Park Drive
Beaver, WV 25813
TEL: *304.255.2500* FAX: *304.255.2572*

CHAIN-OF-CUSTODY RECORD

Subcontractor:
UNDERWRITERS LABORATORIES
110 SOUTH HILL STREET
SOUTH BEND, IN 46617

TEL: (574) 233-4777
FAX:
Acct #:

1998288 1998289 1998290 1998292 pm 1230 218268 1998291 pm1230 1998293

23-Dec-08

Sample ID	Matrix	Date Collected	Bottle Type	Requested Tests: E505	E525.2	E531.1	E547	E548.1	E549.2	
0812H94-01A	Drinking Water	12/23/2008 2:20:22 PM	ALS, PLASTIC, GLA	1	1	1	1	1	1	

>all but 549.2

548 + 549 rcvd on last day of HT pm 1230

2.8°C wet

General Comments:
State Code: VA
After analysis, the samples do not need to be returned and can be disposed per your standard laboratory practices.

	Date/Time		Date/Time
Relinquished by: [signature]	12/29/08 1800	**Received by:** UPS	
Relinquished by:		**Received by:** Pmuff	123008 0930

FIELD BLANK

REIC

Improving the environment, one client at a time...

225 Industrial Park Drive
Beaver, WV 25813
TEL: 304.255.2500
FAX: 304.255.2572
Website: www.reiclabs.com

January 22, 2009

Mr. Russell Rountree
SCHNABEL ENGINEERING SOUTH LLC
300 ED WRIGHT LN SUITE 1
NEWPORT NEWS VA 23606

TEL: (757) 947-1220
FAX (757) 947-1220

RE: 08330106

Order No.: 0812I02

Dear Mr. Russell Rountree:

REI Consultants, Inc. received 1 sample(s) on 12/23/2008 for the analyses presented in the following report.

Please note two changes you may see on your report.

- Results for "Dissolved" parameters will be shown under a separate sample ID, rather than as a separate analysis under the same sample ID. The sample ID for "Dissolved" parameters will include "Field Filtered" or "Lab Filtered", as appropriate.
- Metals results will no longer be identified as "Total" or "Total Recoverable". The methods have not been changed, only their appearance on the report.

If you have any questions regarding these results, please do not hesitate to call.

Sincerely,

Scott Gross
Project Manager

225 Industrial Park Drive
Beaver, WV 25813
TEL: 304.255.2500
FAX: 304.255.2572
Website: www.reiclabs.com

Improving the environment, one client at a time...

Report Narrative

Project Manager:: **Scott Gross**

WO#: **0812102**
Date: **1/22/2009**

CLIENT: SCHNABEL ENGINEERING SOUTH LL
Project: 08330106

All analyses were performed using documented laboratory SOPs that incorporate appropriate quality control procedures as described in the applicable methods. REI Consultants, Inc. (REIC) technical managers have verified compliance of reported results with the REIC's Quality Program and SOPs, except as noted in this case narrative. Any deviation from compliance is explained below and/or identified within the body of this report by a qualifier footnote which is defined at the bottom of each page.

All samples were analyzed using the methods stated in the analytical report without modification, unless otherwise noted.

All sample results are reported on an "as-received" wet weight basis unless otherwise noted.

Results reported for sums of individual parameters, such as Total Trihalomethanes (TTHM) and Total Haloacetic Acids (HAA5), may vary slightly from the sum of the individual parameter results. This apparent anomaly is caused by rounding individual results and summations at reporting, as required by EPA.

Following standard laboratory protocol, sample preservation, such as pH, is verified at time of extraction or analysis based on client requested parameters. Improper preservation is noted on the analytical bench sheet, extraction log, or preservation log and client is notified by close of following business day. All results are reported using preservation compliant samples unless otherwise noted in the analytical report.

The test results in this report meet all NELAP requirements for parameters for which accreditations are required or available. Any exceptions are noted in this report. This report may not be reproduced, except in full, without the written approval of REIC.

In compliance with federal guidelines and standard operating procedures, all reports, including raw data and supporting quality control, will be disposed of after five years unless otherwise arranged by the client via written notification or contract requirement.

If you have any questions please contact the project manager whose name is listed above.

REI Consultants, Inc. Analytical Results

Date: *02-Feb-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812I02 **Lab ID** 0812I02-01A
Client Sample ID:	FIELD BLANK	**DateReceived**	12/23/2008
Project:	08330106	**Collection Date:**	12/22/2008 5:30:00 PM
Site ID:	BATTLEFIELD GOLF CLUB	**Matrix:**	DRINKING WATER

Analyses	Result	Units	Qual	PQL	MCL	Prep Date	Date Analyzed
METALS BY ICP			**E200.7**			Analyst: **BP**	
Aluminum	ND	mg/L		0.100	0.200	12/24/08 12:16 PM	12/31/08 12:38 AM
Boron	ND	mg/L		0.100	NA	12/24/08 12:16 PM	12/31/08 12:38 AM
Iron	ND	mg/L		0.100	0.300	12/24/08 12:16 PM	12/31/08 12:38 AM
Magnesium	ND	mg/L		0.500	NA	12/24/08 12:16 PM	12/31/08 12:38 AM
Manganese	ND	mg/L		0.050	0.050	12/24/08 12:16 PM	12/31/08 12:38 AM
Silica (as SiO2)	ND	mg/L		0.210	NA	12/24/08 12:16 PM	12/29/08 2:57 PM
Sodium	ND	mg/L		0.500	NA	12/24/08 12:16 PM	12/31/08 12:38 AM
METALS BY ICP-MS			**E200.8**			Analyst: **BM**	
Antimony	ND	mg/L		0.0010	0.0060	12/24/08 12:16 PM	12/29/08 4:24 PM
Arsenic	ND	mg/L		0.0050	0.0100	12/24/08 12:16 PM	12/29/08 4:24 PM
Barium	ND	mg/L		0.100	2.00	12/24/08 12:16 PM	12/29/08 4:24 PM
Beryllium	ND	mg/L		0.0020	0.0040	12/24/08 12:16 PM	12/29/08 4:24 PM
Cadmium	ND	mg/L		0.0010	0.0050	12/24/08 12:16 PM	12/29/08 4:24 PM
Chromium	ND	mg/L		0.0050	0.100	12/24/08 12:16 PM	12/29/08 4:24 PM
Cobalt	ND	mg/L		0.100	NA	12/24/08 12:16 PM	12/29/08 4:24 PM
Copper	ND	mg/L		0.0500	1.30	12/24/08 12:16 PM	12/29/08 4:24 PM
Lead	ND	mg/L		0.0050	0.0150	12/24/08 12:16 PM	12/29/08 4:24 PM
Molybdenum	ND	mg/L		0.100	NA	12/24/08 12:16 PM	12/29/08 4:24 PM
Nickel	ND	mg/L		0.0100	0.100	12/24/08 12:16 PM	12/29/08 4:24 PM
Selenium	ND	mg/L		0.0050	0.0500	12/24/08 12:16 PM	12/29/08 4:24 PM
Silver	ND	mg/L		0.0500	NA	12/24/08 12:16 PM	12/29/08 4:24 PM
Thallium	ND	mg/L		0.0010	0.0020	12/24/08 12:16 PM	12/29/08 4:24 PM
Vanadium	ND	mg/L		0.0500	NA	12/24/08 12:16 PM	12/29/08 4:24 PM
Zinc	ND	mg/L		0.0100	5.00	12/24/08 12:16 PM	12/29/08 4:24 PM
HARDNESS, CALCIUM			**SM2340 B**			Analyst: **BP**	
Hardness, Calcium (As CaCO3)	ND	mg/L		1.00	NA		12/31/08 12:38 AM
HARDNESS			**SM2340 B**			Analyst: **BP**	
Hardness, Total (As CaCO3)	1.47	mg/L		1.00	NA	12/24/08 12:16 PM	12/31/08 12:38 AM
MERCURY, TOTAL			**E245.1**			Analyst: **CGW**	
Mercury	ND	mg/L		0.0010	0.0020	12/24/08 12:08 PM	12/30/08 10:52 AM
PCB			**E505**			Analyst: **Sub**	
Aroclor 1016	See Attached			NA	NA		
Aroclor 1221	See Attached			NA	NA		
Aroclor 1232	See Attached			NA	NA		
Aroclor 1242	See Attached			NA	NA		
Aroclor 1248	See Attached			NA	NA		

Key:
- MCL Maximum Contaminant Level
- MDL Minimum Detection Limit
- NA Not Applicable
- ND Not Detected at the PQL or MDL
- PQL Practical Quantitation Limit
- TIC Tentatively Identified Compound, Estimated Concentrati

Qualifiers:
- B Analyte detected in the associated Method Blank
- E Estimated Value above quantitation range
- H Holding times for preparation or analysis exceeded
- S Spike/Surrogate Recovery outside accepted recovery limit
- * Value exceeds Maximum Contaminant Level

REI Consultants, Inc. **Analytical Results** **Date:** *02-Feb-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812I02 **Lab ID** 0812I02-01A
Client Sample ID:	FIELD BLANK	**DateReceived**	12/23/2008
Project:	08330106	**Collection Date:**	12/22/2008 5:30:00 PM
Site ID:	BATTLEFIELD GOLF CLUB	**Matrix:**	DRINKING WATER

Analyses	Result	Units	Qual	PQL	MCL	Prep Date	Date Analyzed
PCB			**E505**			Analyst: **Sub**	
Aroclor 1254	See Attached			NA	NA		
Aroclor 1260	See Attached			NA	NA		
Chlordane	See Attached			NA	NA		
Toxaphene	See Attached			NA	NA		
SEMIVOLATILE ORGANIC COMPOUNDS			**E525.2**			Analyst: **Sub**	
Alachlor	See Attached			NA	NA		
Atrazine	See Attached			NA	NA		
Benzo(a)pyrene	See Attached			NA	NA		
Di(2-ethylhexyl)adipate	See Attached			NA	NA		
Di(2-ethylhexyl)phthalate	See Attached			NA	NA		
Endrin	See Attached			NA	NA		
gamma-BHC	See Attached			NA	NA		
Heptachlor	See Attached			NA	NA		
Heptachlor epoxide	See Attached			NA	NA		
Hexachlorobenzene	See Attached			NA	NA		
Hexachlorocyclopentadiene	See Attached			NA	NA		
Methoxychlor	See Attached			NA	NA		
Simazine	See Attached			NA	NA		
CARBAMATES 531.1			**E531.1**			Analyst: **Sub**	
Aldicarb	See Attached			NA	NA		
Aldicarb sulfone	See Attached			NA	NA		
Aldicarb sulfoxide	See Attached			NA	NA		
Carbofuran	See Attached			NA	NA		
Oxamyl	See Attached			NA	NA		
GLYPHOSATE 547			**E547**			Analyst: **Sub**	
Glyphosate	See Attached			NA	NA		
ENDOTHALL 548.1			**E548.1**			Analyst: **Sub**	
Endothall	See Attached			NA	NA		
DIQUAT 549.2			**E549.2**			Analyst: **Sub**	
Diquat	See Attached			NA	NA		
DIOXIN			**SW8280**			Analyst: **Sub**	
2,3,7,8-TCDD	See Attached			NA	NA		
SEMIVOLATILE ORGANIC COMPOUNDS BY EPA			**E504.1**			Analyst: **JG**	
1,2-Dibromo-3-chloropropane	ND	mg/L		0.000020	0.000200	01/02/09 1:30 PM	01/02/09 6:21 PM

Key:
MCL Maximum Contaminant Level
MDL Minimum Detection Limit
NA Not Applicable
ND Not Detected at the PQL or MDL
PQL Practical Quantitation Limit
TIC Tentatively Identified Compound, Estimated Concentrati

Qualifiers:
B Analyte detected in the associated Method Blank
E Estimated Value above quantitation range
H Holding times for preparation or analysis exceeded
S Spike/Surrogate Recovery outside accepted recovery limit
* Value exceeds Maximum Contaminant Level

REI Consultants, Inc.   Analytical Results

Date: *02-Feb-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812I02 **Lab ID** 0812I02-01A
Client Sample ID:	FIELD BLANK	**DateReceived**	12/23/2008
Project:	08330106	**Collection Date:**	12/22/2008 5:30:00 PM
Site ID:	BATTLEFIELD GOLF CLUB	**Matrix:**	DRINKING WATER

Analyses	Result	Units	Qual	PQL	MCL	Prep Date	Date Analyzed
SEMIVOLATILE ORGANIC COMPOUNDS BY EPA			**E504.1**			Analyst: **JG**	
1,2-Dibromoethane	ND	mg/L		0.000020	0.000050	01/02/09 1:30 PM	01/02/09 6:21 PM
SEMIVOLATILE ORGANIC COMPOUNDS			**E515.1**			Analyst: **JG**	
2,4,5-TP (Silvex)	ND	mg/L		0.000603	0.0500	12/23/08 2:00 PM	12/30/08 12:00 AM
2,4-D	ND	mg/L		0.000121	0.0700	12/23/08 2:00 PM	12/30/08 12:00 AM
Dalapon	ND	mg/L		0.00783	0.200	12/23/08 2:00 PM	12/30/08 12:00 AM
Dinoseb	ND	mg/L		0.000121	0.00700	12/23/08 2:00 PM	12/30/08 12:00 AM
Pentachlorophenol	ND	mg/L		0.000603	0.00100	12/23/08 2:00 PM	12/30/08 12:00 AM
Picloram	ND	mg/L		0.000603	0.500	12/23/08 2:00 PM	12/30/08 12:00 AM
VOLATILE ORGANIC COMPOUNDS			**E524.2**			Analyst: **SDG**	
Benzene	ND	µg/L		1.0	5.0		12/30/08 2:09 PM
Carbon tetrachloride	ND	µg/L		1.0	5.0		12/30/08 2:09 PM
1,2-Dichlorobenzene	ND	µg/L		1.0	600		12/30/08 2:09 PM
1,4-Dichlorobenzene	ND	µg/L		1.0	75.0		12/30/08 2:09 PM
1,2-Dichloroethane	ND	µg/L		1.0	5.0		12/30/08 2:09 PM
1,1-Dichloroethene	ND	µg/L		1.0	7.0		12/30/08 2:09 PM
cis-1,2-Dichloroethene	ND	µg/L		1.0	70.0		12/30/08 2:09 PM
trans-1,2-Dichloroethene	ND	µg/L		1.0	100		12/30/08 2:09 PM
1,2-Dichloropropane	ND	µg/L		1.0	5.0		12/30/08 2:09 PM
Ethylbenzene	ND	µg/L		1.0	700		12/30/08 2:09 PM
Methylene chloride	15.0	µg/L	*	1.0	5.0		12/30/08 2:09 PM
Styrene	ND	µg/L		1.0	100		12/30/08 2:09 PM
Tetrachloroethene	ND	µg/L		1.0	5.0		12/30/08 2:09 PM
Surr: 1,2-Dichlorobenzene-d4	85.4	%REC		75-125	NA		12/30/08 2:09 PM
Surr: 4-Bromofluorobenzene	85.8	%REC		75-125	NA		12/30/08 2:09 PM
RESIDUAL CHLORINE - LAB TEST, HOLD TIME E			**SM4500-CL-G**			Analyst: **CC**	
Chlorine, Total Residual	ND	µg/L		100	NA		12/24/08 11:30 AM
TURBIDITY			**SM2130 B**			Analyst: **CC**	
Turbidity	ND	NTU		0.50	0.50		12/24/08 9:30 AM
COLIFORM BY P/A			**SM9223 B**			Analyst: **CC**	
Fecal Coliform	ABSENT	NA		NA	NA	12/23/08 3:49 PM	12/24/08 3:49 PM
Total Coliform	ABSENT	NA		NA	NA	12/23/08 3:49 PM	12/24/08 3:49 PM
CYANIDE			**E335.4**			Analyst: **BA**	
Cyanide, Total	ND	mg/L		0.020	NA		12/24/08 9:00 AM

Key:			**Qualifiers:**	
	MCL	Maximum Contaminant Level	B	Analyte detected in the associated Method Blank
	MDL	Minimum Detection Limit	E	Estimated Value above quantitation range
	NA	Not Applicable	H	Holding times for preparation or analysis exceeded
	ND	Not Detected at the PQL or MDL	S	Spike/Surrogate Recovery outside accepted recovery limit
	PQL	Practical Quantitation Limit	*	Value exceeds Maximum Contaminant Level
	TIC	Tentatively Identified Compound, Estimated Concentrati		

REI Consultants, Inc. **Analytical Results** Date: *02-Feb-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812I02 **Lab ID** 0812I02-01A
Client Sample ID:	FIELD BLANK	**DateReceived**	12/23/2008
Project:	08330106	**Collection Date:**	12/22/2008 5:30:00 PM
Site ID:	BATTLEFIELD GOLF CLUB	**Matrix:**	DRINKING WATER

Analyses	Result	Units	Qual	PQL	MCL	Prep Date	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**E300.0**			Analyst: **CW**	
Chloride	ND	mg/L		1.00	250		12/30/08 11:22 PM
Fluoride	ND	mg/L		0.20	4.00		12/30/08 11:22 PM
Sulfate	ND	mg/L		5.00	250		12/30/08 11:22 PM
ANIONS BY ION CHROMATOGRAPHY			**E300.0**			Analyst: **CW**	
Nitrogen, Nitrate-Nitrite	0.41	mg/L		0.10	10.0		01/01/09 9:39 AM
TOTAL DISSOLVED SOLIDS			**SM2540 C**			Analyst: **DSA**	
Total Dissolved Solids	1	mg/L		1	500		12/24/08 10:07 PM
ALKALINITY			**SM2320 B**			Analyst: **DSA**	
Alkalinity, Total (As CaCO3)	4.1	mg/L		1.0	NA		12/24/08 7:45 AM
CORROSIVITY, LANGELIER INDEX			**SM2330 B**			Analyst: **IL**	
Langelier Index	-6.51	at 20 °C		NA	NA		01/05/09 12:00 AM
PH - LAB TEST, HOLD TIME EXPIRED			**SM4500-H+-B**			Analyst: **DSA**	
pH	6.08	SU		NA	NA		12/24/08 7:45 AM
ORGANIC CARBON, TOTAL			**SM5310 C**			Analyst: **DSA**	
Total Organic Carbon	ND	mg/L		1.00	NA		12/24/08 8:59 PM

Key:
- MCL Maximum Contaminant Level
- MDL Minimum Detection Limit
- NA Not Applicable
- ND Not Detected at the PQL or MDL
- PQL Practical Quantitation Limit
- TIC Tentatively Identified Compound, Estimated Concentrati

Qualifiers:
- B Analyte detected in the associated Method Blank
- E Estimated Value above quantitation range
- H Holding times for preparation or analysis exceeded
- S Spike/Surrogate Recovery outside accepted recovery limit
- * Value exceeds Maximum Contaminant Level

REIC

REI Consultants, Inc.
225 Industrial Park Rd.
P.O. Box 286, Beaver, WV 25813
Phone: 304-255-2500 or 800-999-0105
FAX: 304-255-2572
e-mail: rlabs@reiclabs.com

CHAIN OF CUSTODY RECORD NO. 263752

CLIENT: Schnabel Engineering
ADDRESS: 300 Ed Wright Lane Suite I
CITY/STATE/ZIP: Newport News, VA 23606
BILL TO: Same
CITY/STATE/ZIP:
PURCHASE ORDER #
QUOTE #

CONTACT PERSON: Russell Rountree
TELEPHONE #: 757-947-1220
FAX #: 757 947-1225
E-MAIL ADDRESS: rrountree@schnabel-eng.com
SITE ID & STATE: Battlefield Golf Club Water Project
PROJECT ID: 08330106
SAMPLER:

SAMPLE LOG AND ANALYSIS REQUEST

TURNAROUND TIME REQUIREMENTS
REGULAR: ___
*RUSH: ___ 5-Day ___ 3-Day ___ 2-Day ___ 1-Day
*Rush work needs prior Laboratory approval and will include surcharges

PRESERVATIVES
0 No Preservative
1 Hydrochloric Acid
2 Nitric Acid
3 Sulfuric Acid
4 Sodium Thiosulfate
5 Sodium Hydroxide
6 Zinc Acetate
7 EDTA

PRESERVATIVE CODES
NOTE PRESERVATIVES →

ANALYSIS REQUESTED & METHOD: Routine Chemical Analysis ✓; Full Chemical Analysis ✓; Synthetic Organic Compounds ✓; Trace Metals and other ✓; Asbestos

SAMPLE ID	NO. & TYPE OF CONTAINERS	SAMPLING DATE / TIME	MATRIX	SAMPLE COMP / GRAB	Routine Chemical Analysis	Full Chemical Analysis	Synthetic Organic Compounds	Trace Metals and other	Asbestos	COMMENTS
FIELD BLANK	20	12-22-08 5:30	W	G	/	/	/	/	/	

→ NO Asbestos per client. Sbe 12/23/08

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
[signature]	12-22-08 7:20	[signature]	12-23-08 1315				
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Temperature Upon Arrival 1.5 °C		☐ FAX Results	☒ Email Results

Fan CX

Pace Analytical™

www.pacelabs.com

Pace Analytical Services, Inc.
1700 Elm Street
Minneapolis, MN 55414
Phone: 612.607.1700
Fax: 612.607.6444

Report Prepared for:

Scott Gross
REI Consultants, Inc.
225 Industrial Park Dr.
Beaver WV 25813

Report Information:

Pace Project #: 1087000
Sample Receipt Date: 12/30/2008
Client Project #: 0812I02
Client Sub PO #: N/A
State Cert #: 9952C

REPORT OF LABORATORY ANALYSIS FOR 2,3,7,8-TCDD

Invoicing & Reporting Options:

The report provided has been invoiced as a Level 2 Drinking Water Report. If an upgrade of this report package is requested, an additional charge may be applied.

Please review the attached invoice for accuracy and forward any questions to Nate Habte, your Pace Project Manager.

Report Summary:

Enclosed are analytical results of one drinking water sample analyzed for 2,3,7,8-TCDD content. This sample was analyzed according to Method 1613B by High Resolution Gas Chromatography/High Resolution Mass Spectrometry.

The results reported for this sample and the associated quality control samples were all within the criteria described in Method 1613B; with the exception of a blank internal standard recovery below the target range for the method. If you have any questions or concerns regarding these results, please contact Nate Habte, your Pace Project Manager.

This report has been reviewed and prepared by:

For Nate Habte

Nate Habte, Project Manager
(612) 607-6407
(612) 607-6444 (fax)
natnael.habte@pacelabs.com

ACCREDITED IN ACCORDANCE WITH nelac

Report of Laboratory Analysis

Report Prepared Date:

January 12, 2009

1130

REI Consultants, Inc.
225 Industrial Park Drive
Beaver, WV 25813
TEL: 304.255.2500 FAX: 304.255.2572

CHAIN-OF-CUSTODY RECORD

187000

PACE – MN

Subcontractor:
EMSL ANALYTICAL
107 HADDON AV
WESTMONT, NJ 08108

TEL: (856) 858-4800
FAX:
Acct #:

23-Dec-08

Sample ID	Matrix	Date Collected	Bottle Type	Requested Tests: SW8280 ①						
0812I02-01A	Drinking Water	12/23/2008 2:45:09 PM	LS, PLASTIC, GLA	1						(10)

2378 – TCDD

General Comments:

State Code: VA
After analysis, the samples do not need to be returned and can be disposed per your standard laboratory practices.

① Method 1613 per Scott G. @ 12/30/08

		Date/Time			Date/Time
Relinquished by:	[signature]	12/29/08 @ 1600	Received by:		
Relinquished by:			Received by:	[signature] PACE	12/30/08 9:48

T=3.0

Report No....1087000_1613DW

Sample Condition Upon Receipt

Pace Analytical

Client Name: REI   Project # 1087000

Courier: ☐ Fed Ex ☑ UPS ☐ USPS ☐ Client ☐ Commercial ☐ Pace Other ______

Tracking #: 12 26X 71313616 0327

Optional
Proj. Due Date:
Proj. Name:

Custody Seal on Cooler/Box Present: ☐ yes ☑ no   Seals intact: ☐ yes ☑ no

Packing Material: ☐ Bubble Wrap ☐ Bubble Bags ☐ None ☐ Other ______   Temp Blank: Yes ____ No ✓

Thermometer Used: 80344042, 179425   Type of Ice: Wet Blue None   ☐ Samples on ice, cooling process has begun

Cooler Temperature: 3.0   Biological Tissue is Frozen: Yes No   Date and Initials of person examining contents: 12/30/08 SL

Temp should be above freezing to 6°C   Comments:

		Comments
Chain of Custody Present:	☑Yes ☐No ☐N/A	1.
Chain of Custody Filled Out:	☑Yes ☐No ☐N/A	2.
Chain of Custody Relinquished:	☑Yes ☐No ☐N/A	3.
Sampler Name & Signature on COC:	☐Yes ☑No ☐N/A	4.
Samples Arrived within Hold Time:	☑Yes ☐No ☐N/A	5.
Short Hold Time Analysis (<72hr):	☐Yes ☑No ☐N/A	6.
Rush Turn Around Time Requested:	☐Yes ☑No ☐N/A	7.
Sufficient Volume:	☑Yes ☐No ☐N/A	8.
Correct Containers Used:	☑Yes ☐No ☐N/A	9.
-Pace Containers Used:	☐Yes ☑No ☐N/A	
Containers Intact:	☑Yes ☐No ☐N/A	10.
Filtered volume received for Dissolved tests	☐Yes ☑No ☐N/A	11.
Sample Labels match COC:	☑Yes ☐No ☐N/A	12.
-Includes date/time/ID/Analysis Matrix: WT		
All containers needing acid/base preservation have been checked. Noncompliance are noted in 13.	☐Yes ☑No ☐N/A	13.
All containers needing preservation are found to be in compliance with EPA recommendation.	☐Yes ☑No ☐N/A	
Exceptions: VOA,Coliform, TOC, Oil and Grease, WI-DRO (water)	☐Yes ☑No	Initial when completed / Lot # of added preservative
Samples checked for dechlorination:	☐Yes ☑No ☐N/A	14.
Headspace in VOA Vials (>6mm):	☐Yes ☑No ☐N/A	15.
Trip Blank Present:	☐Yes ☑No ☐N/A	16.
Trip Blank Custody Seals Present	☐Yes ☐No ☑N/A	
Pace Trip Blank Lot # (if purchased):		

Client Notification/ Resolution: Field Data Required? Y / N

Person Contacted: ______________ Date/Time: ______________

Comments/ Resolution: ______________

Project Manager Review: ______________   Date: 12/30/08

Note: Whenever there is a discrepancy affecting North Carolina compliance samples, a copy of this form will be sent to the North Carolina DEHNR Certification Office (i.e. Out of hold, incorrect preservative, out of temp, incorrect containers)

F-ALL-C003rev.5, 5Aug2008

Pace Analytical™

Pace AnalyticalServices, Inc.
1700 Elm Street - Suite 200
Minneapolis, MN 55414

Tel: 612-607-1700
Fax: 612-607-6444

Drinking Water Analysis Results
2,3,7,8-TCDD -- USEPA Method 1613B

Sample ID...........0812I02-01A
Client...................REI Consultants, Inc.
Lab Sample ID.....1087000001

Date Collected.....12/23/2008
Date Received......12/30/2008
Date Extracted.....01/05/2009

	Sample 0812I02-01A	Method Blank	Lab Spike	Lab Spike Dup
[2,3,7,8-TCDD]	**ND**	ND	--	--
RL	5 pg/L	5 pg/L	--	--
2,3,7,8-TCDD Recovery	--	--	99%	102%
Spike Recovery Limit	--	--	73-146%	73-146%
RPD			2.8%	
IS Recovery	**60%**	30% !	75%	64%
IS Recovery Limits	31-137%	31-137%	25-141%	25-141%
CS Recovery	**87%**	77%	96%	83%
CS Recovery Limits	42-164%	42-164%	37-158%	37-158%
Filename	R90106A16	R90106A05	R90106A03	R90106A04
Analysis Date	01/06/2009	01/06/2009	01/06/2009	01/06/2009
Analysis Time	15:37	10:24	09:27	09:53
Analyst	SMT	SMT	SMT	SMT
Volume	0.955L	0.900L	0.907L	0.913L
Dilution	NA	NA	NA	NA
ICAL Date	12/31/2008	12/31/2008	12/31/2008	12/31/2008
CCAL Filename	R90106A02	R90106A02	R90106A02	R90106A02

! = Outside the Control Limits
ND = Not Detected
RL = Reporting Limit
Limits = Control Limits from Method 1613 (10/94 Revision), Tables 6A and 7A
RPD = Relative Percent Difference of Lab Spike Recoveries
IS = Internal Standard [2,3,7,8-TCDD-$^{13}C_{12}$]
CS = Cleanup Standard [2,3,7,8-TCDD-$^{37}Cl_4$]

Analyst: [signature]

Project No.............1087000

the standard in safety

Underwriters
Laboratories

LABORATORY REPORT

This report contains 4 pages.
(including the cover page)

If you have any questions concerning this report, please do not hesitate to call us at (800) 332-4345 or (574) 233-4777.

Underwriters Laboratories Inc.
110 S. Hill Street, South Bend, IN 46617-2702 USA
T:: 800.332.4345 / F:: 574.233.8207 / W:: ul.com

the standard in safety

Underwriters Laboratories

Laboratory Report

Client: REIC

Attn: Joy Mullins
225 Airport Industrial Park Road
P.O. Box 286
Beaver, WV 25813

Copies to: None

Report: 218271
Priority: Standard Written
Status: Final
PWS ID: Not Supplied

Sample Information

UL ID #	Client ID	Method	Collected Date / Time	Collected By:	Received Date / Time
1998304	0812I02-01A	505	12/23/08 14:45	Client	12/30/08 09:30
1998305	0812I02-01A	525.2	12/23/08 14:45	Client	12/30/08 09:30
1998306	0812I02-01A	531.1	12/23/08 14:45	Client	12/30/08 09:30
1998307	0812I02-01A	547	12/23/08 14:45	Client	12/30/08 09:30
1998308	0812I02-01A	548.1	12/23/08 14:45	Client	12/30/08 09:30
1998309	0812I02-01A	549.2	12/23/08 14:45	Client	12/30/08 09:30

Report Summary

Note: Sample containers, except for Method 549.2, were provided by the client.

Note: The samples submitted for Methods 549.2 and 548.1 analysis were analyzed outside the seven day hold time. The client was notified of the situation and analysis was authorized by Scott Gross of REIC.

Note: In the Method 525.2 analysis, heptachlor epoxide is not reportable in the sample submitted due to matrix interference.

Detailed quantitative results are presented on the following pages.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call Traci Chlebowski at (574) 233-4777.

Note: This report may not be reproduced, except in full, without written approval from Underwriters Laboratories (UL).

Traci Chlebowski — Authorized Signature

Project Manager — Title

1-20-09 — Date

Client Name: REIC
Report #: 218271

Underwriters Laboratories Inc.
110 S. Hill Street, South Bend, IN 46617-2702 USA
T.: 800.332.4345 / F.: 574.233.8207 / W.: ul.com

Client Name: REIC Report #: 218271

Sampling Point: 0812I02-01A PWS ID: Not Supplied

Semi-volatile Organic Chemicals									
Analyte ID #	Analyte	Method	Reg Limit	MRL†	Result	Units	Preparation Date	Analyzed	UL ID #
12674-11-2	Aroclor 1016	505	---	0.08	< 0.08	ug/L	12/31/08 13:50	12/31/08 22:54	1998304
11104-28-2	Aroclor 1221	505	---	0.19	< 0.19	ug/L	12/31/08 13:50	12/31/08 22:54	1998304
11141-16-5	Aroclor 1232	505	---	0.23	< 0.23	ug/L	12/31/08 13:50	12/31/08 22:54	1998304
53469-21-9	Aroclor 1242	505	---	0.26	< 0.26	ug/L	12/31/08 13:50	12/31/08 22:54	1998304
12672-29-6	Aroclor 1248	505	---	0.1	< 0.1	ug/L	12/31/08 13:50	12/31/08 22:54	1998304
11097-69-1	Aroclor 1254	505	---	0.1	< 0.1	ug/L	12/31/08 13:50	12/31/08 22:54	1998304
11096-82-5	Aroclor 1260	505	---	0.2	< 0.2	ug/L	12/31/08 13:50	12/31/08 22:54	1998304
57-74-9	Chlordane	505	2 *	0.1	< 0.1	ug/L	12/31/08 13:50	12/31/08 22:54	1998304
8001-35-2	Toxaphene	505	3 *	1.0	< 1.0	ug/L	12/31/08 13:50	12/31/08 22:54	1998304
15972-60-8	Alachlor	525.2	2 *	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
309-00-2	Aldrin	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
1912-24-9	Atrazine	525.2	3 *	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
50-32-8	Benzo[a]pyrene	525.2	0.2 *	0.02	< 0.02	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
58-89-9	gamma-BHC (Lindane)	525.2	0.2 *	0.02	< 0.02	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
23184-66-9	Butachlor	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
60-57-1	Dieldrin	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
103-23-1	Di(2-ethylhexyl)adipate	525.2	400 *	0.6	< 0.6	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
117-81-7	Di(2-ethylhexyl)phthalate	525.2	6 *	0.6	< 0.6	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
72-20-8	Endrin	525.2	2 *	0.01	< 0.01	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
76-44-8	Heptachlor	525.2	0.4 *	0.04	< 0.04	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
118-74-1	Hexachlorobenzene	525.2	1 *	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
77-47-4	Hexachlorocyclopentadiene	525.2	50 *	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
72-43-5	Methoxychlor	525.2	40 *	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
51218-45-2	Metolachlor	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
21087-64-9	Metribuzin	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
1918-16-7	Propachlor	525.2	---	0.1	< 0.1	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
122-34-9	Simazine	525.2	4 *	0.07	< 0.07	ug/L	12/31/08 09:30	12/31/08 21:47	1998305
116-06-3	Aldicarb	531.1	---	0.5	< 0.5	ug/L	12/31/08 08:20	12/31/08 19:11	1998306
1646-88-4	Aldicarb sulfone	531.1	---	0.7	< 0.7	ug/L	12/31/08 08:20	12/31/08 19:11	1998306
1646-87-3	Aldicarb sulfoxide	531.1	---	0.5	< 0.5	ug/L	12/31/08 08:20	12/31/08 19:11	1998306
63-25-2	Carbaryl	531.1	---	0.5	< 0.5	ug/L	12/31/08 08:20	12/31/08 19:11	1998306
1563-66-2	Carbofuran	531.1	40 *	0.9	< 0.9	ug/L	12/31/08 08:20	12/31/08 19:11	1998306
16655-82-6	3-Hydroxycarbofuran	531.1	---	0.5	< 0.5	ug/L	12/31/08 08:20	12/31/08 19:11	1998306
16752-77-5	Methomyl	531.1	---	0.5	< 0.5	ug/L	12/31/08 08:20	12/31/08 19:11	1998306
23135-22-0	Oxamyl	531.1	200 *	1.0	< 1.0	ug/L	12/31/08 08:20	12/31/08 19:11	1998306
1071-83-6	Glyphosate	547	700 *	6.0	< 6.0	ug/L	12/31/08 13:00	01/02/09 19:47	1998307
145-73-3	Endothall	548.1	100 *	9.0	< 9.0	ug/L	12/31/08 08:05	01/05/09 19:40	1998308
85-00-7	Diquat	549.2	20 *	0.4	< 0.4	ug/L	12/31/08 08:20	12/31/08 13:24	1998309

Any positive Aroclor result would require analysis for total PCB as decachlorobiphenyl by method 508A (MCL = 0.5 ug/L)

† UL has demonstrated it can achieve these report limits in reagent water, but can not document them in all sample matrices.

Reg Limit Type:	MCL	SMCL	AL
Symbol:	*	^	!

173036

REI Consultants, Inc.
225 Industrial Park Drive
Beaver, WV 25813
TEL: *304.255.2500* FAX: *304.255.2572*

CHAIN-OF-CUSTODY RECORD

Subcontractor:
UNDERWRITERS LABORATORIES
110 SOUTH HILL STREET
SOUTH BEND, IN 46617

TEL: (574) 233-4777
FAX:
Acct #:

218271

23-Dec-08

Sample ID	Matrix	Date Collected	Bottle Type	Requested Tests						
				1998304	1998305	1998306	1998307	1998308	1998309	
				E505	E525.2	E531.1	E547	E548.1	E549.2	
0812I02-01A	Drinking Water	12/23/2008 2:45:09 PM	ALS, PLASTIC, GLA	1	1	1	1	1	1	

> all but 549.2

548 + 549 rcvd last day of HT pm 1230

2.8°C wet

General Comments:
State Code: VA
After analysis, the samples do not need to be returned and can be disposed per your standard laboratory practices.

		Date/Time			Date/Time
Relinquished by:	[signature]	12/23/08 1600	Received by:	UPS	
Relinquished by:			Received by:	[signature]	123008 0930

APPENDIX C

Soil Laboratory Test Data

Summary of Laboratory Tests (1 Sheet)
Gradation Curves (2 Sheets)
Hydraulic Conductivity Determination (2 Sheets)

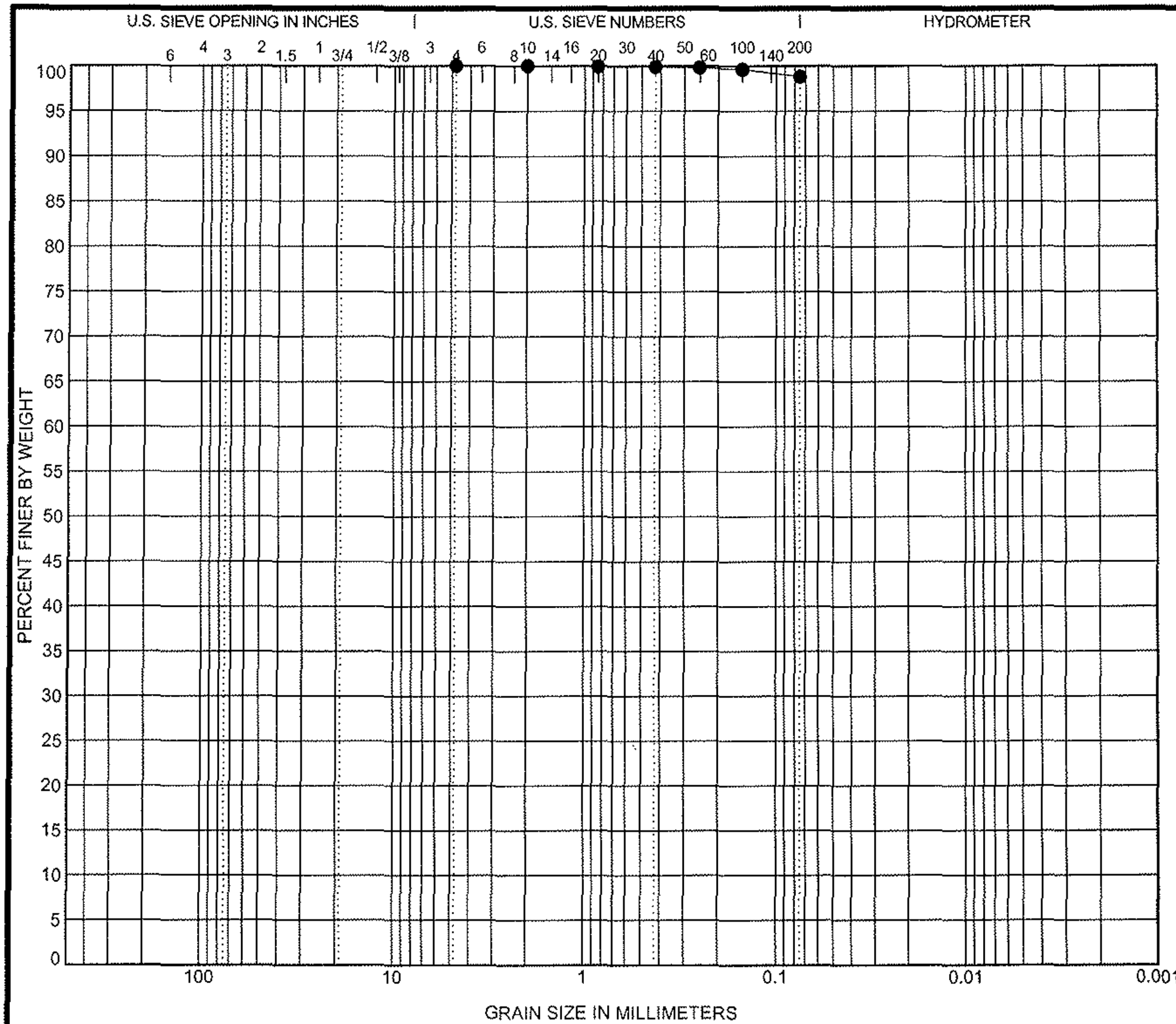
Summary Of Laboratory Tests

Boring No.	Sample Depth ft / Elevation ft	Sample Type	Description of Soil Specimen	Wet Natural Density (pcf)	Natural Moisture (%)	Liquid Limit	Plastic Limit	Plasticity Index	% Passing No. 200 Sieve	% Passing No. 40 Sieve	% Retained No. 4 Sieve
MW-1	55.0-57.0	Tube	LEAN CLAY (CL), contains sand - gray	116.1	37.0	38	24	14	98.8	99.9	0.0
MW-1	60.0-62.0	Tube	LEAN CLAY WITH SAND (CL) - gray	115.3	37.6	33	23	10	81.3	98.1	0.2

Notes:
1. Soil tests in general accordance with ASTM standards.
2. Soil classifications are in general accordance with ASTM D2487(as applicable), based on testing indicated and visual classification.
3. Key to abbreviations: NP=Non-Plastic; -- indicates no test performed

Schnabel
Schnabel Engineering

Project: Battlefield Golf Club Water Project
Bonney Road and Murray Drive
Chesapeake, VA



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen	Sample Description	LL	PL	PI		
● MW-1 55.0 ft	LEAN CLAY (CL), contains sand - gray	38	24	14		

Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
ASTM D422	4.75				0.0	1.2	98.8	

Percent Finer

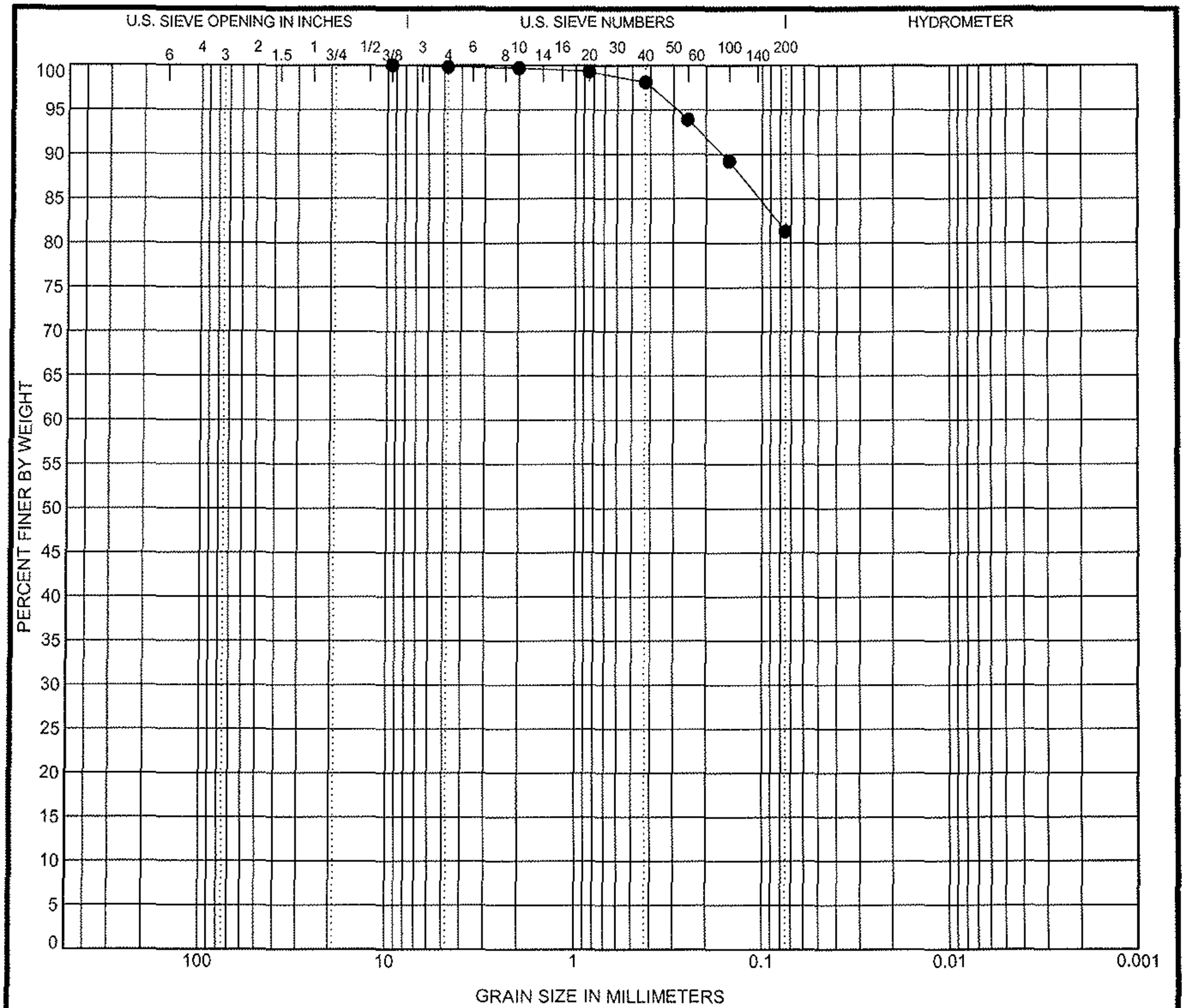
Sieve Size	No. 200	No. 100	No. 60	No. 40	No. 20	No. 10	No. 4
% Finer	98.8	99.6	99.8	99.9	99.9	100.0	100.0

Tested By	Tested Date	Reviewed By	Calc By
DWC	12/10/08	CJS	MJF

Schnabel Engineering

GRADATION CURVE

Project: Battlefield Golf Club Water Project
Bonney Road and Murray Drive
Chesapeake, VA
Contract: 08330106



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen		Sample Description	LL	PL	PI		
●	MW-1	60.0 ft	LEAN CLAY WITH SAND (CL) - gray	33	23	10		

Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
ASTM D422	**9.5**				**0.2**	**18.5**	**81.3**	

Percent Finer

Sieve Size	No. 200	No. 100	No. 60	No. 40	No. 20	No. 10	No. 4	3/8 in.
% Finer	81.3	89.2	93.9	98.1	99.3	99.7	99.8	100.0

Tested By	Tested Date	Reviewed By	Calc By
DWC	12/10/08	CJS	MJF

Schnabel Engineering

GRADATION CURVE

Project: Battlefield Golf Club Water Project
Bonney Road and Murray Drive
Chesapeake, VA

Contract: 08330106

SIEVE 1/SHEET 08330106.GPJ SCHNABEL DATA TEMPLATE 2008_04_22.GDT 2/3/09

Hydraulic Conductivity Determination

Schnabel Engineering

Using Flexible Wall Permeameter (ASTM D5084) 12/22/2008

Project:	Battlefield Golf Club Water Project	Schnabel No.:	08330106
	Bonney Road and Murray Drive	Boring No.:	MW-1
Location:	Chesapeake, VA	Depth:	55-57 ft.

Specimen Data

Specimen Type:	Tube Sample	Cell Press., psi:	40.0
Consol. Stress (psi):	20.0	Back Press., psi:	20.0
Soil Description:	LEAN CLAY (CL), contains sand - gray	Specific Gravity:	2.68

Remarks: Gs assumed.

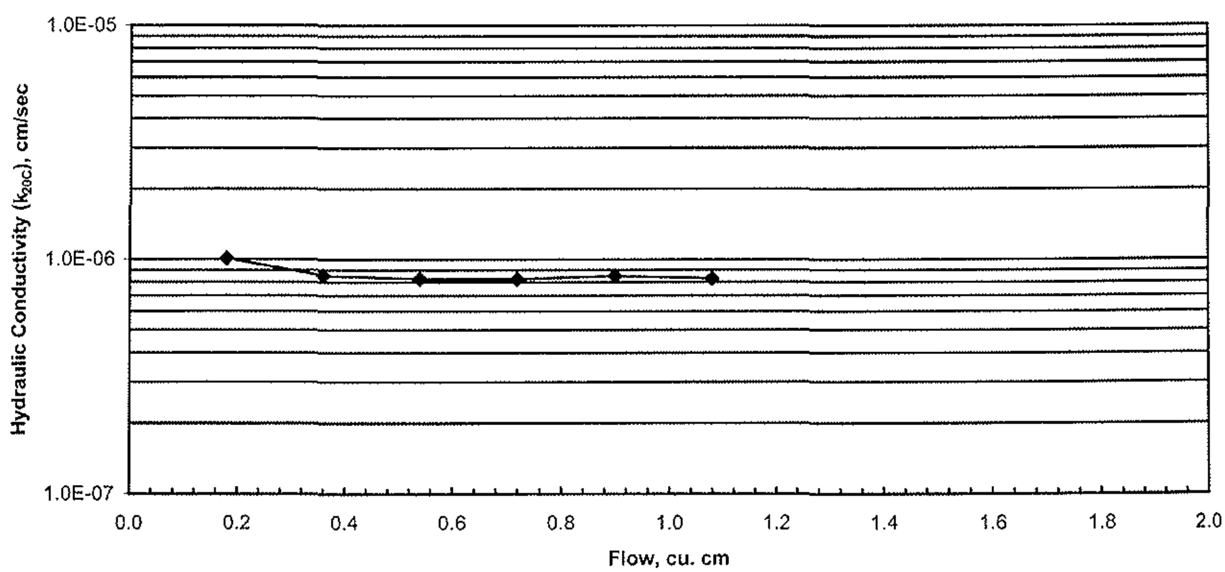
	Initial	Final
Height (in.):	1.33	1.32
Diameter (in.):	2.885	2.84
Volume (in^3):	8.67	8.35
Volume (cm^3):	142.1	136.8
Moist Unit Weight (pcf):	114.9	118.4
Moisture Content (%):	37.0	35.9
Dry Unit Weight (pcf):	83.9	87.1
Saturation:	100	100
Void Ratio:	0.99	0.92

Liquid Limit (LL):	38
Plasticity Index (PI):	14
% < No. 200 Sieve:	98.8

Test Data

Permeant:	De-Aired Water
Hydraulic Gradient:	5
Hydraulic Conductivity (k_{20C}), cm/sec:	8.3E-07

Hydraulic Conductivity vs. Flow



Schnabel Engineering

Hydraulic Conductivity Determination

Using Flexible Wall Permeameter (ASTM D5084)

12/22/2008

Project:	Battlefield Golf Club Water Project	Schnabel No.:	08330106
	Bonney Road and Murray Drive	Boring No.:	MW-1
Location:	Chesapeake, VA	Depth:	60-62 ft.

Specimen Data

Specimen Type:	Tube Sample	Cell Press., psi:	45.0
Consol. Stress (psi):	25.0	Back Press., psi:	20.0
Soil Description:	LEAN CLAY WITH SAND (CL) - gray	Specific Gravity:	2.68
Remarks:	Gs assumed.		

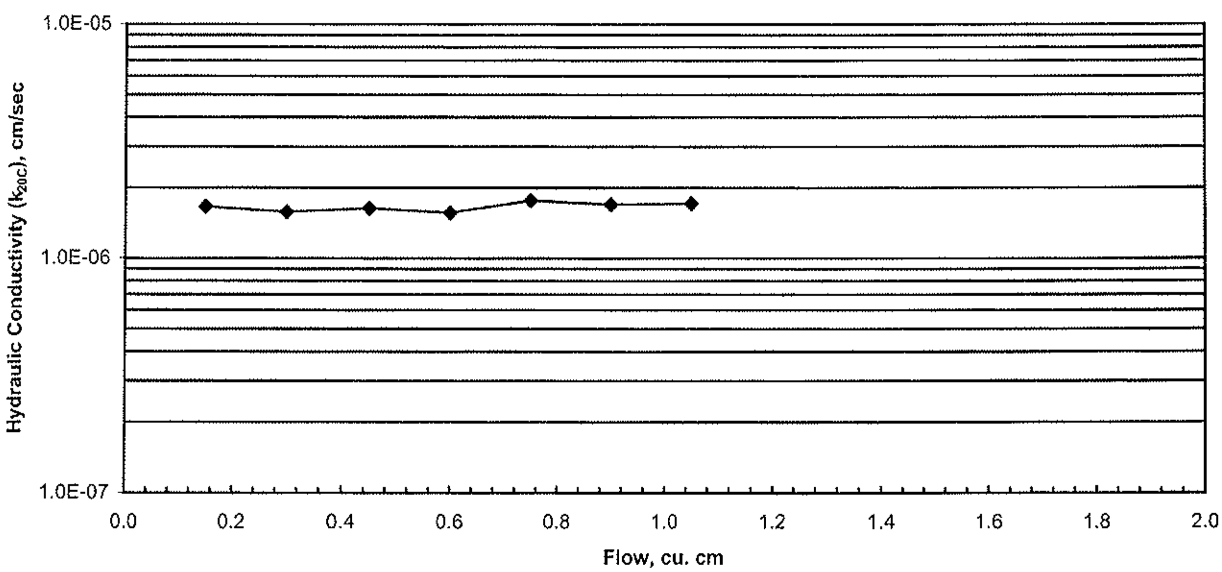
	Initial	Final
Height (in.):	1.34	1.31
Diameter (in.):	2.886	2.78
Volume (in^3):	8.75	7.97
Volume (cm^3):	143.3	130.6
Moist Unit Weight (pcf):	117.0	127.9
Moisture Content (%):	29.5	28.9
Dry Unit Weight (pcf):	90.4	99.2
Saturation:	93	100
Void Ratio:	0.85	0.69

Liquid Limit (LL):	33
Plasticity Index (PI):	10
% < No. 200 Sieve:	81.3

Test Data

Permeant:	De-Aired Water
Hydraulic Gradient:	5
Hydraulic Conductivity (k_{20C}), cm/sec:	1.7E-06

Hydraulic Conductivity vs. Flow



APPENDIX G
Existing Well Groundwater Quality Data

Table 1: Existing Well Information

Water Supply Feasibility Study
Murray Drive -- Whittamore Road Project
City of Chesapeake, VA

Address	Well Depth (ft bgs)	Screen Interval (ft bgs)	Yield (gpm)
Blue Ridge Road			
1505 Blue Ridge	60	50-60	
1521 Blue Ridge	93	60-70	
Centerville Turnpike			
815 Centerville	60	50-60	
1020 Centerville	80	70-80	
1104 Centerville	105	95-105	
Murray Drive			
1101 Murray	123	100-123	
1104 Murray	122	107-122	18
1204 Murray	80	67-80	12
1205 Murray		70-80	
1208 Murray	50	40-50	25
1212 Murray		46	
1215 Murray	43	38-43	25
1220 Murray		42	
1300 Murray	80	75-80	
1304 Murray		45	
1305 Murray	42	32-42	25
1312 Murray		45	
1313 Murray	80	50-80	20
1316 Murray	130	70-130	20
1317 Murray	48	43-48	25
1320 Murray	80	65-80	18
1324 Murray	90	85-90	10
1325 Murray	32	25-32	15
1328 Murray	45	35-45	20
1329 Murray	53	42-53	
1379 Murray	53	42-53	20
Whittamore Road			
1405 Whittamore	55	40-55	10
1407 Whittamore	41	20-40	
1469 Whittamore	42	37-42	

SUMMARY

# of wells w/ screen interval info		29
	Screen interval =20-40 ft bgs	4
	=40-70 ft bgs	16
	=70-90 ft bgs	5
	>100 ft bgs	4
	Average well depth=	71 ft
# of wells w/ yield data		14
	Average yield=	19 gpm

Table 2: Existing Well Water Quality

Water Supply Feasibility Study

Murray Drive -- Whittamore Road Project

City of Chesapeake, VA

Address	Date	As (mg/L)	Ba (mg/L)	Cr (mg/L)	Cd (mg/L)	Pb (mg/L)	Se (mg/L)	Ag (mg/L)	V (mg/L)	Hg (mg/L)	B (mg/L)	Co (mg/L)	Mn (mg/L)	Ni (mg/L)	Zn (mg/L)	Sb (mg/L)	Be (mg/L)	Tl (mg/L)	Cu (mg/L)	Fe (mg/L)	CN (mg/L)	F (mg/L)
Primary MCL		0.010	2.000	0.100	0.005	0.015	0.050		N/A	0.002		N/A		N/A		0.006	0.004	0.002	1.3		0.2	4
Secondary MCL								0.100					0.050		5.000					0.3		2
WHO											0.500											
Blue Ridge Road																						
1505 Blue Ridge	12/05/01	<0.002	<0.1	<0.0005	0.0005	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	0.26	<0.05	0.034	<0.003	0.0008	<0.001	<0.015	1.89	<0.005	<0.1
1521 Blue Ridge	12/04/01	<0.002	<0.1	<0.0005	<0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	<0.1	<0.005	<0.1
1533 Blue Ridge	04/14/08	<	0.0740	<	<	<	<	<	<	<	0.2000	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Centerville Turnpike																						
815 Centerville	12/03/01	0.004	<0.1	0.001	0.0001	0.003	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	<0.1	<0.005	<0.1
833 Centerville	04/08/08	<	0.0260	<	<	<	<	<	<	<	0.0340	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
901 Centerville	04/08/08	<	<	<	<	0.0100	<	<	<	<	0.0840	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
905 Centerville	12/04/01	<0.002	<0.1	<0.0005	0.0002	0.005	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	0.115	<0.1	<0.005	<0.1
909 Centerville	04/14/08	<	<	<	<	0.0020	<	<	<	<	0.0580	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
911 Centerville	04/14/08	<	<	<	<	<	<	<	<	<	0.0190	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1004 Centerville	12/05/01	<0.002	<0.1	<0.0005	<0.0001	0.009	<0.002	<0.0002	NT	<0.0002	NT	NT	0.17	<0.05	0.04	<0.003	0.0005	<0.001	0.402	5.53	<0.005	<0.1
1004 Centerville	12/05/01	<0.002	<0.1	<0.0005	<0.0001	0.002	<0.002	<0.0002	NT	<0.0002	NT	NT	0.18	<0.05	0.04	<0.003	0.0005	<0.001	0.362	5.67	<0.005	<0.1
1020 Centerville	12/03/01	<0.002	<0.1	<0.0005	0.0002	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	0.07	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	1.97	<0.005	<0.1
1102 Centerville	04/07/08	<	<	<	<	<	<	<	<	<	0.0410	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1104 Centerville	12/03/01	<0.002	<0.1	0.001	0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	0.04	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	0.38	<0.005	<0.1
1104 Centerville	04/08/08	<	<	<	<	0.0020	<	<	<	<	0.0530	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1200 Centerville	04/12/08	<	<	<	<	<	<	<	<	<	0.0450	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1208 Centerville	04/12/08	<	<	<	<	<	<	<	<	<	0.0440	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1216 Centerville	04/12/08	<	<	<	<	<	<	<	<	<	0.0450	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1224 Centerville	12/04/01	<0.002	<0.1	<0.0005	<0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	<0.1	<0.005	<0.1
1224 Centerville	04/12/08	<	<	<	<	<	<	<	<	<	0.0440	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1228 Centerville	04/12/08	<	<	<	<	<	<	<	<	<	0.0450	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Murray Drive																						
1101 Murray	12/10/01	<0.002	<0.1	<0.0005	<0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	0.19	<0.005	0.24
1101 Murray	04/06/08	<	0.1020	<	<	<	<	<	<	<	<	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1101 Murray	04/06/08	<	0.0690	<	0.0015	0.0020	<	<	<	<	0.0200	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1101 Murray	07/18/08	<0.0020	<0.005	<0.001	<0.0005	<0.001	<0.0020	<0.001	<0.005	<0.0002	0.108	<0.005	<0.005	<0.005	<0.005	NT	NT	NT	NT	NT	NT	NT
1101 Murray	07/18/08	<0.0020	0.083	<0.001	<0.0005	0.001	<0.0020	<0.001	<0.005	<0.0002	0.022	<0.005	0.250	<0.005	<0.005	NT	NT	NT	NT	NT	NT	NT
1104 Murray	12/06/01	<0.002	<0.1	<0.0005	<0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	<0.1	<0.005	0.24
1104 Murray	04/12/08	<	<	<	<	<	<	<	<	<	0.1370	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1104 Murray	07/18/08	<0.0020	<0.005	<0.001	<0.0005	0.011	<0.0020	<0.001	<0.005	<0.0002	0.148	<0.005	<0.005	<0.005	0.147	NT	NT	NT	NT	NT	NT	NT
1105 Murray	11/30/01	<0.002	<0.1	<0.0005	<0.0001	0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	0.001	0.069	<0.1	<0.005	0.17
1105 Murray	04/07/08	<	<	<	<	<	<	<	<	<	0.1500	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1105 Murray	07/18/08	<0.0020	<0.005	<0.001	<0.0005	<0.001	<0.0020	<0.001	<0.005	<0.0002	0.159	<0.005	<0.005	<0.005	0.009	NT	NT	NT	NT	NT	NT	NT
1108 Murray	04/12/08	<	<	<	<	<	<	<	<	<	0.1150	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1108 Murray	07/18/08	<0.0020	<0.005	<0.001	<0.0005	<0.001	<0.0020	<0.001	<0.005	<0.0002	0.122	<0.005	0.007	<0.005	0.010	NT	NT	NT	NT	NT	NT	NT
1109 Murray	04/07/08	<	0.0100	<	0.0005	0.0010	<	<	<	<	0.0180	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1112 Murray	12/04/01	<0.002	<0.1	<0.0005	<0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	0.19	<0.005	0.2
1112 Murray	04/07/08	<	<	<	<		<	<	<	<	0.1430	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

Address	Date	As (mg/L)	Ba (mg/L)	Cr (mg/L)	Cd (mg/L)	Pb (mg/L)	Se (mg/L)	Ag (mg/L)	V (mg/L)	Hg (mg/L)	B (mg/L)	Co (mg/L)	Mn (mg/L)	Ni (mg/L)	Zn (mg/L)	Sb (mg/L)	Be (mg/L)	Tl (mg/L)	Cu (mg/L)	Fe (mg/L)	CN (mg/L)	F (mg/L)
Primary MCL		0.010	2.000	0.100	0.005	0.015	0.050		N/A	0.002		N/A		N/A		0.006	0.004	0.002	1.3		0.2	4
Secondary MCL								0.100					0.050		5.000					0.3		2
WHO											0.500											
Murray Drive																						
1113 Murray	12/04/01	<0.002	<0.1	<0.0005	<0.0001	0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	<0.1	<0.005	0.16
1113 Murray	04/07/08	<	<	<	<	0.0010	<	<	<	<	0.1640	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1113 Murray	07/19/08	<0.0020	<0.005	<0.001	<0.0005	<0.001	<0.0020	<0.001	<0.005	<0.0002	0.180	<0.005	<0.005	<0.005	0.006	NT	NT	NT	NT	NT	NT	NT
1116 Murray	12/06/01	<0.002	<0.1	<0.0005	0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	0.22	<0.005	0.24
1116 Murray	05/12/08	<	<	<	<	<	<	<	<	<	0.1620	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1117 Murray	12/04/01	<0.002	<0.1	<0.0005	<0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	0.001	<0.015	0.27	<0.005	0.18
1117 Murray	04/08/08	<	<	<	<	<	<	<	<	<	0.1440	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1117 Murray	07/18/08	<0.0020	<0.005	<0.001	<0.0005	<0.001	<0.0020	<0.001	<0.005	<0.0002	0.158	<0.005	<0.005	<0.005	<0.005	NT	NT	NT	NT	NT	NT	NT
1120 Murray	04/12/08	<	<	<	<	<	<	<	<	<	0.1720	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1120 Murray	07/18/08	<0.0020	<0.005	<0.001	<0.0005	<0.001	<0.0020	<0.001	<0.005	<0.0002	0.187	<0.005	<0.005	<0.005	<0.005	NT	NT	NT	NT	NT	NT	NT
1121 Murray	04/07/08	<	<	<	<	0.0010	<	<	<	<	0.0200	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1124 Murray	12/06/01	<0.002	<0.1	<0.0005	0.0001	0.004	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	0.021	<0.003	<0.0001	<0.001	<0.015	0.31	<0.005	0.26
1124 Murray	04/06/08	<	0.1220	<	<	<	<	<	<	<	<	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1124 Murray	07/18/08	<0.0020	<0.005	<0.001	<0.0005	<0.001	<0.0020	<0.001	<0.005	<0.0002	0.128	<0.005	0.007	<0.005	<0.005	NT	NT	NT	NT	NT	NT	NT
1125 Murray	11/30/01	<0.002	<0.1	<0.0005	0.0001	0.002	<0.002	<0.0002	NT	0.0007	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	0.002	<0.015	0.15	<0.005	0.16
1125 Murray	04/14/08	<	<	<	<	<	<	<	<	<	0.1890	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1200 Murray	04/06/08	<	0.2080	<	<	<	<	<	<	<	<	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1200 Murray	07/19/08	<0.0020	<0.005	<0.001	<0.0005	<0.001	<0.0020	<0.001	<0.005	<0.0002	0.220	<0.005	<0.005	<0.005	<0.005	NT	NT	NT	NT	NT	NT	NT
1201 Murray	12/10/01	<0.002	<0.1	<0.0005	<0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	0.23	<0.005	0.29
1201 Murray	04/06/08	<	0.1950	<	<	<	<	<	<	<	<	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1201 Murray	07/19/08	<0.0020	<0.005	<0.001	<0.0005	<0.001	<0.0020	<0.001	<0.005	<0.0002	0.206	<0.005	<0.005	<0.005	0.013	NT	NT	NT	NT	NT	NT	NT
1204 Murray	12/04/01	<0.002	<0.1	<0.0005	<0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	0.32	<0.005	0.25
1204 Murray	04/08/08	<	<	<	<	<	<	<	<	<	0.1590	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1204 Murray	07/19/08	<0.0020	<0.005	<0.001	<0.0005	<0.001	<0.0020	<0.001	<0.005	<0.0002	0.174	<0.005	0.008	<0.005	0.138	NT	NT	NT	NT	NT	NT	NT
1205 Murray	04/07/08	<	<	<	<	<	<	<	<	<	0.1550	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1205 Murray	07/19/08	<0.0020	<0.005	<0.001	<0.0005	<0.001	<0.0020	<0.001	<0.005	<0.0002	0.167	<0.005	0.006	<0.005	<0.005	NT	NT	NT	NT	NT	NT	NT
1208 Murray	12/04/01	<0.002	<0.1	0.001	<0.0001	0.006	<0.002	0.0003	NT	<0.0002	NT	NT	0.11	<0.05	<0.015	<0.003	<0.0001	<0.001	1.623	1.07	<0.005	0.19
1208 Murray	04/12/08	<	0.0070	<	<	0.0020	<	<	<	<	0.1130	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1209 Murray	04/06/08	<	0.1920	<	<	[illegible]	<	<	<	<	<	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1209 Murray	07/19/08	<0.0020	<0.005	<0.001	<0.0005		<0.0020	<0.001	<0.005	<0.0002	0.202	<0.005	0.008	<0.005	<0.005	NT	NT	NT	NT	NT	NT	NT
1212 Murray	04/27/08	<	0.0080	<	<	0.0050	<	<	<	<	0.1310	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1213 Murray	04/06/08	<	0.3960	<	<	0.0010	<	<	<	<	<	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1213 Murray	04/27/08	<	<	<	<	0.0020	<	<	<	<	0.4020	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1213 Murray	07/19/08	<0.0020	<0.005	<0.001	<0.0005	0.006	0.0029	<0.001	<0.005	<0.0002	0.403	<0.005	<0.005	<0.005	<0.005	NT	NT	NT	NT	NT	NT	NT
1215 Murray	12/06/01	<0.002	<0.1	<0.0005	0.0004	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	0.026	<0.003	<0.0001	<0.001	<0.015	<0.1	<0.005	0.29
1215 Murray	04/06/08	<	0.1040	<	<	<	<	<	<	<	<	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1215 Murray	07/18/08	<0.0020	0.017	<0.001	<0.0005	<0.001	<0.0020	<0.001	<0.005	<0.0002	0.116	<0.005	0.119	<0.005	<0.005	NT	NT	NT	NT	NT	NT	NT
1216 Murray	04/07/08	<	<	<	<	<	<	<	<	<	0.2940	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1216 Murray	04/27/08	<	<	<	<	0.0020	<	<	<	<	0.3010	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1216 Murray	07/19/08	<0.0020	<0.005	<0.001	<0.0005	<0.001	0.0029	<0.001	<0.005	<0.0002	0.305	<0.005	0.010	<0.005	<0.005	NT	NT	NT	NT	NT	NT	NT
1219 Murray	04/12/08	<	0.0120	<	<	<	<	<	<	<	0.0890	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1220 Murray	04/07/08	<	0.0120	<	<	<	<	<	<	<	0.1040	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1220 Murray	07/18/08	<0.0020	0.012	<0.001	<0.0005	0.004	<0.0020	<0.001	<0.005	<0.0002	0.113	<0.005	0.096	<0.005	0.113	NT	NT	NT	NT	NT	NT	NT

Address	Date	As (mg/L)	Ba (mg/L)	Cr (mg/L)	Cd (mg/L)	Pb (mg/L)	Se (mg/L)	Ag (mg/L)	V (mg/L)	Hg (mg/L)	B (mg/L)	Co (mg/L)	Mn (mg/L)	Ni (mg/L)	Zn (mg/L)	Sb (mg/L)	Be (mg/L)	Tl (mg/L)	Cu (mg/L)	Fe (mg/L)	CN (mg/L)	F (mg/L)
Primary MCL		0.010	2.000	0.100	0.005	0.015	0.050		N/A	0.002		N/A		N/A		0.006	0.004	0.002	1.3		0.2	4
Secondary MCL								0.100					0.050		5.000					0.3		2
WHO											0.500											
Murray Drive																						
1300 Murray	11/30/01	<0.002	<0.1	<0.0005	0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	0.28	<0.05	<0.015	<0.003	<0.0001	0.001	<0.015	[illegible]	<0.005	0.12
1300 Murray	04/12/08	<	<	<	<	<	<	<	<	<	0.0670	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1301 Murray	11/30/01	<0.002	<0.1	<0.0005	0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	0.002	<0.015	0.27	<0.005	0.23
1301 Murray	04/07/08	<	<	<	<	0.0010	<	<	<	<	0.5600	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1301 Murray	07/19/08	<0.002	<0.005	<0.001	<0.0005	0.001	0.0045	<0.001	<0.005	<0.0002	0.586	<0.005	<0.005	<0.005	<0.005	NT	NT	NT	NT	NT	NT	NT
1304 Murray	04/14/08	<	<	<	<	0.0040	<	<	<	<	0.0420	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1304 Murray	04/27/08	<	0.0160	<	<	0.0040	<	<	<	<	0.0500	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1305 Murray	04/12/08	<	<	<	<	<	<	<	<	<	0.0490	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1305 Murray	04/12/08	<	0.0210	<	<	0.0030	<	<	<	<	0.0680	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1308 Murray	12/10/01	<0.002	<0.1	<0.0005	0.0004	0.003	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	1.54	<0.1	<0.005	0.36
1308 Murray	04/27/08	<	0.0220	<	0.0008	0.0020	<	<	<	<	0.0550	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1309 Murray	04/12/08	<	0.0240	<	<	0.0020	<	<	<	<	0.0490	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1312 Murray	04/14/08	<	0.0780	<	0.0010	0.0070	<	<	<	<	0.0500	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1313 Murray	04/12/08	<	0.0140	<	0.0008	<	<	<	<	<	<	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1316 Murray	04/08/08	<	0.0300	<	0.0010	<	<	<	<	<	0.0090	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1317 Murray	11/30/01	<0.002	<0.1	<0.0005	<0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	0.23	<0.05	<0.015	<0.003	<0.0001	0.001	<0.015	[illegible]	<0.005	0.23
1317 Murray	04/06/08	<	0.0180	<	0.0007	<	<	<	<	<	0.0200	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1320 Murray	11/30/01	<0.002	<0.1	<0.0005	0.0002	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	0.002	0.051	0.16	<0.005	0.12
1320 Murray	04/08/08	<	<	<	<	<	<	<	<	<	0.2150	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1320 Murray	07/19/08	<0.0020	0.027	<0.001	<0.0005	[illegible]	<0.0020	<0.001	<0.005	<0.0002	0.269	<0.005	0.017	<0.005	0.021	NT	NT	NT	NT	NT	NT	NT
1321 Murray	04/08/08	<	<	<	<	0.0010	<	<	<	<	0.0070	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1324 Murray	12/03/01	<0.002	<0.1	<0.0005	0.0001	0.002	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	<0.1	<0.005	0.17
1324 Murray	04/06/08	<	<	<	<	<	<	<	<	<	0.0130	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1324 Murray	04/27/08	<	0.0110	<	0.0008	[illegible]	<	<	<	<	0.0200	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1325 Murray	11/30/01	<0.002	<0.1	<0.0005	0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	<0.1	<0.005	0.25
1325 Murray	04/12/08	<	0.0100	<	0.0012	[illegible]	<	<	<	<	0.0090	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1325 Murray	07/19/08	<0.0020	0.009	<0.001	<0.0005	0.001	<0.0020	<0.001	<0.005	<0.0002	0.018	<0.005	0.298	<0.005	0.011							
1328 Murray																						
1329 Murray	12/10/01	<0.002	<0.1	0.001	0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	0.008	<0.015	<0.1	<0.005	0.37
1329 Murray	04/06/08	<	<	<	<	<	<	<	<	<	0.0140	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1329 Murray	05/12/08	<	0.0110	<	0.0009	<	<	<	<	<	0.0190	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1379 Murray																						
Whittamore Road																						
1109 Whittamore	11/30/01	0.003	<0.1	<0.0005	<0.0001	0.002	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	<0.1	<0.005	<0.1
1109 Whittamore	04/07/08	<	0.0610	<	<	0.0090	<	<	<	<	0.0210	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1204 Whittamore	12/04/01	<0.002	<0.1	<0.0005	<0.0001	0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	0.036	<0.003	<0.0001	<0.001	<0.015	1.47	<0.005	0.17
1404 Whittamore	04/07/08	<	0.0230	<	<	<	<	<	<	<	0.0530	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1405 Whittamore	11/30/01	<0.002	<0.1	<0.0005	0.0002	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	0.001	<0.015	<0.1	<0.005	0.12
1407 Whittamore	11/30/01	<0.002	<0.1	<0.0005	0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	[illegible]	<0.005	<0.1
1408 Whittamore	04/27/08	<	0.0600	<	<	0.0010	<	<	<	<	0.0870	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1411 Whittamore	04/12/08	<	0.0460	<	<	0.0130	<	<	<	<	0.1330	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1412 Whittamore	04/07/08	<	0.0590	<	<	0.0010	<	<	<	<	0.1840	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1419 Whittamore	05/12/08	<	0.0120	<	<	<	<	<	<	<	0.0510	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

Address	Date	As (mg/L)	Ba (mg/L)	Cr (mg/L)	Cd (mg/L)	Pb (mg/L)	Se (mg/L)	Ag (mg/L)	V (mg/L)	Hg (mg/L)	B (mg/L)	Co (mg/L)	Mn (mg/L)	Ni (mg/L)	Zn (mg/L)	Sb (mg/L)	Be (mg/L)	Tl (mg/L)	Cu (mg/L)	Fe (mg/L)	CN (mg/L)	F (mg/L)
Primary MCL		**0.010**	**2.000**	**0.100**	**0.005**	**0.015**	**0.050**		**N/A**	**0.002**		**N/A**		**N/A**		**0.006**	**0.004**	**0.002**	**1.3**		**0.2**	**4**
Secondary MCL								**0.100**					**0.050**		**5.000**					**0.3**		**2**
WHO											**0.500**											
Whittamore Road																						
1420 Whittamore	12/06/01	<0.002	<0.1	<0.0005	<0.0001	0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	0.29	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	1.17	<0.005	0.15
1420 Whittamore	12/06/01	<0.002	<0.1	<0.0005	<0.0001	0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	0.26	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	1.12	<0.005	0.18
1420 Whittamore	04/08/08	<	0.0430	<	<	<	<	<	<	<	0.9050	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1428 Whittamore	04/12/08	<	0.0300	<	<	<	<	<	<	<	0.6120	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1428 Whittamore	07/18/08	<0.0020	0.032	<0.001	<0.0005	<0.001	<0.0020	<0.001	<0.005	<0.0002	0.713	<0.005	0.181	<0.005	<0.005	NT	NT	NT	NT	NT	NT	NT
1433 Whittamore	11/30/01	<0.002	<0.1	<0.0005	0.0002	0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	0.001	<0.015	<0.1	<0.005	0.11
1436 Whittamore	12/06/01	<0.002	<0.1	<0.0005	0.0002	0.010	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	<0.1	<0.005	0.17
1436 Whittamore	12/06/01	<0.002	<0.1	<0.0005	<0.0001	0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	<0.03	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	<0.1	<0.005	0.18
1436 Whittamore	04/12/08	<	0.0150	<	<	<	<	<	<	<	0.3290	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1436 Whittamore	07/18/08	<0.0020	0.025	<0.001	<0.0005	<0.001	<0.0020	<0.001	<0.005	<0.0002	0.385	<0.005	0.138	<0.005	<0.005							
1437 Whittamore	04/27/08	<	0.0740	<	<	0.0010	<	<	<	<	0.0450	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1439 Whittamore	04/07/08	<	0.0220	<	<	0.0010	<	<	<	<	0.0140	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1440 Whittamore	04/14/08	<	0.0910	<	<	<	<	<	<	<	0.0290	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1441 Whittamore	11/30/01	<0.002	<0.1	<0.0005	<0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	0.08	<0.05	0.021	<0.003	<0.0001	0.001	0.032	0.8	<0.005	0.1
1441 Whittamore	04/14/08	<	<	<	<	0.0010	<	<	<	<	0.0220	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1443 Whittamore	04/07/08	<	0.0190	<	<	0.0030	<	<	<	<	0.0060	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1445 Whittamore	04/06/08	<	0.0120	<	<	0.0010	<	<	<	<	0.0370	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1448 Whittamore	04/06/08	<	0.0370	0.0010	<	0.0020	<	<	<	<	0.0450	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1451 Whittamore	04/14/08	<	0.0220	<	<	<	<	<	<	<	0.0770	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1453 Whittamore	04/14/08	<	<	<	<	0.0030	<	<	<	<	0.0410	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1457 Whittamore	04/06/08	<	<	<	<	<	<	<	<	<	0.0280	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1457 Whittamore	04/27/08	<	0.0220	<	<	0.0020	<	<	<	<	0.0320	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1461 Whittamore	04/07/08	<	0.0230	<	<	<	<	<	<	<	0.0330	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1463 Whittamore	04/07/08	<	0.0220	<	<	<	<	<	<	<	0.0160	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1465 Whittamore	04/07/08	<	0.0200	<	<	<	<	<	<	<	0.0250	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1469 Whittamore	12/06/01	<0.002	<0.1	<0.0005	<0.0001	<0.001	<0.002	<0.0002	NT	<0.0002	NT	NT	0.1	<0.05	<0.015	<0.003	<0.0001	<0.001	0.03	1.14	<0.005	0.21
1473 Whittamore	12/10/01	<0.002	<0.1	0.008	<0.0001	0.008	<0.002	0.0004	NT	<0.0002	NT	NT	<0.03	<0.05	0.04	<0.003	<0.0001	<0.001	0.447	0.24	<0.005	0.24
1473 Whittamore	04/07/08	<	0.0140	<	<	0.0010	<	<	<	<	0.0140	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1605 Whittamore	04/14/08	<	0.0360	<	<	<	<	<	<	<	0.1210	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1609 Whittamore	04/12/08	<	0.0350	<	<	0.0020	<	<	<	<	0.1130	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1609 Whittamore	07/18/08	<0.0020	0.034	<0.001	<0.0005	0.002	<0.0020	<0.001	<0.005	<0.0002	0.128	<0.005	0.721	<0.005	0.012	NT	NT	NT	NT	NT	NT	NT
1612 Whittamore	04/07/08	<	0.0300	<	<	<	<	<	<	<	0.1090	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1612 Whittamore	07/19/08	<0.0020	0.029	<0.001	<0.0005	<0.001	<0.0020	<0.001	<0.005	<0.0002	0.116	<0.005	0.213	<0.005	<0.005	NT	NT	NT	NT	NT	NT	NT
1613 Whittamore	04/14/08	<	0.0190	<	0.0013	<	<	<	<	<	0.0740	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1621 Whittamore	04/08/08	<	0.0110	<	0.0005	<	<	<	<	<	0.0100	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1629 Whittamore	04/14/08	<	0.0330	<	<	<	<	<	<	<	0.0780	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Fentress Road																						
1441 Fentress	12/04/01	<0.002	<0.1	<0.0005	<0.0001	0.002	<0.002	<0.0002	NT	<0.0002	NT	NT	0.230	<0.05	<0.015	<0.003	<0.0001	<0.001	<0.015	3.2	<0.005	<0.1

Re-test without softener.

Barn or irrigation water source

NT - Not tested for this analyte

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FAX: 304.255.2572
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1208 MURRAY DR
WELL SCREEN 40-50ft
Columbia AQUIFER

Mr. Russell Rountree
SCHNABEL ENGINEERING SOUTH LLC
300 ED WRIGHT LN SUITE 1
NEWPORT NEWS VA 23606

TEL: (757) 947-1220
FAX (757) 947-1220

RE: 08330106

Order No.: 0812H94

Dear Mr. Russell Rountree:

REI Consultants, Inc. received 1 sample(s) on 12/23/2008 for the analyses presented in the following report.

Please note two changes you may see on your report.

- Results for "Dissolved" parameters will be shown under a separate sample ID, rather than as a separate analysis under the same sample ID. The sample ID for "Dissolved" parameters will include "Field Filtered" or "Lab Filtered", as appropriate.
- Metals results will no longer be identified as "Total" or "Total Recoverable". The methods have not been changed, only their appearance on the report.

If you have any questions regarding these results, please do not hesitate to call.

Sincerely,

Scott Gross
Project Manager

225 Industrial Park Drive
Beaver, WV 25813
TEL: 304.255.2500
FAX: 304.255.2572
Website: www.reiclabs.com

REIC

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Report Narrative

Project Manager:: **Scott Gross**

WO#: **0812H94**
Date:

CLIENT: SCHNABEL ENGINEERING SOUTH LL
Project: 08330106

All analyses were performed using documented laboratory SOPs that incorporate appropriate quality control procedures as described in the applicable methods. REI Consultants, Inc. (REIC) technical managers have verified compliance of reported results with the REIC's Quality Program and SOPs, except as noted in this case narrative. Any deviation from compliance is explained below and/or identified within the body of this report by a qualifier footnote which is defined at the bottom of each page.

All samples were analyzed using the methods stated in the analytical report without modification, unless otherwise noted.

All sample results are reported on an "as-received" wet weight basis unless otherwise noted.

Results reported for sums of individual parameters, such as Total Trihalomethanes (TTHM) and Total Haloacetic Acids (HAA5), may vary slightly from the sum of the individual parameter results. This apparent anomaly is caused by rounding individual results and summations at reporting, as required by EPA.

Following standard laboratory protocol, sample preservation, such as pH, is verified at time of extraction or analysis based on client requested parameters. Improper preservation is noted on the analytical bench sheet, extraction log, or preservation log and client is notified by close of following business day. All results are reported using preservation compliant samples unless otherwise noted in the analytical report.

The test results in this report meet all NELAP requirements for parameters for which accreditations are required or available. Any exceptions are noted in this report. This report may not be reproduced, except in full, without the written approval of REIC.

In compliance with federal guidelines and standard operating procedures, all reports, including raw data and supporting quality control, will be disposed of after five years unless otherwise arranged by the client via written notification or contract requirement.

If you have any questions please contact the project manager whose name is listed above.

REI Consultants, Inc. **Analytical Results** **Date:** *08-Jan-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812H94
Client Sample ID:	1208 MURRAY DRIVE	**Lab ID:**	0812H94-01A
Project:	08330106	**Collection Date:**	12/22/2008 4:25:00 PM
Site ID:	CHESAPEAKE WATER MAIN, VA	**Matrix:**	DRINKING WATER

Analyses	Result	Units	Qual	MDL	PQL	Date Analyzed
METALS BY ICP			**E200.7**			Analyst: **BP**
Aluminum	0.267	mg/L	*	NA	0.100	12/31/2008 12:32:00 AM
Boron	0.111	mg/L		NA	0.100	12/31/2008 12:32:00 AM
Iron	1.79	mg/L	*	NA	0.100	12/31/2008 12:32:00 AM
Magnesium	18.9	mg/L		NA	0.500	12/31/2008 12:32:00 AM
Manganese	0.186	mg/L	*	NA	0.050	12/31/2008 12:32:00 AM
Silica (as SiO2)	27.6	mg/L		NA	0.210	12/29/2008 2:52:00 PM
Sodium	81.1	mg/L		NA	0.500	12/31/2008 12:32:00 AM
METALS BY ICP-MS			**E200.8**			Analyst: **BM**
Antimony	ND	mg/L		NA	0.0010	12/29/2008 4:19:09 PM
Arsenic	ND	mg/L		NA	0.0050	12/29/2008 4:19:09 PM
Barium	ND	mg/L		NA	0.100	12/29/2008 4:19:09 PM
Beryllium	ND	mg/L		NA	0.0020	12/29/2008 4:19:09 PM
Cadmium	ND	mg/L		NA	0.0010	12/29/2008 4:19:09 PM
Chromium	0.0071	mg/L		NA	0.0050	12/29/2008 4:19:09 PM
Cobalt	ND	mg/L		NA	0.100	12/29/2008 4:19:09 PM
Copper	ND	mg/L		NA	0.0500	12/29/2008 4:19:09 PM
Lead	ND	mg/L		NA	0.0050	12/29/2008 4:19:09 PM
Molybdenum	ND	mg/L		NA	0.100	12/29/2008 4:19:09 PM
Nickel	ND	mg/L		NA	0.0100	12/29/2008 4:19:09 PM
Selenium	ND	mg/L		NA	0.0050	12/29/2008 4:19:09 PM
Silver	ND	mg/L		NA	0.0500	12/29/2008 4:19:09 PM
Thallium	ND	mg/L		NA	0.0010	12/29/2008 4:19:09 PM
Vanadium	ND	mg/L		NA	0.0500	12/29/2008 4:19:09 PM
Zinc	0.0218	mg/L		NA	0.0100	12/29/2008 4:19:09 PM
HARDNESS, CALCIUM			**SM2340 B**			Analyst: **BP**
Hardness, Calcium (As CaCO3)	104	mg/L		NA	1.00	12/31/2008 12:32:00 AM
HARDNESS			**SM2340 B**			Analyst: **BP**
Hardness, Total (As CaCO3)	182	mg/L		NA	1.00	12/31/2008 12:32:00 AM
MERCURY, TOTAL			**E245.1**			Analyst: **CGW**
Mercury	ND	mg/L		NA	0.0010	12/30/2008 10:50:00 AM
SEMIVOLATILE ORGANIC COMPOUNDS BY EPA			**E504.1**			Analyst: **JG**
1,2-Dibromo-3-chloropropane	ND	mg/L		NA	0.000020	1/2/2009 6:07:05 PM
1,2-Dibromoethane	ND	mg/L		NA	0.000020	1/2/2009 6:07:05 PM

Key:				
	MCL	Maximum Contaminant Level	B	Analyte detected in the associated Method Blank
	MDL	Minimum Detection Limit	E	Estimated Value above quantitation range
	NA	Not Applicable	H	Holding times for preparation or analysis exceeded
	ND	Not Detected at the PQL or MDL	S	Spike/Surrogate Recovery outside accepted recovery limits
	PQL	Practical Quantitation Limit	*	Value exceeds Maximum Contaminant Level
	TIC	Tentatively Identified Compound, Estimated Concentration		

PEI Consultants, Inc. **Analytical Results** **Date:** *08-Jan-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812H94
Client Sample ID:	1208 MURRAY DRIVE	**Lab ID:**	0812H94-01A
Project:	08330106	**Collection Date:**	12/22/2008 4:25:00 PM
Site ID:	CHESAPEAKE WATER MAIN, VA	**Matrix:**	DRINKING WATER

Analyses	Result	Units	Qual	MDL	PQL	Date Analyzed
SEMIVOLATILE ORGANIC COMPOUNDS			**E515.1**			Analyst: **JG**
2,4,5-TP (Silvex)	ND	mg/L		NA	0.000607	12/30/2008
2,4-D	ND	mg/L		NA	0.000121	12/30/2008
Dalapon	ND	mg/L		NA	0.00789	12/30/2008
Dinoseb	ND	mg/L		NA	0.000121	12/30/2008
Pentachlorophenol	ND	mg/L		NA	0.000607	12/30/2008
Picloram	ND	mg/L		NA	0.000607	12/30/2008
VOLATILE ORGANIC COMPOUNDS			**E524.2**			Analyst: **SDG**
Benzene	ND	µg/L		NA	1.0	12/29/2008 10:46:00 AM
Carbon tetrachloride	ND	µg/L		NA	1.0	12/29/2008 10:46:00 AM
1,2-Dichlorobenzene	ND	µg/L		NA	1.0	12/29/2008 10:46:00 AM
1,4-Dichlorobenzene	ND	µg/L		NA	1.0	12/29/2008 10:46:00 AM
1,2-Dichloroethane	ND	µg/L		NA	1.0	12/29/2008 10:46:00 AM
1,1-Dichloroethene	ND	µg/L		NA	1.0	12/29/2008 10:46:00 AM
cis-1,2-Dichloroethene	ND	µg/L		NA	1.0	12/29/2008 10:46:00 AM
ans-1,2-Dichloroethene	ND	µg/L		NA	1.0	12/29/2008 10:46:00 AM
2-Dichloropropane	ND	µg/L		NA	1.0	12/29/2008 10:46:00 AM
Ethylbenzene	ND	µg/L		NA	1.0	12/29/2008 10:46:00 AM
Methylene chloride	ND	µg/L		NA	1.0	12/29/2008 10:46:00 AM
Styrene	ND	µg/L		NA	1.0	12/29/2008 10:46:00 AM
Tetrachloroethene	ND	µg/L		NA	1.0	12/29/2008 10:46:00 AM
Surr: 1,2-Dichlorobenzene-d4	88.2	%REC			75-125	12/29/2008 10:46:00 AM
Surr: 4-Bromofluorobenzene	94.5	%REC			75-125	12/29/2008 10:46:00 AM
RESIDUAL CHLORINE - LAB TEST, HOLD TIME E			**SM4500-CL-G**			Analyst: **CC**
Chlorine, Total Residual	ND	µg/L		NA	100	12/24/2008 11:30:00 AM
TURBIDITY			**SM2130 B**			Analyst: **CC**
Turbidity	2.87	NTU	*	NA	0.50	12/24/2008 9:30:00 AM
COLIFORM BY P/A			**SM9223 B**			Analyst: **CC**
Fecal Coliform	ABSENT	NA		NA	NA	12/24/2008 2:57:00 PM
Total Coliform	ABSENT	NA		NA	NA	12/24/2008 2:57:00 PM
CYANIDE			**E335.4**			Analyst: **BA**
Cyanide, Total	ND	mg/L		NA	0.020	12/24/2008 9:00:00 AM
ANIONS BY ION CHROMATOGRAPHY			**E300.0**			Analyst: **CW**
Chloride	124	mg/L		NA	5.00	12/30/2008 11:04:00 PM

Key:

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PQL	Practical Quantitation Limit	*	Value exceeds Maximum Contaminant Level
TIC	Tentatively Identified Compound, Estimated Concentration		

REI Consultants, Inc. — Analytical Results

Date: *08-Jan-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812H94
Client Sample ID:	1208 MURRAY DRIVE	**Lab ID:**	0812H94-01A
Project:	08330106	**Collection Date:**	12/22/2008 4:25:00 PM
Site ID:	CHESAPEAKE WATER MAIN, VA	**Matrix:**	DRINKING WATER

Analyses	Result	Units	Qual	MDL	PQL	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**E300.0**			Analyst: **CW**
Fluoride	0.33	mg/L		NA	0.20	12/30/2008 11:04:00 PM
Sulfate	24.2	mg/L		NA	5.00	12/30/2008 11:04:00 PM
ANIONS BY ION CHROMATOGRAPHY			**E300.0**			Analyst: **CW**
Nitrogen, Nitrate-Nitrite	ND	mg/L		NA	0.10	1/1/2009 9:01:00 AM
TOTAL DISSOLVED SOLIDS			**SM2540 C**			Analyst: **DSA**
Total Dissolved Solids	377	mg/L		NA	1	12/23/2008 6:05:00 PM
ALKALINITY			**SM2320 B**			Analyst: **DSA**
Alkalinity, Total (As CaCO3)	156	mg/L		NA	1.0	12/24/2008 7:45:00 AM
CORROSIVITY, LANGELIER INDEX			**SM2330 B**			Analyst: **IL**
Langelier Index	-0.77	at 20 °C		NA	NA	1/5/2009
PH - LAB TEST, HOLD TIME EXPIRED			**SM4500-H+-B**			Analyst: **DSA**
pH	6.98	SU		NA	NA	12/24/2008 7:45:00 AM
ORGANIC CARBON, TOTAL			**SM5310 C**			Analyst: **DSA**
Total Organic Carbon	2.01	mg/L		NA	1.00	12/24/2008 7:12:00 AM

Key:

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1204 MURRAY DR.
WELL SCREEN 67-80 ft
YORKTOWN - EASTOVER AQUIFER

Mr. Russell Rountree
SCHNABEL ENGINEERING SOUTH LLC
300 ED WRIGHT LN SUITE 1
NEWPORT NEWS VA 23606

TEL: (757) 947-1220
FAX (757) 947-1220

RE: 08330106

Order No.: 0812H90

Dear Mr. Russell Rountree:

REI Consultants, Inc. received 1 sample(s) on 12/23/2008 for the analyses presented in the following report.

Please note two changes you may see on your report.

- Results for "Dissolved" parameters will be shown under a separate sample ID, rather than as a separate analysis under the same sample ID. The sample ID for "Dissolved" parameters will include "Field Filtered" or "Lab Filtered", as appropriate.
- Metals results will no longer be identified as "Total" or "Total Recoverable". The methods have not been changed, only their appearance on the report.

If you have any questions regarding these results, please do not hesitate to call.

Sincerely,

Scott Gross
Project Manager

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Beaver, WV 25813
TEL: 304.255.2500
FAX: 304.255.2572
Website: www.reiclabs.com

Report Narrative

Project Manager:: **Scott Gross**

WO#: **0812H90**
Date:

CLIENT: SCHNABEL ENGINEERING SOUTH LL
Project: 08330106

All analyses were performed using documented laboratory SOPs that incorporate appropriate quality control procedures as described in the applicable methods. REI Consultants, Inc. (REIC) technical managers have verified compliance of reported results with the REIC's Quality Program and SOPs, except as noted in this case narrative. Any deviation from compliance is explained below and/or identified within the body of this report by a qualifier footnote which is defined at the bottom of each page.

All samples were analyzed using the methods stated in the analytical report without modification, unless otherwise noted.

All sample results are reported on an "as-received" wet weight basis unless otherwise noted.

Results reported for sums of individual parameters, such as Total Trihalomethanes (TTHM) and Total Haloacetic Acids (HAA5), may vary slightly from the sum of the individual parameter results. This apparent anomaly is caused by rounding individual results and summations at reporting, as required by EPA.

Following standard laboratory protocol, sample preservation, such as pH, is verified at time of extraction or analysis based on client requested parameters. Improper preservation is noted on the analytical bench sheet, extraction log, or preservation log and client is notified by close of following business day. All results are reported using preservation compliant samples unless otherwise noted in the analytical report.

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If you have any questions please contact the project manager whose name is listed above.

REI Consultants, Inc. **Analytical Results** **Date:** *08-Jan-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812H90
Client Sample ID:	1204 MURRAY DRIVE	**Lab ID:**	0812H90-01A
Project:	08330106	**Collection Date:**	12/22/2008 4:45:00 PM
Site ID:	CHESAPEAKE WATER MAIN, VA	**Matrix:**	DRINKING WATER

Analyses	Result	Units	Qual	MDL	PQL	Date Analyzed
METALS BY ICP			**E200.7**			Analyst: **BP**
Aluminum	0.188	mg/L		NA	0.100	12/31/2008 12:27:00 AM
Boron	0.163	mg/L		NA	0.100	12/31/2008 12:27:00 AM
Iron	0.184	mg/L		NA	0.100	12/31/2008 12:27:00 AM
Magnesium	18.8	mg/L		NA	0.500	12/31/2008 12:27:00 AM
Manganese	ND	mg/L		NA	0.050	12/31/2008 12:27:00 AM
Silica (as SiO2)	19.2	mg/L		NA	0.210	12/29/2008 2:46:00 PM
Sodium	106	mg/L		NA	0.500	12/31/2008 12:27:00 AM
METALS BY ICP-MS			**E200.8**			Analyst: **BM**
Antimony	ND	mg/L		NA	0.0010	12/29/2008 4:01:58 PM
Arsenic	ND	mg/L		NA	0.0050	12/29/2008 4:01:58 PM
Barium	ND	mg/L		NA	0.100	12/29/2008 4:01:58 PM
Beryllium	ND	mg/L		NA	0.0020	12/29/2008 4:01:58 PM
Cadmium	ND	mg/L		NA	0.0010	12/29/2008 4:01:58 PM
Chromium	0.0052	mg/L		NA	0.0050	12/29/2008 4:01:58 PM
Cobalt	ND	mg/L		NA	0.100	12/29/2008 4:01:58 PM
Copper	ND	mg/L		NA	0.0500	12/29/2008 4:01:58 PM
Lead	ND	mg/L		NA	0.0050	12/29/2008 4:01:58 PM
Molybdenum	ND	mg/L		NA	0.100	12/29/2008 4:01:58 PM
Nickel	ND	mg/L		NA	0.0100	12/29/2008 4:01:58 PM
Selenium	ND	mg/L		NA	0.0050	12/29/2008 4:01:58 PM
Silver	ND	mg/L		NA	0.0500	12/29/2008 4:01:58 PM
Thallium	ND	mg/L		NA	0.0010	12/29/2008 4:01:58 PM
Vanadium	ND	mg/L		NA	0.0500	12/29/2008 4:01:58 PM
Zinc	0.0151	mg/L		NA	0.0100	12/29/2008 4:01:58 PM
HARDNESS, CALCIUM			**SM2340 B**			Analyst: **BP**
Hardness, Calcium (As CaCO3)	67.4	mg/L		NA	1.00	12/31/2008 12:27:00 AM
HARDNESS			**SM2340 B**			Analyst: **BP**
Hardness, Total (As CaCO3)	145	mg/L		NA	1.00	12/31/2008 12:27:00 AM
MERCURY, TOTAL			**E245.1**			Analyst: **CGW**
Mercury	ND	mg/L		NA	0.0010	12/30/2008 10:49:00 AM
SEMIVOLATILE ORGANIC COMPOUNDS BY EPA			**E504.1**			Analyst: **JG**
1,2-Dibromo-3-chloropropane	ND	mg/L		NA	0.000020	1/2/2009 5:53:07 PM
1,2-Dibromoethane	ND	mg/L		NA	0.000020	1/2/2009 5:53:07 PM

Key:

MCL	Maximum Contaminant Level	B	Analyte detected in the associated Method Blank
MDL	Minimum Detection Limit	E	Estimated Value above quantitation range
NA	Not Applicable	H	Holding times for preparation or analysis exceeded
ND	Not Detected at the PQL or MDL	S	Spike/Surrogate Recovery outside accepted recovery limits
PQL	Practical Quantitation Limit	*	Value exceeds Maximum Contaminant Level
TIC	Tentatively Identified Compound, Estimated Concentration		

REI Consultants, Inc. **Analytical Results** **Date:** *08-Jan-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812H90
Client Sample ID:	1204 MURRAY DRIVE	**Lab ID:**	0812H90-01A
Project:	08330106	**Collection Date:**	12/22/2008 4:45:00 PM
Site ID:	CHESAPEAKE WATER MAIN, VA	**Matrix:**	DRINKING WATER

Analyses	Result	Units	Qual	MDL	PQL	Date Analyzed
SEMIVOLATILE ORGANIC COMPOUNDS			**E515.1**			Analyst: **JG**
2,4,5-TP (Silvex)	ND	mg/L		NA	0.000608	12/30/2008
2,4-D	ND	mg/L		NA	0.000122	12/30/2008
Dalapon	ND	mg/L		NA	0.00790	12/30/2008
Dinoseb	ND	mg/L		NA	0.000122	12/30/2008
Pentachlorophenol	ND	mg/L		NA	0.000608	12/30/2008
Picloram	ND	mg/L		NA	0.000608	12/30/2008
VOLATILE ORGANIC COMPOUNDS			**E524.2**			Analyst: **SDG**
Benzene	ND	µg/L		NA	1.0	12/30/2008 1:37:00 PM
Carbon tetrachloride	ND	µg/L		NA	1.0	12/30/2008 1:37:00 PM
1,2-Dichlorobenzene	ND	µg/L		NA	1.0	12/30/2008 1:37:00 PM
1,4-Dichlorobenzene	ND	µg/L		NA	1.0	12/30/2008 1:37:00 PM
1,2-Dichloroethane	ND	µg/L		NA	1.0	12/30/2008 1:37:00 PM
1,1-Dichloroethene	ND	µg/L		NA	1.0	12/30/2008 1:37:00 PM
cis-1,2-Dichloroethene	ND	µg/L		NA	1.0	12/30/2008 1:37:00 PM
trans-1,2-Dichloroethene	ND	µg/L		NA	1.0	12/30/2008 1:37:00 PM
1,2-Dichloropropane	ND	µg/L		NA	1.0	12/30/2008 1:37:00 PM
Ethylbenzene	ND	µg/L		NA	1.0	12/30/2008 1:37:00 PM
Methylene chloride	ND	µg/L		NA	1.0	12/30/2008 1:37:00 PM
Styrene	ND	µg/L		NA	1.0	12/30/2008 1:37:00 PM
Tetrachloroethene	ND	µg/L		NA	1.0	12/30/2008 1:37:00 PM
Surr: 1,2-Dichlorobenzene-d4	80.1	%REC			75-125	12/30/2008 1:37:00 PM
Surr: 4-Bromofluorobenzene	85.0	%REC			75-125	12/30/2008 1:37:00 PM
RESIDUAL CHLORINE - LAB TEST, HOLD TIME E			**SM4500-CL-G**			Analyst: **CC**
Chlorine, Total Residual	ND	µg/L		NA	100	12/24/2008 10:00:00 AM
TURBIDITY			**SM2130 B**			Analyst: **CC**
Turbidity	0.65	NTU	*	NA	0.50	12/24/2008 9:30:00 AM
COLIFORM BY P/A			**SM9223 B**			Analyst: **CC**
Fecal Coliform	ABSENT	NA		NA	NA	12/24/2008 2:15:00 PM
Total Coliform	ABSENT	NA		NA	NA	12/24/2008 2:15:00 PM
CYANIDE			**E335.4**			Analyst: **BA**
Cyanide, Total	ND	mg/L		NA	0.020	12/24/2008 9:00:00 AM
ANIONS BY ION CHROMATOGRAPHY			**E300.0**			Analyst: **CW**
Chloride	136	mg/L		NA	10.0	12/29/2008 6:39:00 PM

Key:

MCL	Maximum Contaminant Level	B	Analyte detected in the associated Method Blank
MDL	Minimum Detection Limit	E	Estimated Value above quantitation range
NA	Not Applicable	H	Holding times for preparation or analysis exceeded
ND	Not Detected at the PQL or MDL	S	Spike/Surrogate Recovery outside accepted recovery limits
PQL	Practical Quantitation Limit	*	Value exceeds Maximum Contaminant Level
TIC	Tentatively Identified Compound, Estimated Concentration		

REI Consultants, Inc. Analytical Results

Date: *08-Jan-09*

CLIENT:	SCHNABEL ENGINEERING SOUTH LLC	**WorkOrder:**	0812H90
Client Sample ID:	1204 MURRAY DRIVE	**Lab ID:**	0812H90-01A
Project:	08330106	**Collection Date:**	12/22/2008 4:45:00 PM
Site ID:	CHESAPEAKE WATER MAIN, VA	**Matrix:**	DRINKING WATER

Analyses	Result	Units	Qual	MDL	PQL	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**E300.0**			Analyst: **CW**
Fluoride	0.46	mg/L		NA	0.20	12/29/2008 6:39:00 PM
Sulfate	13.9	mg/L		NA	5.00	12/29/2008 6:39:00 PM
ANIONS BY ION CHROMATOGRAPHY			**E300.0**			Analyst: **CW**
Nitrogen, Nitrate-Nitrite	ND	mg/L		NA	0.10	1/1/2009 8:42:00 AM
TOTAL DISSOLVED SOLIDS			**SM2540 C**			Analyst: **DSA**
Total Dissolved Solids	401	mg/L		NA	1	12/23/2008 6:05:00 PM
ALKALINITY			**SM2320 B**			Analyst: **DSA**
Alkalinity, Total (As CaCO3)	162	mg/L		NA	1.0	12/23/2008 3:06:00 PM
CORROSIVITY, LANGELIER INDEX			**SM2330 B**			Analyst: **IL**
Langelier Index	0.14	at 20 °C		NA	NA	1/5/2009
PH - LAB TEST, HOLD TIME EXPIRED			**SM4500-H+-B**			Analyst: **DSA**
pH	8.07	SU		NA	NA	12/23/2008 3:06:00 PM
ORGANIC CARBON, TOTAL			**SM5310 C**			Analyst: **DSA**
Total Organic Carbon	1.45	mg/L		NA	1.00	12/24/2008 7:12:00 AM

Key:

MCL	Maximum Contaminant Level	B	Analyte detected in the associated Method Blank
MDL	Minimum Detection Limit	E	Estimated Value above quantitation range
NA	Not Applicable	H	Holding times for preparation or analysis exceeded
ND	Not Detected at the PQL or MDL	S	Spike/Surrogate Recovery outside accepted recovery limits
PQL	Practical Quantitation Limit	*	Value exceeds Maximum Contaminant Level
TIC	Tentatively Identified Compound, Estimated Concentration		

APPENDIX H
Vicinity Groundwater Quality Data from VDEQ

SOW 91-A

Form GW-2
1978-10,000

COMMONWEALTH OF VIRGINIA

WATER WELL COMPLETION REPORT

BWCM No. 234-136

(Certification of Completion/County Permit)

State Water Control Board
P. O. Box 11143
2111 North Hamilton St.
Richmond, Va. 23230

SWCB Permit ______
County Permit ______

County/City Chesapeake

County/City Stamp

Certification of inspecting official:
This well does ____ does not ____
meet code/low requirements.
S. ______
Date ______

For Office Use

Virginia Plane Coordinates
______ N
______ E
Latitude & Longitude
36° 42' 27" N
76° 07' 49" W
Topo. Map No. ______
Elevation ______ ft.
Formation ______
Lithology ______
River Basin ______
Province ______
Type Logs ______
Cuttings ~~[illegible]~~
Water Analysis yes
Aquifer Test ______

Owner SWCB
Well Designation or Number 234-136
Address SOW 91-A
Phone ______
Drilling Contractor SWCB
Address 2111 No Hamilton St.
Richmond, Va.
Phone ______

Tax Map I.D. No. ______
Subdivision ______
Section ______
Block ______
Lot ______
Class Well: I ____, IIA ____, IIB ____, IIIA ____, IIIB ____, IIIC ____, IIID ____, IIIE ____

WELL LOCATION: ______ (feet/miles ______ direction) of ______
and ______ feet/miles ______ (direction) of ______
(If possible please include map showing location marked)

Date started ______ Date completed ______ Type rig Failing CF 15

1. WELL DATA: New X Reworked ____ Deepened ____
Total depth ______ ft.
Depth to bedrock ______ ft.
Hole size (Also include reamed zones)
6.5 inches from 0 to ~~97~~ 400 ft.
____ inches from ____ to ____ ft.
____ inches from ____ to ____ ft.
Casing size (I.D.) and material
4 inches from 0 to 92 ft.
Material ______
Wt. per foot ______ or wall thickness ______ in.
____ inches from ____ to ____ ft.
Material ______
Wt. per foot ______ or wall thickness ______ in.
____ inches from ____ to ____ ft.
Material ______
Wt. per foot ______ or wall thickness ______ in.
Screen size and mesh for each zone (where applicable)
4 inches from 92 to 97 ft.
Mesh size ______ Type ______
____ inches from ____ to ____ ft.
Mesh size ______ Type ______
____ inches from ____ to ____ ft.
Mesh size ______ Type ______
____ inches from ____ to ____ ft.
Mesh size ______ Type ______
Gravel pack
From ______ to ______ ft.
From ______ to ______ ft.
Grout
From ____ to ____ ft., Type ______
From ____ to ____ ft., Type ______

2. WATER DATA Water temperature ______ °F
Static water level (unpumped level-measured) ______ ft.
Stabilized measured pumping water level ______ ft.
Stabilized yield ______ gpm after ______ hours
Natural Flow: Yes ____ No ____, flow rate ______ gpm
Comment on quality ______

3. WATER ZONES: From ____ To ____
From ____ To ____ . From ____ To ____
From ____ To ____ . From ____ To ____

4. USE DATA:
Type of use: Drinking ____, Livestock Watering ____,
Irrigation ____ Food processing ____, Household ____,
Manufacturing ____, Fire safety ____, Cleaning ____,
Recreation ____, Aesthetic ____, Cooling or heating ____,
Injection ____, Other observation
Type of facility: Domestic ____, Public water supply ____,
Public institution ____, Farm ____, Industry ____,
Commercial ____, Other ______

5. PUMP DATA: Type ______ Rated H.P. ______,
Intake depth ______ Capacity ______ at ______ head

6. WELLHEAD: Type well seal ______
Pressure tank ____ gal., Loc. ______
Sample tap ______, Measurement port ______
Well vent ______, Pressure relief valve ______
Gate valve ______, Check valve (when required) ______
Electrical disconnect switch on power supply ______

7. DISINFECTION: Well disinfected ____ yes ____ no
Date ______, Disinfectant used ______
Amount ______, Hours used ______

8. ABANDONMENT (where applicable) yes ____ no ____
Casing pulled yes ____ no ____ not applicable ______
Plugging grout From ____ to ____ material ______

OVER

Groundwater Research Station
77-9 (78-3)
Fentress

Total Depth:400'

U.S.G.A. 7.5 Quad Fentress Lat: 36°42' 27"

Long: 76° 07'49"

Depth	Geology	Hydraulic Conductivity
o-10'	Poorly sorted, Sub-Angular, Silt(80%) and Very Fine Sand(20%) to Medium Quartz Sand. Trace Hornblende	20 GPD/FT.^{2}
10-20'	Well sorted, Sub-Angular, Fine to Medium Quartz Sand. Trace Hornblende, Hematite, Mica	400 GPD/FT.^{2}
20-30'	Bimodally sorted, Sub-Anagular, Silt(30%) and Fine and Medium Quartz sand.(70%) Trace Limonite, Magnetite, Chlorite.	150 GPD/FT.^{2}
30-40'	Poorly sorted, Sub-Angular, Silt(20%) to Coarse (10%) Quartz Sand(40% Medium Sand). Trace Glauconite, Magnetite, Mica, Chlorite.	100 GPD/FT.^{2}
40-50'	Poorly sorted, Sub-Angular, Silt(60%) to Very Fine to Coarse (20%) Quartz Sand. (Medium Sand 20%)) Glauconite, Iron Stains, Hematite, (Sand washed out).	200 GPD/FT.^{2}
50-60'	Poorly sorted, Sub-Angular, Very Fine to Coarse Quartz Sand. Glauconite, Chlorite.	600 GPD/FT.^{2}
60-70'	Poorly sorted, Sub-Angular, Silt (20%)to Well Rounded Very Coarse (20%) Quartz Sand.(Medium sand is 30%) Hornblende, Glauconite, Feldspar.	300 GPD/FT.^{2}
70-80'	Poorly sorted, Sub-Angular, Silt(20%) to Very Coarse (20%) Quartz Sand. (Medium Sand is 20%) Limey. Shell Fragments, Glauconite, Magnetite.	450 GPD/FT.^{2}
80-90	Poorly sorted, Sub-Angular, Silt(10%) to Very Coarse Quartz Sand. (Coarse 30%)(Limey) Shell Fragments, Plagioclase Grains, Glauconite, Hornblende.	400 GPD/FT.^{2}

90-100	Poorly sorted, Sub-Angular, Clay and Silt (30%) to Very Fine (30%) to Coarse Quartz Sand. (Limey) Ilmenite, Shell Fragments, Glauconite, Asbestos (Serpenite)	100 GPD/FT.^{2}
100-110	Poorly sorted, Sub-Angular, Silt (50%)(Fine to Medium Sand)30%) (Very Limey) Echinoid Spines, Glauconite, Shell FRagments (20%), Fish bone, Gypsum.	20 GPD/FT.^{2}
110-120	(Same) Coquina (Very Limey) Kyanite Trace	20 GPD/FT.^{2}
120-130	(Same)	20 GPD/FT.^{2}
130-140	Poorly sorted, Sub-Angular, Silt(30%) Very Fine Sand (40%) to Coarse Quartz Sand. (Very Limey) Shell Fragments(20%), Fish bone, Echinoid Spines, Magnetite, Silt and Clay Washed Out.	30 GPD/FT.^{2}
140-150	Poorly sorted, Sub-Angular, Clay(20%) and Silt(70%) Coarse sand(5%)(Very Limey) Shell Fragments, (5%), Limonite.	10 GPD/FT.^{2}
150-160	(Same)	10 GPD/FT.^{2}
160-170	(Same) More Clay(30%)(No Coarses)	1 GPD/FT.^{2}
170-180	(Same)	1 GPD/FT.^{2}
180-190	(Same) Glauconite (5%)	1 GPD/FT.^{2}
190-200	(Same)	1 GPD/FT.^{2}
200-210	(Same) Glauconite (10%)	1 GPD/FT.^{2}
210-220	(Same) Glauconite 20%	1 GPD/FT.^{2}
220-230	(Same)	1 GPD/FT.^{2}
230-240	(Same) More Clay	.8 GPD/FT.^{2}
240-250	(Same)	.8 GPD/FT.^{2}
250-260	(Same) More Clay	.5 GPD/FT.^{2}
260-270	(Same)	.5 GPD/FT.^{2}
270-280	(Same)	.5 GPD/FT.^{2}
280-290	Poorly sorted, Sub-Angular, Tan(Iron Oxide) Fine to Medium (30%) Quartz Sand and (Clay and Silt)(70%)(Limey) Glauconite$<$1%	1.5 GPD/FT.^{2}
290-300	Clay (30%) and Silt (60%)(Limonite Nodules 2%) (Limey) 5% Shell and Pebbles.	1.o GPD/FT.^{2}
300-310	(Same) No Limonite(Very Slightly Limey)	1.0 GPD/FT.^{2}
310-320	(Same) Large Well Rounded Pebbles	1.0 GPD/FT.^{2}

320-330	(Same)	1.0 GPD/FT.^{2}
330-340	(Same)	.8 GPD/FT.^{2}
340-400	(SAme)Gradually Increasing in Clay Content (Very Slightly Limey)	.7 GPD/FT.^{2}

TOTAL DEPTH: 400'

Sample Datetime	Time datum	Time datum reliability code	Sample Medium Code	Agency Collecting Sample, Code	Analysis Source	Hydro-logic Event	Hydro-logic Condition	Sample type
1989-03-	EST	T	WG	USGS-WRD	9	9	A	9
2003-08-	EDT	K	WG	USGS-WRD	9	9	A	9

USGS 364227076074701 61B 2 SOW 091A

Chesapeake City, Virginia
Hydrologic Unit Code 03010205
Latitude 36°42'27", Longitude 76°07'47" NAD27
Land-surface elevation 15.00 feet above sea level NGVD29
The depth of the well is 97.0 feet below land surface.
The depth of the hole is 400 feet below land surface.
This well is completed in the UPPER CHESAPEAKE GROUP (121CSPKU) local aquifer.

Water Quality Remark Code	Description
<	Less than.
M	Presence verified but not quantified.

Value Qualifier Code	Description

d	Diluted sample: method hi range exceeded

Project Code	Laboratory sample comment	Sampling depth, feet (00003)	Temperature, water, deg C (00010)	Agency analyzing sample, code (00028)	Flow rate, instantaneous gal/min (00059)	Color, water, fltrd, Pt-Co units (00080)	Specific conductance, wat unf uS/cm 25 degC (00095)	Hydrogen ion, water, unfltrd calcd, mg/L (00191)
445108900	RR:CA-58,MG=27,NA=206		16.8	80020		15	1650	0.00010
24829RCX6		50.0	18.2	80020	4.1		1690	0.00004

Dis- solved oxygen, mg/L (00300)	Dis- solved oxygen, percent of sat- uration (00301)	pH, water, unfltrd field, std units (00400)	pH, water, unfltrd lab, std units (00403)	Carbon dioxide water, unfltrd mg/L (00405)	ANC, wat unf fixed end pt, field, mg/L as CaCO3 (00410)	Carbon- ate, wat flt infl pt titr., field, mg/L (00452)	Bicar- bonate, wat flt infl pt titr., field, mg/L (00453)	Ammoni a water, fltrd, mg/L as N (00608)
		7.0	7.4	57	294			1.20
2.1	23	7.4	7.5			0.0	331	

Ammonia + org-N, water, unfltrd mg/L as N (00625)	Nitrate + nitrite water fltrd, mg/L as N (00631)	Phos- phorus, water, unfltrd mg/L as P (00665)	Organic carbon, water, unfltrd mg/L (00680)	Hard- ness, water, mg/L as CaCO3 (00900)	Calcium water, fltrd, mg/L (00915)	Magnes- ium, water, fltrd, mg/L (00925)	Sodium, water, fltrd, mg/L (00930)	Sodium adsorp- tion ratio (00931)
1.2	< 0.100	0.25	5.6	270	59.0	29.0	240	6.4
				250	57.4	26.3	210	5.8

hard

Sodium fraction of cations percent (00932)	Potassium, water, fltrd, mg/L (00935)	Chloride, water, fltrd, mg/L (00940)	Sulfate water, fltrd, mg/L (00945)	Fluoride, water, fltrd, mg/L (00950)	Silica, water, fltrd, mg/L as SiO2 (00955)	Boron, water, fltrd, ug/L (01020)	Iron, water, unfltrd recover-able, ug/L (01045)	Iron, water, fltrd, ug/L (01046)
64	18.0	420	27.0	0.30	37.0	470	5000	440
62	22.8	358 d	14.1	0.20	42.4			599

300
2°

500
WHO

Manganese, water, unfltrd recoverable, ug/L (01055)	Manganese, water, fltrd, ug/L (01056)	Zinc, water, fltrd, ug/L (01090)	Aluminum, water, fltrd, ug/L (01106)	Alkalinity, wat flt fxd end lab, mg/L as CaCO3 (29801)	Depth to water level below LSD, meters (30210)	Alkalinity, wat flt inf tit field, mg/L as CaCO3 (39086)	Residue on evap. at 180deg C wat flt mg/L (70300)	Residue water, fltrd, sum of constituents mg/L (70301)
50	15.0	8	20		2.31		1070	1010
	14.0			276	2.62	271	930	896

50
20

Residue water, fltrd, tons/ acre-ft (70303)	Ammonia water, fltrd, mg/L (71846)	Bromide water, fltrd, mg/L (71870)	Sample purpose code (71999)	Pump or flow period prior to sam-pling, minutes (72004)	Sam-pling condi-tion, code (72006)	Depth to top sample intrval feet below LSD (72015)	Depth to bot sample intrval feet below LSD (72016)	Depth to water level, feet below LSD (72019)
1.46	1.55					92.00	97.00	7.58
1.26		1.14 d	10.00	45	0.10	97.00	92.00	8.60

Sam- pling method, code (82398)	Specif. conduc- tance, wat unf lab, uS/cm 25 degC (90095)	ANC, wat unf fixed end pt, lab, mg/L as CaCO3 (90410)	Sulfide water, unfltrd field, mg/L (99119)
	1710	288	
4040	1620		M

SOW 91-B

Form GW-2
1978-10,000

COMMONWEALTH OF VIRGINIA
WATER WELL COMPLETION REPORT

BWCM No. 234-65

(Certification of Completion/County Permit)

State Water Control Board
P. O. Box 11143
2111 North Hamilton St.
Richmond, Va. 23230

SWCB Permit ______
County Permit ______

Certification of inspecting official:
This well does ____ does not ____
meet code/law requirements.
S. ______
Date ______

For Office Use

County/(City) Chesapeake

County/City Stamp

Virginia Plane Coordinates
______ N
______ E
Latitude & Longitude
36° 42' 27" N
76° 07' 49" W
Topo. Map No. ______
Elevation ______ ft.
Formation ______
Lithology ______
River Basin ______
Province ______
Type Logs ______
Cuttings 10 ft. intervals
Water Analysis yes
Aquifer Test ______

Owner SWCB
Well Designation or Number ______
Address ______
Phone ______

Drilling Contractor SWCB
Address 2111 N. Hamilton St.
Richmond, Va.
Phone ______

Tax Map I.D. No. ______
Subdivision ______
Section ______
Block ______
Lot ______
Class Well: I ____, IIA ____,
IIB ____, IIIA ____, IIIB ____
IIIC ____ IIID ____ IIIE ____

WELL LOCATION: ______ (feet/miles ______ direction) of ______
and ______ feet/miles ______ (direction) of ______
(If possible please include map showing location marked)

Date started 5-6-79 Date completed ______ Type rig Mud Rotary Failing CF-15

1. WELL DATA: New X Reworked ______ Deepened ______
Total depth 1060 ft.
Depth to bedrock ______ ft.
Hole size (Also include reamed zones)
6.5 inches from 0 to 1060 ft.
______ inches from ______ to ______ ft.
______ inches from ______ to ______ ft.
Casing size (I.D.) and material
4 inches from 0 to 1040 ft.
Material Steel
Wt. per foot ______ or wall thickness ______ in.
______ inches from ______ to ______ ft.
Material ______
Wt. per foot ______ or wall thickness ______ in.
______ inches from ______ to ______ ft.
Material ______
Wt. per foot ______ or wall thickness ______ in.
Screen size and mesh for each zone (where applicable)
4 inches from 1040 to 1060 ft.
Mesh size ______ Type ______
______ inches from ______ to ______ ft.
Mesh size ______ Type ______
______ inches from ______ to ______ ft.
Mesh size ______ Type ______
______ inches from ______ to ______ ft.
Mesh size ______ Type ______
Gravel pack
From ______ to ______ ft.
From ______ to ______ ft.
Grout
From ______ to ______ ft., Type ______
From ______ to ______ ft., Type ______

2. WATER DATA Water temperature ______ °F
Static water level (unpumped level-measured) ______
Stabilized measured pumping water level ______
Stabilized yield ______ gpm after ______ hours
Natural Flow: Yes ____ No ____, flow rate ______ gpm
Comment on quality ______

3. WATER ZONES: From ____ To ____
From ____ To ____, From ____ To ____
From ____ To ____, From ____ To ____

4. USE DATA:
Type of use: Drinking ____, Livestock Watering ____,
Irrigation ____ Food processing ____, Household ____,
Manufacturing ____, Fire safety ____, Cleaning ____,
Recreation ____, Aesthetic ____, Cooling or heating ____,
Injection ____, Other observation
Type of facility: Domestic ____, Public water supply ____,
Public institution ____, Farm ____, Industry ____,
Commercial ____, Other ____

5. PUMP DATA: Type ______ Rated H.P. ______,
Intake depth ____ Capacity ____ at ____ head

6. WELLHEAD: Type well seal ______
Pressure tank ____ gal., Loc. ______
Sample tap ____, Measurement port ______
Well vent ____, Pressure relief valve ______
Gate valve ____, Check valve (when required) ______
Electrical disconnect switch on power supply ______

7. DISINFECTION: Well disinfected ____ yes ____ no
Date ____, Disinfectant used ______
Amount ____, Hours used ______

8. ABANDONMENT (where applicable) yes ____ no ____
Casing pulled yes ____ no ____ not applicable ____
Plugging grout From ____ to ____ material ______

OVER

79-4(A)
Fentress

Depth / Time (min)	Description
0 - 10/1.0	Brown to Gray Clay w/Trace med sand
10 - 110/20.0	Gray med To Coarse Sand w/Trace Br. Clay
110-160/13.0	Med To Very Coarse Sand, Trace shell frag. & Glauconit
160-180/6.0	fine to Coarse Sand, Shell, Glauconite w/Trace Clay
180 - 230/15.0	Med To Coarse Sand, shell frag, w/ Abundant Glauconite
230 - 260/10.0	VCS, Shell frag Glauconite
260 - 280/30.0	Hard Limey Cemented Glauconite with shell & med To Coarse Sand
280 - 300/5.0	fine Sandy clay w/ Glauconite & shell frag.
300 - 330/9.0	Gray Clay Trace fine sand, shell frag, Glauconite.
330 - 600/115.0	Gray Clay
600 - 700/580	Green Clay w/Some Sand & Black sand.
700 - 780/?	Pebbles, shell frag, Gray Clay w/ med To fine Sand.
780 - 800/?	fine to Coarse Sand w/few Pebbles, Shells
800 - 880/?	Clayey fine To VCS w/ few Pebbles Trace shell frag
880 - 910/?	Micaceous Silty fine to VCS occasional Pebble
? 1000/?	Micaceous Silty Clay w/ Trace Coarse Sand.
1000 - 1080/?	Gray VCS w/ Pebbles.

Sample Datetime	Time datum	Time datum reliability code	Sample Medium Code	Agency Collecting Sample, Code	Analysis Source	Hydro-logic Event	Hydro-logic Condition	Geo-logic unit
1989-03-	EST	T	WG	USGS-WRD	9	9	A	
2001-03-	EST	T	WG	USGS-WRD	9	X	X	211CRCSU
2008-06-	EDT	K	WG	USGS-WRD	9	X	X	211CRCSU

USGS 364227076074702 61B 5 SOW 091B

Chesapeake City, Virginia
Hydrologic Unit Code 03010205
Latitude 36°42'27", Longitude 76°07'47" NAD27
Land-surface elevation 15.00 feet above sea level NGVD29
The depth of the well is 1,060 feet below land surface.
The depth of the hole is 1,200 feet below land surface.
This well is completed in the Northern Atlantic Coastal Plain aquifer system (S100NATLCP)
This well is completed in the UPPER CRETACEOUS SERIES (211CRCSU) local aquifer.

Water Quality Remark Code	Description
<	Less than.
E	Estimated.
M	Presence verified but not quantified.

Value Qualifier Code	Description
@	Holding time exceeded
c	See laboratory comment
d	Diluted sample: method hi range exceeded

Sample type	Project Code	Laboratory sample comment	Temperature, water, deg C (00010)	Temperature, air, deg C (00020)	Barometric pressure, mm Hg (00025)	Agency analyzing sample, code (00028)	Flow rate, instantaneous gal/min (00059)	Color, water, fltrd, Pt-Co units (00080)
9	445108900	CL-RR	18.5			80020		4
9	445110600		20.0	15.7	753	80020	4.0	
9	24829RC20		21.3		757		6.8	

) national aquifer.

Specif- ic conduc- tance, wat unf uS/cm 25 degC (00095)	Hydro- gen ion, water, unfltrd calcd, mg/L (00191)	Dis- solved oxygen, mg/L (00300)	Dis- solved oxygen, percent of sat- uration (00301)	pH, water, unfltrd field, std units (00400)	pH, water, unfltrd lab, std units (00403)	Carbon dioxide water, unfltrd mg/L (00405)	ANC, wat unf fixed end pt, field, mg/L as CaCO3 (00410)	Carbon- ate, wat flt infl pt titr., field, mg/L (00452)
6000	0.00001			8.0	7.9	8.7	453	
5780	0.00001	0.0	0.0	7.9	8.0			< 1
5880		0.1		7.9	8.1			E 2

Bicar-bonate, wat flt infl pt titr., field, mg/L (00453)	Ammonia water, fltrd, mg/L as N (00608)	Ammonia + org-N, water, unfltrd mg/L as N (00625)	Nitrate + nitrite water fltrd, mg/L as N (00631)	Phos-phorus, water, unfltrd mg/L as P (00665)	Organic carbon, water, unfltrd mg/L (00680)	Hard-ness, water, mg/L as CaCO3 (00900)	Calcium water, fltrd, mg/L (00915)	Magnes-ium, water, fltrd, mg/L (00925)
	2.20	2.0	< 0.100	0.03	0.5	87	15.0	12.0
554						87	16.6	11.0
E 547							15.8 d	10.9 dc

Sodium, water, fltrd, mg/L (00930)	Sodium adsorption ratio (00931)	Sodium fraction of cations percent (00932)	Potassium, water, fltrd, mg/L (00935)	Chloride, water, fltrd, mg/L (00940)	Sulfate water, fltrd, mg/L (00945)	Fluoride, water, fltrd, mg/L (00950)	Silica, water, fltrd, mg/L as SiO2 (00955)	Boron, water, fltrd, ug/L (01020)
1100	51	95	25.0	1500	120	1.30	13.0	3600
1180	55	95	27.3	1540	109	1.49	11.8	
1200 d			26.8 dc	1590 d	117 d	1.43	10.5 dc	

Iron, water, unfltrd recover -able, ug/L (01045)	Iron, water, fltrd, ug/L (01046)	Mangan-ese, water, unfltrd recover -able, ug/L (01055)	Mangan-ese, water, fltrd, ug/L (01056)	Zinc, water, fltrd, ug/L (01090)	Alum-inum, water, fltrd, ug/L (01106)	Alka-linity, wat flt fxd end lab, mg/L as CaCO3 (29801)	Depth to water level below LSD, meters (30210)	Alka-linity, wat flt inf tit field, mg/L as CaCO3 (39086)
760	110	20	20	20	20		14.7	
	478		18.9			462	20.8	455
	425 dc		11.4 dc			454 @c		452

Residue on evap. at 180deg C wat flt mg/L (70300)	Residue water, fltrd, sum of consti- tuents mg/L (70301)	Residue water, fltrd, tons/ acre-ft (70303)	Ammonia water, fltrd, mg/L (71846)	Bromide water, fltrd, mg/L (71870)	Alti- tude of land surface feet (72000)	Pump or flow period prior to sam- pling, minutes (72004)	Sam- pling condi- tion, code (72006)	Depth to top sample intrval feet below LSD (72015)
3050	3060	4.15	2.83					1040.00
2940	3170	3.99		6.12	15.0	495	8.00	1040.00
3260				5.92 d	15.0	403	8.00	1040.00

Depth to bot sample intrval feet below LSD (72016)	Depth to water level, feet below LSD (72019)	Sampler type, code (84164)	Specif. conduc-tance, wat unf lab, uS/cm 25 degC (90095)	ANC, wat unf fixed end pt, lab, mg/L as CaCO3 (90410)	Sulfide water, unfltrd field, mg/L (99119)
1060.00	48.21		5740	463	
1060.00	68.30	4040	5720		
1060.00	77.60	4040	5840		M

Form GW-2
1978-10,000

SOW 91-C

COMMONWEALTH OF VIRGINIA

WATER WELL COMPLETION REPORT

BWCM No. 234-66

(Certification of Completion/County Permit)

[illegible] Water Control Board
Box 11143
[illegible] North Hamilton St.
Richmond, Va. 23230

SWCB Permit ____
County Permit ____

Certification of inspecting official:
This well does ____ does not ____
meet code/low requirements.
S. ____
Date ____
For Office Use

County/City Chesapeake

County/City Stamp

Virginia Plane Coordinates
____ N
____ E
Latitude & Longitude
364228 N
760749 W
Topo. Map No. ____
Elevation ____ ft.
Formation ____
Lithology ____
River Basin ____
Province ____
Type Logs [illegible] D
Cuttings no
Water Analysis ____
Aquifer Test ____

Owner Fentress obs. 91C
Well Designation or Number ____
Address ____
Phone ____
Drilling Contractor SWCB
Address ____
Phone ____

Tax Map I.D. No. ____
Subdivision ____
Section ____
Block ____
Lot ____
Class Well: I ____, IIA ____,
IIB ____, IIIA ____, IIIB ____
IIIC ____ IIID ____ IIIE ____

WELL LOCATION: ____ (feet/miles ____ direction) of ____
and ____ feet/miles ____ (direction) of ____
(If possible please include map showing location marked)

Date started 5/23/79 Date completed 5/24/79 Type rig rot

1. WELL DATA: New ✓ Reworked ____ Deepened ____
Total depth 800 ft.
Depth to bedrock ____ ft.
[Hol]e size (Also include reamed zones)
7 inches from 0 to 800 ft.
____ inches from ____ to ____ ft.
____ inches from ____ to ____ ft.
Casing size (I.D.) and material
4 inches from 0 to 760 ft.
Material ____
Wt. per foot ____ or wall thickness ____ in.
____ inches from ____ to ____ ft.
Material ____
Wt. per foot ____ or wall thickness ____ in.
____ inches from ____ to ____ ft.
Material ____
Wt. per foot ____ or wall thickness ____ in.
Screen size and mesh for each zone (where applicable)
3 inches from 760 to 780 ft.
Mesh size ____ Type ____
____ inches from ____ to ____ ft.
Mesh size ____ Type ____
____ inches from ____ to ____ ft.
Mesh size ____ Type ____
____ inches from ____ to ____ ft.
Mesh size ____ Type ____
Gravel pack
From ____ to ____ ft.
From ____ to ____ ft.
Grout
From ____ to ____ ft., Type ____
From ____ to ____ ft., Type ____

2. WATER DATA Water temperature ____ °F.
Static water level (unpumped level-measured) ____ ft.
Stabilized measured pumping water level ____ ft.
Stabilized yield ____ gpm after ____ hours
Natural Flow: Yes ✓ No ____, flow rate ____ gpm
Comment on quality tastes salty

3. WATER ZONES: From ____ To ____
From ____ To ____, From ____ To ____
From ____ To ____, From ____ To ____

4. USE DATA:
Type of use: Drinking ____, Livestock Watering ____,
Irrigation ____, Food processing ____, Household ____,
Manufacturing ____, Fire safety ____, Cleaning ____,
Recreation ____, Aesthetic ____, Cooling or heating ____,
Injection ____, Other research
Type of facility: Domestic ____, Public water supply ____,
Public institution ____, Farm ____, Industry ____,
Commercial ____, Other ____

5. PUMP DATA: Type ____ Rated H.P. ____,
Intake depth ____ Capacity ____ at ____ head

6. WELLHEAD: Type well seal ____
Pressure tank ____ gal., Loc. ____
Sample tap ____, Measurement port ____
Well vent ____, Pressure relief valve ____
Gate valve ____, Check valve (when required) ____
Electrical disconnect switch on power supply ____

7. DISINFECTION: Well disinfected ____ yes ____ no
Date ____, Disinfectant used ____
Amount ____, Hours used ____

8. ABANDONMENT (where applicable) yes ____ no ____
Casing pulled yes ____ no ____ not applicable ____
Plugging grout From ____ to ____ material ____

OVER

Sample Datetime	Time datum	Time datum reliability code	Sample Medium Code	Agency Collecting Sample, Code	Analysis Source	Hydro-logic Event	Hydro-logic Condition	Geo-logic unit
1989-03-	EST	T	WG	USGS-WRD	9	9	A	
1993-07-	EDT	T	WG	USGS-WRD	9	9	A	
1996-07-	EDT	T	WG	USGS-WRD	9	9	A	000SAND
1998-04-	EDT	T	WG	USGS-WRD	9	9	A	000SAND
2006-06-	EDT	K	WG	USGS-WRD	9	9	A	211CRAQU

USGS 364227076074703 61B 6 SOW 091C

Chesapeake City, Virginia
Hydrologic Unit Code 03010205
Latitude 36°42'27", Longitude 76°07'47" NAD27
Land-surface elevation 15.00 feet above sea level NGVD29
The depth of the well is 780 feet below land surface.
The depth of the hole is 800 feet below land surface.
This well is completed in the Northern Atlantic Coastal Plain aquifer system (S100NATLCP)
This well is completed in the UPPER CRETACEOUS AQUIFER SYSTEM (211CRAQU) local aq

PEE DEE Aquifer

Water Quality Remark Code	Description
<	Less than.
M	Presence verified but not quantified.

Value Qualifier Code	Description
@	Holding time exceeded
c	See laboratory comment
d	Diluted sample: method hi range exceeded

Sample type	Project Code	Temperature, water, deg C (00010)	Temperature, air, deg C (00020)	Barometric pressure, mm Hg (00025)	Agency analyzing sample, code (00028)	Flow rate, instantaneous gal/min (00059)	Color, water, fltrd, Pt-Co units (00080)	Specific conductance, wat unf uS/cm 25 degC (00095)
9	445108900	18.0			80020		4	80000
9	445108910	19.8	34.0	766	80020			9400
9	44511060	20.0	25.5	755	80020	3.0		9500
9	445110600	20.0	14.0	764	80020			9480
9	24829RC20	19.8	23.5	751	80020	8.5		8780

) national aquifer.
uifer.

Hydrogen ion, water, unfltrd calcd, mg/L (00191)	Dis-solved oxygen, mg/L (00300)	Dis-solved oxygen, percent of saturation (00301)	pH, water, unfltrd field, std units (00400)	pH, water, unfltrd lab, std units (00403)	Carbon dioxide water, unfltrd mg/L (00405)	ANC, wat unf fixed end pt, field, mg/L as CaCO3 (00410)	Carbonate, wat flt infl pt titr., field, mg/L (00452)	Bicarbonate, wat flt infl pt titr., field, mg/L (00453)
0.00003			7.6	7.6	30	617		
0.00002	0.1	0.0	7.7	7.7	29		0.0	914
0.00003	0.2	2	7.5	7.6	45			828
0.00003	0.0	0.0	7.5	7.6	45		0.0	749
0.00003	M	0.0	7.5	7.8			3	888

Organic nitro-gen, water, unfltrd mg/L (00605)	Ammonia water, fltrd, mg/L as N (00608)	Ammonia + org-N, water, unfltrd mg/L as N (00625)	Nitrate + nitrite water fltrd, mg/L as N (00631)	Phos-phorus, water, unfltrd mg/L as P (00665)	Organic carbon, water, unfltrd mg/L (00680)	Hard-ness, water, mg/L as CaCO3 (00900)	Calcium water, fltrd, mg/L (00915)	Magnes-ium, water, fltrd, mg/L (00925)
0.50	5.90	6.4	< 0.100	0.11	5.1	200	25.0	33.0
						190	25.0	32.0
						180	24.0	30.0
						210	28.6	34.0
						190	25.9 dc	30.9 dc

Sodium, water, fltrd, mg/L (00930)	Sodium adsorption ratio (00931)	Sodium fraction of cations percent (00932)	Potassium, water, fltrd, mg/L (00935)	Chloride, water, fltrd, mg/L (00940)	Sulfate water, fltrd, mg/L (00945)	Fluoride, water, fltrd, mg/L (00950)	Silica, water, fltrd, mg/L as SiO2 (00955)	Boron, water, fltrd, ug/L (01020)
1900	59	94	55.0	2600	160	1.30	16.0	6500
1900	59	94	52.0	2500	170	1.6	14.0	
1800	58	94	57.0	2600	170	1.40	16.0	
1980	59	94	54.5	2520	167	1.21	16.8	
1850 dc	58	94	54.4 dc	2570 d	160 d	1.32	15.7 dc	

Iron, water, unfltrd recover -able, ug/L (01045)	Iron, water, fltrd, ug/L (01046)	Mangan-ese, water, unfltrd recover -able, ug/L (01055)	Mangan-ese, water, fltrd, ug/L (01056)	Zinc, water, fltrd, ug/L (01090)	Alum-inum, water, fltrd, ug/L (01106)	Alka-linity, wat flt fxd end lab, mg/L as CaCO3 (29801)	Depth to water level below LSD, meters (30210)	Alka-linity, wat flt fxd end field, mg/L as CaCO3 (39036)
8200	280	40	10	< 10	20		1.67	
	130		< 10					
	300		< 10.0					
	278		< 40.0				0.055	610
	207 dc		5.4 dc			725 @c	2.18	

Alka- linity, wat flt inf tit field, mg/L as CaCO3 (39086)	Residue on evap. at 180deg C wat flt mg/L (70300)	Residue water, fltrd, sum of consti- tuents mg/L (70301)	Residue water, fltrd, tons/ acre-ft (70303)	Ammonia water, fltrd, mg/L (71846)	Bromide water, fltrd, mg/L (71870)	Alti- tude of land surface feet (72000)	Pump or flow period prior to sam- pling, minutes (72004)	Sam- pling condi- tion, code (72006)
	5050	5170	6.87	7.60				
749	5480	5150	7.45		3.90			
679	5230	5120	7.11		9.90	15.0	265	8.00
614	5110	5180	6.95		9.29			8.00
733	5320	5160	7.23		9.69 d	15.0	215	8.00

Depth to top sample intrval feet below LSD (72015)	Depth to bot sample intrval feet below LSD (72016)	Depth to water level, feet below LSD (72019)	Sam-pling method, code (82398)	Sampler type, code (84164)	Specif. conduc-tance, wat unf lab, uS/cm 25 degC (90095)	ANC, wat unf fixed end pt, lab, mg/L as CaCO3 (90410)	Sulfide water, unfltrd field, mg/L (99119)
760.00	780.00	5.48			9100	727	
			8010	4040	9170	724	
760.00	780.00			4040	9230	729	
760.00	780.00	0.18		4040	9060	729	
760.00	780.00	7.15		4040	9250		M

SOW 91-D

Form GW-2
1978-10,000

COMMONWEALTH OF VIRGINIA
WATER WELL COMPLETION REPORT

BWCM No. 234-67

(Certification of Completion/County Permit)

State Water Control Board
P. O. Box 11143
2111 North Hamilton St.
Richmond, Va. 23230

SWCB Permit ______
County Permit ______

Certification of inspecting official:
This well does ____ does not ____ meet code/low requirements.
S. ______
Date ______
For Office Use

County/City chesapeake

County/City Stamp

Virginia Plane Coordinates
______ N
______ E
Latitude & Longitude
36° 42' 07" N
76° 07' 49" W
Topo. Map No. ______
Elevation ______ ft.
Formation ______
Lithology ______
River Basin ______
Province ______
Type Logs ______
Cuttings ______
Water Analysis ______
Aquifer Test ______

Owner SWCB
Well Designation or Number SOW 91-D
Address ______
Phone ______
Drilling Contractor SWCB
Address 2111 N. Hamilton St.
Richmond, Va.
Phone ______

Tax Map I.D. No. ______
Subdivision ______
Section ______
Block ______
Lot ______
Class Well I ______, IIA ______,
IIB ______, IIIA ______, IIIB ______
IIIC ______ IIID ______ IIIE ______

WELL LOCATION: ______ (feet/miles ______ direction) of ______
and ______ feet/miles ______ (direction) of ______
(If possible please include map showing location marked)

Date started ______ Date completed ______ Type rig Falling F-15

1. WELL DATA: New X Reworked ______ Deepened ______
Total depth 22 ft.
Depth to bedrock ______ ft.
Hole size (Also include reamed zones)
4 inches from 0 to ~~40~~ 22 ft.
______ inches from ______ to ______ ft.
______ inches from ______ to ______ ft.
Casing size (I.D.) and material
4 inches from 0 to 17 ft.
Material ______
Wt. per foot ______ or wall thickness ______ in.
______ inches from ______ to ______ ft.
Material ______
Wt. per foot ______ or wall thickness ______ in.
______ inches from ______ to ______ ft.
Material ______
Wt. per foot ______ or wall thickness ______ in.
Screen size and mesh for each zone (where applicable)
4 inches from 17 to 22 ft.
Mesh size ______ Type ______
______ inches from ______ to ______ ft.
Mesh size ______ Type ______
______ inches from ______ to ______ ft.
Mesh size ______ Type ______
______ inches from ______ to ______ ft.
Mesh size ______ Type ______
Gravel pack
From ______ to ______ ft.
From ______ to ______ ft.
Grout
From ______ to ______ ft., Type ______
From ______ to ______ ft., Type ______

2. WATER DATA Water temperature ______ °F
Static water level (unpumped level-measured) ______ ft
Stabilized measured pumping water level ______ ft.
Stabilized yield ______ gpm after ______ hours
Natural Flow: Yes ____ No ____, flow rate ______ gpm
Comment on quality ______

3. WATER ZONES: From ____ To ____
From ____ To ____, From ____ To ____
From ____ To ____, From ____ To ____

4. USE DATA:
Type of use: Drinking ____, Livestock Watering ____,
Irrigation ____ Food processing ____, Household ____,
Manufacturing ____, Fire safety ____, Cleaning ____,
Recreation ____, Aesthetic ____, Cooling or heating ____,
Injection ____, Other Observation
Type of facility: Domestic ____, Public water supply ____,
Public institution ____, Farm ____, Industry ____,
Commercial ____, Other ____

5. PUMP DATA: Type ______ Rated H.P. ______,
Intake depth ____ Capacity ____ at ____ head

6. WELLHEAD: Type well seal ______
Pressure tank ____ gal., Loc. ______
Sample tap ____, Measurement port ______
Well vent ____, Pressure relief valve ______
Gate valve ____, Check valve (when required) ______
Electrical disconnect switch on power supply ______

7. DISINFECTION: Well disinfected ____ yes ____ no
Date ____, Disinfectant used ______
Amount ____, Hours used ______

8. ABANDONMENT (where applicable) yes ____ no ____
Casing pulled yes ____ no ____ not applicable ____
Plugging grout From ____ to ____ material ______

OVER

Sample Datetime	Time datum	Time datum reliability code	Sample Medium Code	Agency Collecting Sample, Code	Analysis Source	Hydro-logic Event	Hydro-logic Condition	Sample type
1989-03-	EST	T	WG	USGS-WRD	9	9	A	9
2003-08-	EDT	K	WG	USGS-WRD	9	9	A	9

USGS 364227076074704 61B 7 SOW 091D

Chesapeake City, Virginia
Hydrologic Unit Code 03010205
Latitude 36°42'27", Longitude 76°07'47" NAD27
Land-surface elevation 15.00 feet above sea level NGVD29
The depth of the well is 22.0 feet below land surface.
The depth of the hole is 22.0 feet below land surface.
This well is completed in the QUATERNARY SYSTEM (110QRNR) local aquifer.

Water Quality Remark Code	**Description**
<	Less than.
M	Presence verified but not quantified.

Value Qualifier Code	**Description**

d	Diluted sample: method hi range exceeded

Project Code	Laboratory sample comment	Sampling depth, feet (00003)	Temperature, water, deg C (00010)	Agency analyzing sample, code (00028)	Flow rate, instantaneous gal/min (00059)	Color, water, fltrd, Pt-Co units (00080)	Specific conductance, wat unf uS/cm 25 degC (00095)	Hydrogen ion, water, unfltrd calcd, mg/L (00191)
445108900	RR:ALK DROPPED,CL=24,SO4=25		15.0	80020		13	200	0.00253
24829RCX6		19.0	18.7	80020	2.7		325	0.00139

Dis- solved oxygen, mg/L (00300)	Dis- solved oxygen, percent of sat- uration (00301)	pH, water, unfltrd field, std units (00400)	pH, water, unfltrd lab, std units (00403)	Carbon dioxide water, unfltrd mg/L (00405)	ANC, wat unf fixed end pt, field, mg/L as CaCO3 (00410)	Carbon- ate, wat flt infl pt titr., field, mg/L (00452)	Bicar- bonate, wat flt infl pt titr., field, mg/L (00453)	Organic nitro- gen, water, unfltrd mg/L (00605)
		5.6	6.0	311	64			0.18
0.5	5	5.9	5.7			0.0	90	

Ammonia water, fltrd, mg/L as N (00608)	Ammonia + org-N, water, unfltrd mg/L as N (00625)	Nitrate + nitrite water fltrd, mg/L as N (00631)	Phos- phorus, water, unfltrd mg/L as P (00665)	Organic carbon, water, unfltrd mg/L (00680)	Hard- ness, water, mg/L as CaCO3 (00900)	Noncarb hard- ness, wat flt lab, mg/L as CaCO3 (00905)	Calcium water, fltrd, mg/L (00915)	Magnes- ium, water, fltrd, mg/L (00925)
0.120	0.30	< 0.100	0.06	3.0	40		6.80	5.60
					72	48	11.5	10.4

Sodium, water, fltrd, mg/L (00930)	Sodium adsorption ratio (00931)	Sodium fraction of cations percent (00932)	Potassium, water, fltrd, mg/L (00935)	Chloride, water, fltrd, mg/L (00940)	Sulfate water, fltrd, mg/L (00945)	Fluoride, water, fltrd, mg/L (00950)	Silica, water, fltrd, mg/L as SiO2 (00955)	Boron, water, fltrd, ug/L (01020)
14.0	1.0	42	1.10	24.0	12.0	0.10	20.0	40
17.9	0.9	35	1.38	8.08	63.4	< 0.17	17.4	

500
WHO

Iron, water, unfltrd recover-able, ug/L (01045)	Iron, water, fltrd, ug/L (01046)	Mangan-ese, water, unfltrd recover-able, ug/L (01055)	Mangan-ese, water, fltrd, ug/L (01056)	Zinc, water, fltrd, ug/L (01090)	Alum-inum, water, fltrd, ug/L (01106)	Alka-linity, wat flt fxd end lab, mg/L as CaCO3 (29801)	Depth to water level below LSD, meters (30210)	Alka-linity, wat flt inf tit field, mg/L as CaCO3 (39086)
12 mg/L 12000	15000	240	280	36	20		0.323	
	29500 d		388			24	0.829	74

300 50

Residue on evap. at 180deg C wat flt mg/L (70300)	Residue water, fltrd, sum of consti-tuents mg/L (70301)	Residue water, fltrd, tons/ acre-ft (70303)	Ammonia water, fltrd, mg/L (71846)	Bromide water, fltrd, mg/L (71870)	Sample purpose code (71999)	Pump or flow period prior to sam-pling, minutes (72004)	Sam-pling condi-tion, code (72006)	Depth to top sample intrval feet below LSD (72015)
159	137	0.22	0.15					17.00
201	204	0.27		0.15 d	10.00	40	0.10	22.00

Depth to bot sample intrval feet below LSD (72016)	Depth to water level, feet below LSD (72019)	Sam-pling method, code (82398)	Specif. conduc-tance, wat unf lab, uS/cm 25 degC (90095)	ANC, wat unf fixed end pt, lab, mg/L as CaCO3 (90410)	Sulfide water, unfltrd field, mg/L (99119)
22.00	1.06		195	62	
17.00	2.72	4040	215		M

Fo.n GW-2
1978-10,000

COMMONWEALTH OF VIRGINIA

WATER WELL COMPLETION REPORT

BWCM No. 234-191

(Certification of Completion/County Permit)

-te Water Control Board
). Box 11143
..11 North Hamilton St.
Richmond, Va. 23230

SWCB Permit ______
County Permit ______

Certification of inspecting official: This well does ____ does not ____ meet code/low requirements.
S. ______
Date ______
For Office Use

County/City Chesapeake

County/City Stamp

Virginia Plane Coordinates
______ N
______ E
Latitude & Longitude
36 42' 27" N
76 07' 47" W
Topo. Map No. 2B
Elevation 15 ft.
Formation KLP
Lithology SD
River Basin 5
Province 1
Type Logs E
Cuttings No
Water Analysis Yes
Aquifer Test No

Owner Observation Well # 91-E
Well Designation or Number Fentress
Address ______
Phone ______
Drilling Contractor SWCB - Creason
Address ______
Phone ______

Tax Map I.D. No. ______
Subdivision ______
Section ______
Block ______
Lot ______
Class Well I ______, IIA ______, IIB ______, IIIA ______, IIIB ______, IIIC ______ IIID ______ IIIE ______

Fentress [Observation Well # 91-E]
WELL LOCATION: ______ (feet/miles ______ direction) of ______
and ______ feet/miles ______ (direction) of ______
(If possible please include map showing location marked)

Date started 9-29-88 Date completed 11-30-88 Type rig Mud Rotary

1. WELL DATA: New x Reworked ______ Deepened ______
Total depth 1831' ft.
Depth to bedrock ______ ft.
Hole size (Also include reamed zones)
12 inches from 0 to 82' ft.
7 inches from 83 to 1697' ft.
3.5 inches from 1698' to 1873' ft.
Casing size (I.D.) and material
4 inches from 0 to 1697' ft.
Material Black Steel
Wt. per foot ______ or wall thickness ______ in.
2 inches from 1626' to 1821' ft.
Material Black Steel
Wt. per foot ______ or wall thickness ______ in.
______ inches from ______ to ______ ft.
Material ______
Wt. per foot ______ or wall thickness ______ in.
Screen size and mesh for each zone (where applicable)
2 inches from 1821' to 1831' ft.
Mesh size .020 Type SS Pipe Base
______ inches from ______ to ______ ft.
Mesh size ______ Type ______
______ inches from ______ to ______ ft.
Mesh size ______ Type ______
______ inches from ______ to ______ ft.
Mesh size ______ Type ______
Gravel pack
From ______ to ______ ft.
From ______ to ______ ft.
Grout
From 0 to 1697' ft., Type Aqua-Gel Goldseal
From ______ to ______ ft., Type ______

2. WATER DATA Water temperature 60.8 °F
Static water level (unpumped level-measured) 39.68 TOC ft
Stabilized measured pumping water level 85.0 TOC ft
Stabilized yield 7.9 gpm after 7.5 hours
Natural Flow: Yes ____ No x , flow rate ______ g pm
Comment on quality Salty

3. WATER ZONES: From ______ To ______
From ______ To ______ From ______ To ______
From ______ To ______ From ______ To ______

4. USE DATA:
Type of use: Drinking ______, Livestock Watering ______, Irrigation ______ Food processing ______, Household ______, Manufacturing ______, Fire safety ______, Cleaning ______, Recreation ______, Aesthetic ______, Cooling or heating ______, Injection ______, Other Observation
Type of facility: Domestic ______, Public water supply ______, Public institution ______, Farm ______, Industry ______, Commercial ______, Other Observation

5. PUMP DATA: Type ______ Rated H.P. ______
Intake depth ______ Capacity ______ at ______ head

6. WELLHEAD: Type well seal ______
Pressure tank ______ gal., Loc. ______
Sample tap ______, Measurement port ______
Well vent ______, Pressure relief valve ______
Gate valve ______ Check valve (when required) ______
Electrical disconnect switch on power supply ______

7. DISINFECTION: Well disinfected ______ yes ______ no
Date ______, Disinfectant used ______
Amount ______, Hours used ______

8. ABANDONMENT (where applicable) yes ______ no ______
Casing pulled yes ______ no ______ not applicable ______
Plugging grout From ______ to ______ material ______

OVER

Sample Datetime	Time datum	Time datum reliability code	Sample Medium Code	Agency Collecting Sample, Code	Analysis Source	Hydro-logic Event	Hydro-logic Condition	Geo-logic unit
1989-03-	EST	T	WG	USGS-WRD	9	9	A	
1993-07-	EDT	T	WG	USGS-WRD	9	9	A	
1998-04-	EDT	T	WG	USGS-WRD	9	9	A	217PTXN
2006-06-	EDT	K	WG	USGS-WRD	9	9	A	217PTXN

USGS 364227076074706 61B 12 SOW 091E

Chesapeake City, Virginia
Hydrologic Unit Code 03010205
Latitude 36°42'27", Longitude 76°07'47" NAD27
Land-surface elevation 15.00 feet above sea level NGVD29
The depth of the well is 1,831.00 feet below land surface.
The depth of the hole is 1,873.00 feet below land surface.
This well is completed in the Northern Atlantic Coastal Plain aquifer system (S100NATLCP)
This well is completed in the PATUXENT FORMATION (217PTXN) local aquifer.

Water Quality Remark Code	**Description**
<	Less than.
>	Greater than.

E	Estimated.

Value Qualifier Code	Description
@	Holding time exceeded
c	See laboratory comment
d	Diluted sample: method hi range exceeded
n	Below the LRL and above the LT-MDL

Sample type	**Project Code**	**Labor- atory sample comment**	**Temper- ature, water, deg C -10**	**Temper- ature, air, deg C -20**	**Baro- metric pres- sure, mm Hg -25**	**Agency ana- lyzing sample, code** -28	**Flow rate, instan- taneous gal/min -59**	**Color, water, fltrd, Pt-Co units -80**
9	445108900	NH4 & NH4+ORG-RR	16.0			80020		4
9	445108910	CATIONS DUP'ED	21.2	35.0	761	80020		
7	445110600		21.0	15.0	768	80020		
9	24829RC20	A-1860004 High chloride expected	21.6	29.6	751	80020	3.8	

) national aquifer.

Specific conductance, wat unf uS/cm 25 degC -95	Hydrogen ion, water, unfltrd calcd, mg/L -191	Dissolved oxygen, mg/L -300	Dissolved oxygen, percent of saturation -301	pH, water, unfltrd field, std units -400	pH, water, unfltrd lab, std units -403	Carbon dioxide water, unfltrd mg/L -405	ANC, wat unf fixed end pt, field, mg/L as CaCO3 -410	Carbonate, wat flt infl pt titr., field, mg/L -452
> 8000	0.00016			6.8	6.7	35	113	
46600	0.00004	0.1	1	7.4	7.0	6.4		0.0
47600	0.00008	0.1	1	7.1	6.6	12		0.0
44000	0.00005	0.1	2	7.3	6.7			0.0

Bicar- bonate, wat flt infl pt titr., field, mg/L -453	Organic nitro- gen, water, unfltrd mg/L -605	Ammonia water, fltrd, mg/L as N -608	Ammonia + org-N, water, unfltrd mg/L as N -625	Nitrate + nitrite water fltrd, mg/L as N -631	Phos- phorus, water, unfltrd mg/L as P -665	Organic carbon, water, unfltrd mg/L -680	Hard- ness, water, mg/L as CaCO3 -900	Noncarb hard- ness, wat flt field, mg/L as CaCO3 -904
	5.4	3.50	8.9	< 0.100	0.02	0.7	3300	
142							3900	3800
116							4600	4500
E 109							4400	E 4300

Noncarb hard- ness, wat flt lab, mg/L as CaCO3 -905	Calcium water, fltrd, mg/L -915	Magnes- ium, water, fltrd, mg/L -925	Sodium, water, fltrd, mg/L -930	Sodium adsorp- tion ratio -931	Sodium frac- tion of cations percent -932	Potas- sium, water, fltrd, mg/L -935	Chlor- ide, water, fltrd, mg/L -940	Sulfate water, fltrd, mg/L -945
	960	230	8100	61	84	94.0	17000	580
	1000	350	2400	17	56	100	15000	630
	1080	470	9530	61	81	118	17200	586
4300	1010 d	448 d'	8970 d	59	81	107 d	17600 d	578 d

Fluor-ide, water, fltrd, mg/L -950	Silica, water, fltrd, mg/L as SiO2 -955	Boron, water, fltrd, ug/L -1020	Iron, water, unfltrd recover-able, ug/L (01045)	Iron, water, fltrd, ug/L (01046)	Mangan-ese, water, unfltrd recover-able, ug/L (01055)	Mangan-ese, water, fltrd, ug/L (01056)	Zinc, water, fltrd, ug/L (01090)	Alum-inum, water, fltrd, ug/L (01106)
0.10	16.0	5200	15000	16000	3300	3400	420	< 50
1.7	14.0			17000		3300		
< 0.10	18.5			19000		3580		
E 0.07 n	19.3 d			18000 d		3050 d		

Alka- linity, wat flt fxd end lab, mg/L as CaCO3 (29801)	Depth to water level below LSD, meters (30210)	Alka- linity, wat flt fxd end field, mg/L as CaCO3 (39036)	Alka- linity, wat flt inf tit field, mg/L as CaCO3 (39086)	Residue on evap. at 180deg C wat flt mg/L (70300)	Residue water, fltrd, sum of consti- tuents mg/L (70301)	Residue water, fltrd, tons/ acre-ft (70303)	Ammonia water, fltrd, mg/L (71846)	Bromide water, fltrd, mg/L (71870)
	11.4			28600	27100	38.9	4.51	
			116	32100	19600	43.7		3.50
	24.5	91	95	30500	29100	41.5		62.2
76 @c	27.1		90	30900	E 28900	42.0		67.3 d

Altitude of land surface feet (72000)	Pump or flow period prior to sampling, minutes (72004)	Sampling condition, code (72006)	Depth to top sample intrval feet below LSD (72015)	Depth to bot sample intrval feet below LSD (72016)	Depth to water level, feet below LSD (72019)	Sampling method, code (82398)	Sampler type, code (84164)	Specif. conductance, wat unf lab, uS/cm 25 degC (90095)
			1821.00	1831.00	37.28			40700
						8010	4040	43900
		8.00	1820.00	1830.00	80.42		4040	41900
15.[illegible]	816	8.00	1820.00	1830.00	88.90		4040	E 46900

ANC, wat unf fixed end pt, lab, mg/L as $CaCO_3$ (90410)
88
83
78

Form GW-2
1978-10,000

COMMONWEALTH OF VIRGINIA

WATER WELL COMPLETION REPORT

BWCM No. 234-192

(Certification of Completion/County Permit)

State Water Control Board
P. O. Box 11143
2111 North Hamilton St.
Richmond, Va. 23230

SWCB Permit
County Permit

Certification of inspecting official:
This well does ____ does not ____
meet code/low requirements.
S.
Date

For Office Use

County/City Chesapeake

County/City Stamp

Virginia Plane Coordinates
N
E
Latitude & Longitude
36° 42' 27" N
76° 07' 47" W
Topo. Map No. 2B
Elevation 15 ft.
Formation KMP
Lithology SD
River Basin 5
Province 1
Type Logs E
Cuttings No
Water Analysis Yes
Aquifer Test NO

Owner Observation Well # 91-F
Well Designation or Number
Address
Phone
Drilling Contractor SWCB - Creason
Address
Phone

Tax Map I.D. No.
Subdivision
Section
Block
Lot
Class Well I ____, IIA ____,
IIB ____ IIIA ____, IIIB ____
IIIC ____ IIID ____ IIIE ____

Fentress [Observation Well # 91-F]
WELL LOCATION: ____ (feet/miles ____ direction) of
and ____ feet/miles ____ (direction) of
(If possible please include map showing location marked)

Date started 5-23-88 Date completed 7-26-88 Type rig Mud Rotary

1. WELL DATA: New X Reworked ____ Deepened ____
Total depth 1390' ft.
Depth to bedrock ____ ft.
Hole size (Also include reamed zones)
3.5 inches from 0 to 1124' ft.
7.25 inches from 0 to 1290' ft.
3.5 inches from 1290' to 1390' ft.
Casing size (I.D.) and material
4 inches from 0 to 1290' ft.
Material Black Steel
Wt. per foot ____ or wall thickness .237 in.
2 inches from 1274' to 1370' ft
Material Black Steel
Wt. per foot ____ or wall thickness ____ in.
2 inches from 1380' to 1390' ft.
Material
Wt. per foot ____ or wall thickness ____ in.
Screen size and mesh for each zone (where applicable)
2 inches from 1370' to 1380' ft.
Mesh size ____ Type ____
____ inches from ____ to ____ ft.
Mesh size ____ Type ____
____ inches from ____ to ____ ft.
Mesh size ____ Type ____
____ inches from ____ to ____ ft.
Mesh size ____ Type ____
Gravel pack
From ____ to ____ ft.
From ____ to ____ ft.
Grout
From 0 to 1290' ft., Type Benseal/EZ Mud
From ____ to ____ ft., Type ____

2. WATER DATA Water temperature 60.8 °F
Static water level (unpumped level measured) 56.72 TOC ft
Stabilized measured pumping water level Approx. 100 ft
Stabilized yield 9.4 gpm after 4.5 hours
Natural Flow: Yes ____ No X , flow rate ____ gpm
Comment on quality Salty Hydrogen Sulfide Odor

3. WATER ZONES: From ____ To ____
From ____ To ____ From ____ To ____
From ____ To ____ From ____ To ____

4. USE DATA:
Type of use: Drinking ____, Livestock Watering ____,
Irrigation ____ Food processing ____, Household ____,
Manufacturing ____, Fire safety ____, Cleaning ____,
Recreation ____, Aesthetic ____, Cooling or heating ____,
Injection ____, Other Observation
Type of facility: Domestic ____, Public water supply ____
Public institution ____, Farm ____, Industry ____,
Commercial ____, Other Observation

5. PUMP DATA: Type ____ Rated H.P. ____,
Intake depth ____ Capacity ____ at ____ head

6. WELLHEAD: Type well seal ____
Pressure tank ____ gal., Loc. ____
Sample tap ____, Measurement port ____
Well vent ____, Pressure relief valve ____
Gate valve ____, Check valve (when required) ____
Electrical disconnect switch on power supply ____

7. DISINFECTION: Well disinfected ____ yes ____ no
Date ____, Disinfectant used ____
Amount ____, Hours used ____

8. ABANDONMENT (where applicable) yes ____ no ____
Casing pulled yes ____ no ____ not applicable ____
Plugging grout From ____ to ____ material ____

OVER

Sample Datetime	Time datum	Time datum reliability code	Sample Medium Code	Agency Collecting Sample, Code	Analysis Source	Hydro-logic Event	Hydro-logic Condition	Geo-logic unit
1989-03-	EST	T	WG	USGS-WRD	9	9	A	
1993-07-	EDT	T	WG	USGS-WRD	9	9	A	
1997-04-	EDT	T	WG	USGS-WRD	9	9	A	217PPSC
2006-06-	EDT	K	WG	USGS-WRD	9	9	A	217PPSC

USGS 364227076074707 61B 13 SOW 091F

Chesapeake City, Virginia
Hydrologic Unit Code 03010205
Latitude 36°42'27", Longitude 76°07'47" NAD27
Land-surface elevation 15.00 feet above sea level NGVD29
The depth of the well is 1,390.00 feet below land surface.
The depth of the hole is 1,390.00 feet below land surface.
This well is completed in the Northern Atlantic Coastal Plain aquifer system (S100NATLCP)
This well is completed in the PATAPSCO FORMATION (217PPSC) local aquifer.

Water Quality Remark Code	Description
<	Less than.
E	Estimated.

M	Presence verified but not quantified.

Value Qualifier Code	Description
@	Holding time exceeded
c	See laboratory comment
d	Diluted sample: method hi range exceeded

Sample type	Project Code	Laboratory sample comment	Temperature, water, deg C -10	Temperature, air, deg C -20	Barometric pressure, mm Hg -25	Agency analyzing sample, code -28	Flow rate, instantaneous gal/min -59	Color, water, fltrd, Pt-Co units -80
9	445108900	NH4 & NH4+ORG-RR	16.0			80020		10
9	445108910		21.0	33.0	765	80020		
9	445110600		20.0	12.0		80020		
9	24829RC20		21.0	30.0	765	80020	2.9	

) national aquifer.

Specific conductance, wat unf uS/cm 25 degC -95	Hydrogen ion, water, unfltrd calcd, mg/L -191	Dissolved oxygen, mg/L -300	Dissolved oxygen, percent of saturation -301	pH, water, unfltrd field, std units -400	pH, water, unfltrd lab, std units -403	Carbon dioxide water, unfltrd mg/L -405	ANC, wat unf fixed end pt, field, mg/L as CaCO3 -410	Carbonate, wat flt infl pt titr., field, mg/L -452
9000	0.00006			7.2	7.4	30	242	
15500	0.00003	0.1	1	7.6	7.5	13		0.0
15500	0.00005	0.7		7.3	7.6	24		0.0
14200	0.00002	0.1	0.0	7.6	7.7			E 0.0

Bicar-bonate, wat flt infl pt titr., field, mg/L -453	Organic nitro-gen, water, unfltrd mg/L -605	Ammonia water, fltrd, mg/L as N -608	Ammonia + org-N, water, unfltrd mg/L as N -625	Nitrate + nitrite water fltrd, mg/L as N -631	Phos-phorus, water, unfltrd mg/L as P -665	Organic carbon, water, unfltrd mg/L -680	Hard-ness, water, mg/L as CaCO3 -900	Noncarb hard-ness, wat flt field, mg/L as CaCO3 -904
	0.10	5.00	5.1	< 0.100	0.02	0.3	570	
313							560	300
351							560	270
E 293							520	E 280

Noncarb hard-ness, wat flt lab, mg/L as CaCO3 -905	Calcium water, fltrd, mg/L -915	Magnes-ium, water, fltrd, mg/L -925	Sodium, water, fltrd, mg/L -930	Sodium adsorp-tion ratio -931	Sodium frac-tion of cations percent -932	Potas-sium, water, fltrd, mg/L -935	Chlor-ide, water, fltrd, mg/L -940	Sulfate water, fltrd, mg/L -945
	120	65.0	3000	55	91	43.0	5000	280
	120	63.0	3000	55	91	44.0	4600	290
	122	61.2	3110	57	92	54.4	5060	279
280	113 d	58.6 d	2740 d	52	91	48.6 d	4850 d	263 d

Fluor- ide, water, fltrd, mg/L -950	Silica, water, fltrd, mg/L as SiO2 -955	Boron, water, fltrd, ug/L -1020	Iron, water, unfltrd recover -able, ug/L (01045)	Iron, water, fltrd, ug/L (01046)	Mangan- ese, water, unfltrd recover -able, ug/L (01055)	Mangan- ese, water, fltrd, ug/L (01056)	Zinc, water, fltrd, ug/L (01090)	Alum- inum, water, fltrd, ug/L (01106)
0.40	13.0	5200	3900	3800	280	220	20	< 20
0.9	12.0			3200		200		
0.45	13.7			3870		240		
0.43	13.1 d			4070 d		244 d		

Alka-linity, wat flt fxd end lab, mg/L as CaCO3 (29801)	Depth to water level below LSD, meters (30210)	Alka-linity, wat flt fxd end field, mg/L as CaCO3 (39036)	Alka-linity, wat flt inf tit field, mg/L as CaCO3 (39086)	Residue on evap. at 180deg C wat flt mg/L (70300)	Residue water, fltrd, sum of consti-tuents mg/L (70301)	Residue water, fltrd, tons/ acre-ft (70303)	Ammonia water, fltrd, mg/L (71846)	Bromide water, fltrd, mg/L (71870)
	17.0			8900	8680	12.1	6.44	
			256	9090	8290	12.4		3.70
		280	282	8720	8900	11.9		18.3
249 @c	23.7		241	8830	E 8260	12.0		18.9 d

Altitude of land surface feet (72000)	Pump or flow period prior to sampling, minutes (72004)	Sampling condition, code (72006)	Depth to top sample intrval feet below LSD (72015)	Depth to bot sample intrval feet below LSD (72016)	Depth to water level, feet below LSD (72019)	Sampling method, code (82398)	Sampler type, code (84164)	Specif. conductance, wat unf lab, uS/cm 25 degC (90095)
			1370.00	1380.00	55.62			14800
						8010	4040	15000
			1370.00	1380.00			4040	15200
15.0	475	8.00	1370.00	1380.00	77.88		4040	E 10600

ANC, wat unf fixed end pt, lab, mg/L as CaCO3 (90410)	Sulfide water, unfltrd field, mg/L (99119)
246	
247	
250	
	M

Fo..n GW-2
1978-10,000

COMMONWEALTH OF VIRGINIA
WATER WELL COMPLETION REPORT

BWCM No. 234-193

(Certification of Completion/County Permit)

..te Water Control Board
..O. Box 11143
..111 North Hamilton St.
Richmond, Va. 23230

SWCB Permit ____
County Permit ____

Certification of inspecting official:
This well does ____ does not ____ meet code/low requirements.
S. ____
Date ____
For Office Use

County/City Chesapeake

County/City Stamp

Virginia Plane Coordinates
____ N
____ E
Latitude & Longitude
36° 42' 27" N
76° 07' 47" W
Topo. Map No. 2B
Elevation 15 ft.
Formation KUP
Lithology SD
River Basin 5
Province 1
Type Logs E
Cuttings No
Water Analysis Yes
Aquifer Test No

Owner Observation Well # 91-G
Well Designation or Number Fentress
Address ____
Phone ____
Drilling Contractor SWCB - Creason
Address ____
Phone ____

Tax Map I.D. No. ____
Subdivision ____
Section ____
Block ____
Lot ____
Class Well I ____, IIA ____,
IIB ____, IIIA ____, IIIB ____
IIIC ____ IIID ____ IIIE ____

Fentress [Observation Well # 91-G]
WELL LOCATION: ____ (feet/miles ____ direction) of ____
and ____ feet/miles ____ (direction) of ____
(If possible please include map showing location marked)

Date started 7-28-88 Date completed 8-15-88 Type rig Mud Rotary

1. WELL DATA: New X Reworked ____ Deepened ____
Total depth 1113' ft.
Depth to bedrock ____ ft.
..ole size (Also include reamed zones)
12 inches from 0 to 25' ft.
6.75 inches from 0 to 1000' ft.
3.5 inches from 1000' to 1113' ft.
Casing size (I.D.) and material
4 inches from 0 to 1000' ft.
Material Black Steel
Wt. per foot ____ or wall thickness .237 in.
2 inches from 987' to 1093' ft
Material Black Steel
Wt. per foot ____ or wall thickness ____ in.
2 inches from 1103' to 1113' ft.
Material Black Steel
Wt. per foot ____ or wall thickness ____ in.
Screen size and mesh for each zone (where applicable)
2 inches from 1093' to 1103' ft.
Mesh size .020 Type SS Pipe Base
____ inches from ____ to ____ ft.
Mesh size ____ Type ____
____ inches from ____ to ____ ft.
Mesh size ____ Type ____
____ inches from ____ to ____ ft.
Mesh size ____ Type ____
Gravel pack
From ____ to ____ ft.
From ____ to ____ ft
Grout
From 0 to 1000' ft., Type Aqua-Gel Goldseal
From ____ to ____ ft., Type ____

2. WATER DATA Water temperature 64.4 °F
Static water level (unpumped level-measured) 52.22 TOC ft
Stabilized measured pumping water level Approx. 100' ft
Stabilized yield 10 gpm after 3.5 hours
Natural Flow: Yes ____ No X, flow rate ____ gpm
Comment on quality Salty Hydrogen Sulfide Odor
3. WATER ZONES: From ____ To ____
From ____ To ____, From ____ To ____
From ____ To ____, From ____ To ____
4. USE DATA:
Type of use: Drinking ____, Livestock Watering ____,
Irrigation ____, Food processing ____, Household ____
Manufacturing ____, Fire safety ____, Cleaning ____,
Recreation ____, Aesthetic ____, Cooling or heating ____,
Injection ____, Other Observation
Type of facility: Domestic ____, Public water supply ____,
Public institution ____, Farm ____, Industry ____,
Commercial ____, Other Observation
5. PUMP DATA: Type ____ Rated H.P. ____
Intake depth ____ Capacity ____ at ____ head
6. WELLHEAD: Type well seal ____
Pressure tank ____ gal., Loc. ____
Sample tap ____, Measurement port ____
Well vent ____, Pressure relief valve ____
Gate valve ____, Check valve (when required) ____
Electrical disconnect switch on power supply ____
7. DISINFECTION: Well disinfected ____ yes ____ no
Date ____, Disinfectant used ____
Amount ____, Hours used ____
8. ABANDONMENT (where applicable) yes ____ no ____
Casing pulled yes ____ no ____ not applicable ____
Plugging grout From ____ to ____ material ____

OVER

Sample Datetime	Time datum	Time datum reliability code	Sample Medium Code	Agency Collecting Sample, Code	Analysis Source	Hydro-logic Event	Hydro-logic Condition	Geo-logic unit
1989-03-	EST	T	WG	USGS-WRD	9	9	A	
1993-07-	EDT	T	WG	USGS-WRD	9	9	A	
1997-04-	EDT	T	WG	USGS-WRD	9	9	A	211CRCSU
2006-06-	EDT	K	WG	USGS-WRD	9	9	A	211CRCSU

USGS 364227076074708 61B 14 SOW 091G

Chesapeake City, Virginia
Hydrologic Unit Code 03010205
Latitude 36°42'27", Longitude 76°07'47" NAD27
Land-surface elevation 15.00 feet above sea level NGVD29
The depth of the well is 1,113.00 feet below land surface.
The depth of the hole is 1,113.00 feet below land surface.
This well is completed in the Northern Atlantic Coastal Plain aquifer system (S100NATLCP)
This well is completed in the UPPER CRETACEOUS SERIES (211CRCSU) local aquifer.

Water Quality Remark Code	**Description**
<	Less than.
E	Estimated.

M	Presence verified but not quantified.

Value Qualifier Code	Description
@	Holding time exceeded
c	See laboratory comment
d	Diluted sample: method hi range exceeded

Sample type	Project Code	Laboratory sample comment	Temperature, water, deg C (00010)	Temperature, air, deg C (00020)	Barometric pressure, mm Hg (00025)	Agency analyzing sample, code (00028)	Flow rate, instantaneous gal/min (00059)	Color, water, fltrd, Pt-Co units (00080)
9	445108900	NH4 & NH4+ORG-RR	18.0			80020		22
9	445108910	BOTTLES OK	20.4	32.0	765	80020		
7	445110600		19.9	12.0	757	80020		
9	24829RC20		20.6	32.0	763	80020	3.0	

) national aquifer.

Specific conductance, wat unf uS/cm 25 degC (00095)	Hydrogen ion, water, unfltrd calcd, mg/L (00191)	Dissolved oxygen, mg/L (00300)	Dissolved oxygen, percent of saturation (00301)	pH, water, unfltrd field, std units (00400)	pH, water, unfltrd lab, std units (00403)	Carbon dioxide water, unfltrd mg/L (00405)	ANC, wat unf fixed end pt, field, mg/L as CaCO3 (00410)	Carbonate, wat flt infl pt titr., field, mg/L (00452)
6000	0.00002			7.7	7.9	17	429	
6010	0.00001	0.1	1	8.0	8.0	8.5		0.0
6080	0.00001			8.1	8.0	6.8		0.0
5140	0.00001	0.1	0.0	8.0	8.1			E 2

Bicar-bonate, wat flt infl pt titr., field, mg/L (00453)	Ammonia water, fltrd, mg/L as N (00608)	Ammonia + org-N, water, unfltrd mg/L as N (00625)	Nitrate + nitrite water fltrd, mg/L as N (00631)	Phos-phorus, water, unfltrd mg/L as P (00665)	Organic carbon, water, unfltrd mg/L (00680)	Hard-ness, water, mg/L as CaCO3 (00900)	Calcium water, fltrd, mg/L (00915)	Magnes-ium, water, fltrd, mg/L (00925)
	2.80	2.8	< 0.100	0.03	0.1	110	21.0	13.0
547						73	14.0	9.20
582						89	17.7	10.9
E 536						85	16.8 d	10.3 d

Sodium, water, fltrd, mg/L (00930)	Sodium adsorption ratio (00931)	Sodium fraction of cations percent (00932)	Potassium, water, fltrd, mg/L (00935)	Chloride, water, fltrd, mg/L (00940)	Sulfate water, fltrd, mg/L (00945)	Fluoride, water, fltrd, mg/L (00950)	Silica, water, fltrd, mg/L as SiO2 (00955)	Boron, water, fltrd, ug/L (01020)
1200	51	95	23.0	1600	130	1.40	13.0	3500
1100	56	96	27.0	1400	120	1.5	10.0	
1210	56	96	25.2	1640	122	1.42	12.6	
1160 d	55	96	25.3 d	1370 d	99.4 d	1.30	11.7 d	

Iron, water, unfltrd recover -able, ug/L (01045)	Iron, water, fltrd, ug/L (01046)	Mangan-ese, water, unfltrd recover -able, ug/L (01055)	Mangan-ese, water, fltrd, ug/L (01056)	Zinc, water, fltrd, ug/L (01090)	Alum-inum, water, fltrd, ug/L (01106)	Alka-linity, wat flt fxd end lab, mg/L as CaCO3 (29801)	Depth to water level below LSD, meters (30210)	Alka-linity, wat flt fxd end field, mg/L as CaCO3 (39036)
800	650	40	40	< 10	< 10		15.6	
	410		35.0					
	658		51.8					480
	922 d		66.7 d			378 @c	22.4	

Alka- linity, wat flt inf tit field, mg/L as CaCO3 (39086)	Residue on evap. at 180deg C wat flt mg/L (70300)	Residue water, fltrd, sum of consti- tuents mg/L (70301)	Residue water, fltrd, tons/ acre-ft (70303)	Ammonia water, fltrd, mg/L (71846)	Bromide water, fltrd, mg/L (71870)	Alti- tude of land surface feet (72000)	Pump or flow period prior to sam- pling, minutes (72004)	Sam- pling condi- tion, code (72006)
	3310	3270	4.50	3.61				
448	3340	2950	4.54		2.30			
477	3260	3330	4.43		6.01			
443	2870	E 2960	3.90		5.18 d	15.0	640	8.00

Depth to top sample intrval feet below LSD (72015)	Depth to bot sample intrval feet below LSD (72016)	Depth to water level, feet below LSD (72019)	Sam-pling method, code (82398)	Sampler type, code (84164)	Specif. conduc-tance, wat unf lab, uS/cm 25 degC (90095)	ANC, wat unf fixed end pt, lab, mg/L as CaCO3 (90410)	Sulfide water, unfltrd field, mg/L (99119)
1093.00	1103.00	51.32			5880	442	
			8010	4040	5890	442	
1090.00	1100.00			4040	5980	444	
1090.00	1100.00	73.42		4040	5260		M

Form GW-2
1978-10,000

COMMONWEALTH OF VIRGINIA

WATER WELL COMPLETION REPORT

BWCM No. 234-194

(Certification of Completion/County Permit)

State Water Control Board
P.O. Box 11143
211 North Hamilton St.
Richmond, Va. 23230

SWCB Permit
County Permit

Certification of inspecting official:
This well does ____ does not ____
meet code/low requirements.
S. ____
Date ____

For Office Use

County/City Chesapeake

County/City Stamp

Virginia Plane Coordinates
____ N
____ E
Latitude & Longitude
36° 42' 27" N
76° 07' 47" W
Topo. Map No. 2B
Elevation 15 ft.
Formation KVB
Lithology SD
River Basin 5
Province 1
Type Logs E
Cuttings No
Water Analysis Yes
Aquifer Test No

Owner Observation Well # 91-H
Well Designation or Number Fentress
Address
Phone
Drilling Contractor SWCB - Creason
Address
Phone

Tax Map I.D. No.
Subdivision
Section
Block
Lot
Class Well I ____, IIA ____,
IIB ____, IIIA ____, IIIB ____
IIIC ____ IIID ____ IIIE ____

Fentress [Observation Well # 91-H]
WELL LOCATION: ____ (feet/miles ____ direction) of ____
and ____ feet/miles ____ (direction) of ____
(If possible please include map showing location marked)

Date started 8-21-88 Date completed 8-25-88 Type rig Mud Rotary

1. WELL DATA: New X Reworked ____ Deepened ____
Total depth 790' ft.
Depth to bedrock ____ ft.
Hole size (Also include reamed zones)
12 inches from 0 to 25' ft.
6.75 inches from 25' to 700' ft.
3.5 inches from 700' to 790' ft.
Casing size (I.D.) and material
4 inches from 0 to 700' ft.
Material Black Steel
Wt. per foot ____ or wall thickness .237 in.
2 inches from 674' to 759' ft.
Material Black Steel
Wt. per foot ____ or wall thickness ____ in.
2 inches from 769' to 790' ft.
Material
Wt. per foot ____ or wall thickness ____ in.
Screen size and mesh for each zone (where applicable)
2 inches from 759' to 769' ft.
Mesh size .020 Type SS Wire Wrapped
____ inches from ____ to ____ ft.
Mesh size ____ Type ____
____ inches from ____ to ____ ft.
Mesh size ____ Type ____
____ inches from ____ to ____ ft.
Mesh size ____ Type ____
Gravel pack
From ____ to ____ ft.
From ____ to ____ ft.
Grout
From 0 to 700 ft., Type Aqua-Gel Goldseal
From ____ to ____ ft., Type ____

2. WATER DATA Water temperature 61.7 °F
Static water level (unpumped level measured) Flowing ft
Stabilized measured pumping water level Approx. 160 ft
Stabilized yield 7.5 gpm after 3.5 hours
Natural Flow: Yes X No ____, flow rate Less Than 1 gpm
Comment on quality Salty Hydrogen Sulfide Odor

3. WATER ZONES: From ____ To ____
From ____ To ____ From ____ To ____
From ____ To ____ From ____ To ____

4. USE DATA:
Type of use: Drinking ____, Livestock Watering ____,
Irrigation ____ Food processing ____, Household ____
Manufacturing ____, Fire safety ____, Cleaning ____,
Recreation ____, Aesthetic ____, Cooling or heating ____,
Injection ____, Other Observation
Type of facility: Domestic ____, Public water supply ____,
Public institution ____, Farm ____, Industry ____,
Commercial ____, Other Observation

5. PUMP DATA: Type ____ Rated H.P. ____,
Intake depth ____ Capacity ____ at ____ head

6. WELLHEAD: Type well seal ____
Pressure tank ____ gal., Loc. ____
Sample tap ____, Measurement port ____
Well vent ____, Pressure relief valve ____
Gate valve ____, Check valve (when required) ____
Electrical disconnect switch on power supply ____

7. DISINFECTION: Well disinfected ____ yes ____ no
Date ____, Disinfectant used ____
Amount ____, Hours used ____

8. ABANDONMENT (where applicable) yes ____ no ____
Casing pulled yes ____ no ____ not applicable ____
Plugging grout From ____ to ____ material ____

OVER

Sample Datetime	Time datum	Time datum reliability code	Sample Medium Code	Agency Collecting Sample, Code	Analysis Source	Hydro-logic Event	Hydro-logic Condition	Geo-logic unit
1989-03-	EST	T	WG	USGS-WRD	9	9	A	
2001-03-	EST	T	WG	USGS-WRD	9	X	X	211CRAQU
2006-06-	EDT	K	WG	USGS-WRD	9	9	A	211CRAQU

USGS 364227076074709 61B 15 SOW 091H

Chesapeake City, Virginia
Hydrologic Unit Code 03010205
Latitude 36°42'27", Longitude 76°07'47" NAD27
Land-surface elevation 15.00 feet above sea level NGVD29
The depth of the well is 790.00 feet below land surface.
The depth of the hole is 790.00 feet below land surface.
This well is completed in the Northern Atlantic Coastal Plain aquifer system (S100NATLCP)
This well is completed in the UPPER CRETACEOUS AQUIFER SYSTEM (211CRAQU) local aq

PEE DEE Aquifer

Water Quality Remark Code	Description
<	Less than.
M	Presence verified but not quantified.

Value Qualifier Code	Description
@	Holding time exceeded
c	See laboratory comment
d	Diluted sample: method hi range exceeded

Sample type	Project Code	Laboratory sample comment	Temperature, water, deg C (00010)	Temperature, air, deg C (00020)	Barometric pressure, mm Hg (00025)	Agency analyzing sample, code (00028)	Flow rate, instantaneous gal/min (00059)	Color, water, fltrd, Pt-Co units (00080)
9	445108900	NH4 & NH4+ORG-RR	16.5			80020		25
9	445110600		20.8	23.4	744	80020	6.7	
9	24829RC20		18.9	23.1	751	80020	3.0	

) national aquifer.
uifer.

Specific conductance, wat unf uS/cm 25 degC (00095)	Hydrogen ion, water, unfltrd calcd, mg/L (00191)	Dissolved oxygen, mg/L (00300)	Dissolved oxygen, percent of saturation (00301)	pH, water, unfltrd field, std units (00400)	pH, water, unfltrd lab, std units (00403)	Carbon dioxide water, unfltrd mg/L (00405)	ANC, wat unf fixed end pt, field, mg/L as CaCO3 (00410)	Carbonate, wat flt infl pt titr., field, mg/L (00452)
7000	0.00001			8.1	7.8	10	630	
7800	0.00002	0.0	0.0	7.8	7.9			< 1
7570	0.00001	0.1	0.0	7.9	8.0			4

Bicar-bonate, wat flt infl pt titr., field, mg/L (00453)	Ammonia water, fltrd, mg/L as N (00608)	Ammonia + org-N, water, unfltrd mg/L as N (00625)	Nitrate + nitrite water fltrd, mg/L as N (00631)	Phos-phorus, water, unfltrd mg/L as P (00665)	Organic carbon, water, unfltrd mg/L (00680)	Hard-ness, water, mg/L as CaCO3 (00900)	Calcium water, fltrd, mg/L (00915)	Magnes-ium, water, fltrd, mg/L (00925)
	4.40	4.3	< 0.100	0.19	0.9	140	20.0	22.0
775						130	19.8	20.4
778						130	18.7 dc	20.2 dc

$$TDS = Ca^{2+} + Mg^{2+} + Na^{+} + K^{+} + Cl^{-} + SO_4^{2-}$$

$$= 18.7 + 20.2 + 1550 + 42.9 + 2140 + 159$$

$$= 3930.8 \text{ mg/L}$$

Sodium, water, fltrd, mg/L (00930)	Sodium adsorption ratio (00931)	Sodium fraction of cations percent (00932)	Potassium, water, fltrd, mg/L (00935)	Chloride, water, fltrd, mg/L (00940)	Sulfate water, fltrd, mg/L (00945)	Fluoride, water, fltrd, mg/L (00950)	Silica, water, fltrd, mg/L as SiO2 (00955)	Boron, water, fltrd, ug/L (01020)
1700	62	95	39.0	2100	180	1.30	11.0	6100
1600	60	95	44.0	2150	156	1.47	9.94	
1550 dc	59	95	42.9 dc	2140 d	159 d	1.38	9.91 dc	

Iron, water, unfltrd recover -able, ug/L (01045)	Iron, water, fltrd, ug/L (01046)	Mangan-ese, water, unfltrd recover -able, ug/L (01055)	Mangan-ese, water, fltrd, ug/L (01056)	Zinc, water, fltrd, ug/L (01090)	Alum-inum, water, fltrd, ug/L (01106)	Alka-linity, wat flt fxd end lab, mg/L as CaCO3 (29801)	Depth to water level below LSD, meters (30210)	Alka-linity, wat flt inf tit field, mg/L as CaCO3 (39086)
4500	790	50	10	< 10	30			
	296		24.3			642	0.241	636
	547 dc		33.9 dc			638 @c	1.01	646

Residue on evap. at 180deg C wat flt mg/L (70300)	Residue water, fltrd, sum of consti- tuents mg/L (70301)	Residue water, fltrd, tons/ acre-ft (70303)	Ammonia water, fltrd, mg/L (71846)	Bromide water, fltrd, mg/L (71870)	Alti- tude of land surface feet (72000)	Pump or flow period prior to sam- pling, minutes (72004)	Sam- pling condi- tion, code (72006)	Depth to top sample intrval feet below LSD (72015)
4390	4460	5.97	5.67					759.00
4580	4390	6.23		7.82	15.0	200	8.00	759.00
4540	4340	6.18		8.01 d	15.0	499	8.00	759.00

Depth to bot sample intrval feet below LSD (72016)	Depth to water level, feet below LSD (72019)	Sampler type, code (84164)	Specif. conduc- tance, wat unf lab, uS/cm 25 degC (90095)	ANC, wat unf fixed end pt, lab, mg/L as CaCO3 (90410)	Sulfide water, unfltrd field, mg/L (99119)
769.00			7810	633	
769.00	0.79	4040	7760		
769.00	3.30	4040	7910		M

Form GW-2
1978-10,000

COMMONWEALTH OF VIRGINIA

WATER WELL COMPLETION REPORT

● BWCM No. 234-195

(Certification of Completion/County Permit)

State Water Control Board
P. O. Box 11143
111 North Hamilton St.
Richmond, Va. 23230

SWCB Permit ______
County Permit ______
Certification of inspecting official:
This well does ____ does not ____ meet code/low requirements.
S. ______
Date ______
For Office Use

County/City Chesapeake

County/City Stamp

● Virginia Plane Coordinates
______ N
______ E
Latitude & Longitude
36° 42' 27" N
76° 07' 47" W
● Topo. Map No. 2B
● Elevation 15 ft.
● Formation TA
● Lithology SD
● River Basin 5
● Province 1
● Type Logs E
● Cutting No
● Water Analysis Yes
● Aquifer Test No

● Owner Observation Well # 91-J
● Well Designation or Number Fentress
Address ______
Phone ______
● Drilling Contractor SWCB - Creason
Address ______
Phone ______

Tax Map I D No ______
Subdivision ______
Section ______
Block ______
Lot ______
Class Well I ____, IIA ____, IIB ____, IIIA ____, IIIB ____, IIIC ____ IIID ____ IIIE ____

Fentress [Observation Well # 91-J]
WELL LOCATION: ______ (feet/miles ______ direction) of ______
and ______ feet/miles ______ (direction) of ______
(If possible please include map showing location marked)

Date started 9-1-88 ● Date completed 9-14-88 Type rig Mud Rotary

1. WELL DATA: New X Reworked ____ Deepened ____
● Total depth 690' ft.
● Depth to bedrock ______ ft.
Hole size (Also include reamed zones)
● 7.25 inches from 0 to 602' ft.
● 3.5 inches from 602' to 690' ft.
● ____ inches from ____ to ____ ft.
● Casing size (I.D.) and material
● 4.5 inches from 0 to 602' ft.
Material PVC
Wt. per foot ____ or wall thickness ____ in.
● 2 inches from 586' to 670' ft.
Material Black Steel
Wt. per foot ____ or wall thickness ____ in.
● 2 inches from 680' to 690' ft.
Material Black Steel
Wt. per foot ____ or wall thickness ____ in.
● Screen size and mesh for each zone (where applicable)
● 2 inches from 670' to 680' ft.
● Mesh size .010 Type SS Wire Wrapped
● ____ inches from ____ to ____ ft.
● Mesh size ____ Type ____
● ____ inches from ____ to ____ ft.
● Mesh size ____ Type ____
● ____ inches from ____ to ____ ft.
● Mesh size ____ Type ____
● Gravel pack
● From ____ to ____ ft.
● From ____ to ____ ft.
● Grout
● From 0 to 602' ft., Type Aqua-Gel Goldseal
● From ____ to ____ ft., Type ____

2. WATER DATA ● Water temperature 62.6 °F
● Static water level (unpumped level-measured) Flowing ft.
● Stabilized measured pumping water level 22.52 ft.
● Stabilized yield 10 gpm after 2.5 hours
Natural Flow: Yes X No ____, flow rate Less Than 1 gpm
Comment on quality Salty, Hydrogen sulfide odor

3. WATER ZONES: From ____ To ____
From ____ To ____ From ____ To ____
From ____ To ____ From ____ To ____

4. USE DATA:
Type of use Drinking ____, Livestock Watering ____,
Irrigation ____, Food processing ____, Household ____,
Manufacturing ____, Fire safety ____, Cleaning ____,
Recreation ____, Aesthetic ____, Cooling or heating ____,
Injection ____, Other Observation
● Type of facility Domestic ____, Public water supply ____,
Public institution ____, Farm ____, Industry ____,
Commercial ____, Other Observation

5. PUMP DATA: Type ____ ● Rated H.P. ____,
● Intake depth ____ ● Capacity ____ at ____ head

6. WELLHEAD: Type well seal ____
Pressure tank ____ gal., Loc. ____
Sample tap ____, Measurement port ____
Well vent ____, Pressure relief valve ____
Gate valve ____ Check valve (when required) ____
Electrical disconnect switch on power supply ____

7. DISINFECTION: Well disinfected ____ yes ____ no
Date ____, Disinfectant used ____
Amount ____, Hours used ____

8. ABANDONMENT (where applicable) ● yes ____ no ____
Casing pulled yes ____ no ____ not applicable ____
Plugging grout From ____ to ____ material ____

OVER

Sample Datetime	Time datum	Time datum reliability code	Sample Medium Code	Agency Collecting Sample, Code	Analysis Source	Hydro-logic Event	Hydro-logic Condition	Geo-logic unit
1989-03-	EST	T	WG	USGS-WRD	9	9	A	
1993-07-	EDT	T	WG	USGS-WRD	9	9	A	
1996-07-	EDT	T	WG	USGS-WRD	9	9	A	124EOCN
1998-04-	EDT	T	WG	USGS-WRD	9	9	A	124EOCN
2006-06-	EDT	K	WG	USGS-WRD	9	9	A	124EOCN

USGS 364227076074710 61B 16 SOW 091J

Chesapeake City, Virginia
Hydrologic Unit Code 03010205
Latitude 36°42'27", Longitude 76°07'47" NAD27
Land-surface elevation 15.00 feet above sea level NGVD29
The depth of the well is 690.00 feet below land surface.
The depth of the hole is 690.00 feet below land surface.
This well is completed in the Northern Atlantic Coastal Plain aquifer system (S100NATLCP)
This well is completed in the EOCENE SERIES (124EOCN) local aquifer.

Water Quality Remark Code	**Description**
<	Less than.
E	Estimated.

M	Presence verified but not quantified.

Value Qualifier Code	Description
@	Holding time exceeded
c	See laboratory comment
d	Diluted sample: method hi range exceeded

Sample type	Project Code	Laboratory sample comment	Temperature, water, deg C (00010)	Temperature, air, deg C (00020)	Barometric pressure, mm Hg (00025)	Agency analyzing sample, code (00028)	Flow rate, instantaneous gal/min (00059)	Color, water, fltrd, Pt-Co units (00080)
9	445108900	NH4 & NH4+ORG-RR	17.0			80020		7
9	445108910		20.6	30.0	762	80020		
9	445110600		21.0	35.0	761	80020	3.2	
9	445110600		21.0	21.0	765	80020		
9	24829RC20		20.9	25.5	751	80020	4.7	

) national aquifer.

Specific conductance, wat unf uS/cm 25 degC (00095)	Hydrogen ion, water, unfltrd calcd, mg/L (00191)	Dissolved oxygen, mg/L (00300)	Dissolved oxygen, percent of saturation (00301)	pH, water, unfltrd field, std units (00400)	pH, water, unfltrd lab, std units (00403)	Carbon dioxide water, unfltrd mg/L (00405)	ANC, wat unf fixed end pt, field, mg/L as CaCO3 (00410)	Carbonate, wat flt infl pt titr., field, mg/L (00452)
8000	0.00004			7.4	7.6	55	716	
9700	0.00002	0.1	1	7.7	7.9	30		0.0
9620	0.00003	0.2	2	7.5	7.7	44		
9530	0.00003	0.0	0.0	7.5	7.6			0.0
8570	0.00003	M	0.0	7.5	7.8			E 2

Bicar- bonate, wat flt infl pt titr., field, mg/L (00453)	Organic nitro- gen, water, unfltrd mg/L (00605)	Ammonia water, fltrd, mg/L as N (00608)	Ammonia + org-N, water, unfltrd mg/L as N (00625)	Nitrate + nitrite water fltrd, mg/L as N (00631)	Phos- phorus, water, unfltrd mg/L as P (00665)	Organic carbon, water, unfltrd mg/L (00680)	Hard- ness, water, mg/L as CaCO3 (00900)	Calcium water, fltrd, mg/L (00915)
	0.20	5.00	5.2	< 0.100	0.02	1.5	210	31.0
890							190	19.0
653							200	24.0
787							210	28.4
E 865 @							170	21.6 d

Magnesium, water, fltrd, mg/L (00925)	**Sodium, water, fltrd, mg/L (00930)**	**Sodium adsorption ratio (00931)**	**Sodium fraction of cations percent (00932)**	**Potassium, water, fltrd, mg/L (00935)**	**Chloride, water, fltrd, mg/L (00940)**	**Sulfate water, fltrd, mg/L (00945)**	**Fluoride, water, fltrd, mg/L (00950)**	**Silica, water, fltrd, mg/L as SiO2 (00955)**
33.0	1900	57	95	4.80	2600	180	1.30	18.0
34.0	2200	70	96	11.0	2700	21.0	1.3	17.0
34.0	1900	58	94	55.0	2700	160	1.40	19.0
33.8	1980	60	94	56.0	2500	157	1.17	16.9
29.2 d	1840 d	61	94	49.8 d	2590 d	149 d	1.34	17.0 d

$$TDS = Na^{+} + K^{+} + Ca^{2+} + Mg^{2+} + Cl^{-} + SO_4^{2-}$$

$$= 1840 + 49.8 + 21.6 + 29.2 + 2570 + 149$$

$$= 4679.6 \text{ mg/L}$$

Boron, water, fltrd, ug/L (01020)	Iron, water, unfltrd recover -able, ug/L (01045)	Iron, water, fltrd, ug/L (01046)	Mangan-ese, water, unfltrd recover -able, ug/L (01055)	Mangan-ese, water, fltrd, ug/L (01056)	Zinc, water, fltrd, ug/L (01090)	Alum-inum, water, fltrd, ug/L (01106)	Alka-linity, wat flt fxd end lab, mg/L as CaCO3 (29801)	Depth to water level below LSD, meters (30210)
6000	740	430	10	< 10	10	< 10		
		100		10				
		210		8.0				
		278		43.7				0.000
		307 d		5.6 d			712 @c	1.10

500
WHO

Alka-linity, wat flt fxd end field, mg/L as CaCO3 (39036)	Alka-linity, wat flt inf tit field, mg/L as CaCO3 (39086)	Residue on evap. at 180deg C wat flt mg/L (70300)	Residue water, fltrd, sum of consti-tuents mg/L (70301)	Residue water, fltrd, tons/ acre-ft (70303)	Ammonia water, fltrd, mg/L (71846)	Bromide water, fltrd, mg/L (71870)	Alti-tude of land surface feet (72000)	Pump or flow period prior to sam-pling, minutes (72004)
		5160	5210	7.02	6.44			
	729	5350	5450	7.28		5.20		
	535	5300	5220	7.21		9.70	15.0	
640	643	5010	5180	6.81		9.37		
	713	5350	E 5140	7.28		9.71 d	15.0	308

Sampling condition, code (72006)	Depth to top sample intrval feet below LSD (72015)	Depth to bot sample intrval feet below LSD (72016)	Depth to water level, feet below LSD (72019)	Sampling method, code (82398)	Sampler type, code (84164)	Specif. conductance, wat unf lab, uS/cm 25 degC (90095)	ANC, wat unf fixed end pt, lab, mg/L as CaCO3 (90410)	Sulfide water, unfltrd field, mg/L (99119)
	670.00	680.00				9190	727	
				8010	4040	9460	719	
	670.00	680.00			4040	9300	725	
8.00	670.00	680.00	0.00		4040	9190		
8.00	670.00	680.00	3.60		4040	9300		M

Form GW-2
1978-10,000

COMMONWEALTH OF VIRGINIA

WATER WELL COMPLETION REPORT

BWCM No. 234-196

(Certification of Completion/County Permit)

State Water Control Board
P. O. Box 11143
2111 North Hamilton St.
Richmond, Va. 23230

SWCB Permit ______
County Permit ______

Certification of inspecting official:
This well does ______ does not ______
meet code/low requirements.
S. ______
Date ______

For Office Use

County/City Chesapeake

County/City Stamp

Virginia Plane Coordinates
______ N
______ E

Latitude & Longitude
36° 42' 27" N
76° 07' 47" W

Topo. Map No. 2B
Elevation 15 ft.
Formation TY
Lithology SD
River Basin 5
Province 1
Type Logs E
Cuttings No
Water Analysis Yes
Aquifer Test No

Owner Observation Well # 91-K
Well Designation or Number Fentress
Address ______
Phone ______

Drilling Contractor SWCB - Creason
Address ______
Phone ______

Tax Map I.D. No. ______
Subdivision ______
Section ______
Block ______
Lot ______
Class Well I ______, IIA ______,
IIB ______, IIIA ______, IIIB ______
IIIC ______ IIID ______ IIIE ______

Fentress [Observation Well # 91-K]

WELL LOCATION: ______ (feet/miles ______ direction) of ______
and ______ feet/miles ______ (direction) of ______
(If possible please include map showing location marked)

Date started 9-15-88 Date completed 9-19-88 Type rig Mud Rotary

1. WELL DATA: New X Reworked ______ Deepened ______

Total depth 108' ft.
Depth to bedrock ______ ft.
Hole size (Also include reamed zones)
7.25 inches from 0 to 80' ft.
3.5 inches from 80' to 108' ft.
______ inches from ______ to ______ ft.

Casing size (I.D.) and material
4.5 inches from 0 to 80' ft.
Material PVC
Wt. per foot ______ or wall thickness ______ in.
2 inches from 78' to 88' ft.
Material Black Steel
Wt. per foot ______ or wall thickness ______ in.
2 inches from 98' to 108' ft.
Material Black Steel
Wt. per foot ______ or wall thickness ______ in.

Screen size and mesh for each zone (where applicable)
2 inches from 88' to 98' ft.
Mesh size .010 Type PVC
______ inches from ______ to ______ ft.
Mesh size ______ Type ______
______ inches from ______ to ______ ft.
Mesh size ______ Type ______
______ inches from ______ to ______ ft.
Mesh size ______ Type ______

Gravel pack
From ______ to ______ ft.
From ______ to ______ ft.

Grout
From 0 to 80' ft., Type Aqua-Gel Goldseal
From ______ to ______ ft., Type ______

2. WATER DATA Water temperature 59.9 °F
Static water level (unpumped level measured) 7.22 TOC ft
Stabilized measured pumping water level 32.15 TOC ft
Stabilized yield 10 gpm after 1 hours
Natural Flow. Yes ______ No X, flow rate ______ gpm
Comment on quality Hydrogen Sulfide Odor

3. WATER ZONES: From ______ To ______
From ______ To ______ From ______ To ______
From ______ To ______ From ______ To ______

4. USE DATA:
Type of use. Drinking ______, Livestock Watering ______,
Irrigation ______ Food processing ______, Household ______
Manufacturing ______, Fire safety ______, Cleaning ______,
Recreation ______, Aesthetic ______, Cooling or heating ______,
Injection ______, Other Observation
Type of facility: Domestic ______, Public water supply ______,
Public institution ______, Farm ______, Industry ______,
Commercial ______, Other Observation

5. PUMP DATA: Type ______ Rated H.P. ______
Intake depth ______ Capacity ______ at ______ head

6. WELLHEAD: Type well seal ______
Pressure tank ______ gal., Loc. ______
Sample tap ______, Measurement port ______
Well vent ______, Pressure relief valve ______
Gate valve ______, Check valve (when required) ______
Electrical disconnect switch on power supply ______

7. DISINFECTION: Well disinfected ______ yes ______ no
Date ______, Disinfectant used ______
Amount ______, Hours used ______

8. ABANDONMENT (where applicable) yes ______ no ______
Casing pulled yes ______ no ______ not applicable ______
Plugging grout From ______ to ______ material ______

OVER

Sample Datetime	Time datum	Time datum reliability code	Sample Medium Code	Agency Collecting Sample, Code	Analysis Source	Hydro-logic Event	Hydro-logic Condition	Sample type
1989-03-	EST	T	WG	USGS-WRD	9	9	A	9

USGS 364227076074711 61B 17 SOW 091K

Chesapeake City, Virginia
Hydrologic Unit Code 03010205
Latitude 36°42'27", Longitude 76°07'47" NAD27
Land-surface elevation 15.00 feet above sea level NGVD29
The depth of the well is 108.00 feet below land surface.
The depth of the hole is 108.00 feet below land surface.
This well is completed in the Northern Atlantic Coastal Plain aquifer system (S100NATLCP
This well is completed in the UPPER CHESAPEAKE GROUP (121CSPKU) local aquifer.

Water Quality Remark Code	**Description**
<	Less than.

Project Code	Temperature, water, deg C (00010)	Agency analyzing sample, code (00028)	Color, water, fltrd, Pt-Co units (00080)	Specific conductance, wat unf uS/cm 25 degC (00095)	Hydrogen ion, water, unfltrd calcd, mg/L (00191)	pH, water, unfltrd field, std units (00400)	pH, water, unfltrd lab, std units (00403)	Carbon dioxide water, unfltrd mg/L (00405)
445108900	15.5	80020	17	1500	0.00005	7.3	7.7	27

) national aquifer.

ANC, wat unf fixed end pt, field, mg/L as CaCO3 (00410)	Organic nitro-gen, water, unfltrd mg/L (00605)	Ammonia water, fltrd, mg/L as N (00608)	Ammonia + org-N, water, unfltrd mg/L as N (00625)	Nitrate + nitrite water fltrd, mg/L as N (00631)	Phos-phorus, water, unfltrd mg/L as P (00665)	Organic carbon, water, unfltrd mg/L (00680)	Hard-ness, water, mg/L as CaCO3 (00900)	Calcium water, fltrd, mg/L (00915)
276	0.30	1.10	1.4	< 0.100	0.16	4.9	240	54.0

hard

$$TDS = Ca^{2+} + Mg^{2+} + Na^{+} + K^{+} + Cl^{-} + SO_4^{2-}$$

$$TDS = 54 + 26 + 240 + 21 + 340 + 20$$

$$TDS = 701 \frac{mg}{L}$$

Magnesium, water, fltrd, mg/L (00925)	Sodium, water, fltrd, mg/L (00930)	Sodium adsorption ratio (00931)	Sodium fraction of cations percent (00932)	Potassium, water, fltrd, mg/L (00935)	Chloride, water, fltrd, mg/L (00940)	Sulfate water, fltrd, mg/L (00945)	Fluoride, water, fltrd, mg/L (00950)	Silica, water, fltrd, mg/L as SiO2 (00955)
26.0	240	6.7	66	21.0	340	20.0	0.20	36.0

250

20

Boron, water, fltrd, ug/L (01020)	Iron, water, unfltrd recover -able, ug/L (01045)	Iron, water, fltrd, ug/L (01046)	Mangan- ese, water, unfltrd recover -able, ug/L (01055)	Mangan- ese, water, fltrd, ug/L (01056)	Zinc, water, fltrd, ug/L (01090)	Alum- inum, water, fltrd, ug/L (01106)	Depth to water level below LSD, meters (30210)	Residue on evap. at 180deg C wat flt mg/L (70300)
320	1000	470	20	12.0	6	≤ 10	1.80	897

500
WHO

300
20

Residue water, fltrd, sum of consti- tuents mg/L (70301)	Residue water, fltrd, tons/ acre-ft (70303)	Ammonia water, fltrd, mg/L (71846)	Depth to top sample intrval feet below LSD (72015)	Depth to bot sample intrval feet below LSD (72016)	Depth to water level, feet below LSD (72019)	Specif. conduc- tance, wat unf lab, uS/cm 25 degC (90095)	ANC, wat unf fixed end pt, lab, mg/L as CaCO3 (90410)
905	1.22	1.42	88.00	98.00	5.92	1620	282

1620 μmho/cm

$$\Lambda_0 = \lambda_0^+ + \lambda_0^- = 50.1 + 76.3 = 126.4 \text{ mho-cm}^2/\text{eq}$$

$$N \cong \frac{1000K}{\Lambda_0} = \frac{1000(1620 \times 10^{-6})}{126.4} = 1.28 \times 10^{-2} \text{ eq/L}$$

$$\text{NaCl concentration} = \left(1.28 \times 10^{-2} \tfrac{\text{eq}}{\text{L}}\right)\left(58.5 \times 10^3\right) = 750 \tfrac{\text{mg}}{\text{L}}$$

$500 \frac{\text{mg}}{\text{L}}$

2°

Fo..n GW-2
1978-10,000

COMMONWEALTH OF VIRGINIA

WATER WELL COMPLETION REPORT

BWCM No. 234-197

(Certification of Completion/County Permit)

State Water Control Board
P. O. Box 11143
2111 North Hamilton St.
Richmond, Va. 23230

SWCB Permit
County Permit

Certification of inspecting official:
This well does ____ does not ____
meet code/low requirements.
S.
Date

For Office Use

County/City Chesapeake

County/City Stamp

Virginia Plane Coordinates
____ N
____ E

Latitude & Longitude
36° 42' 27" N
76° 07' 47" W

Topo. Map No. 2B
Elevation 15 ft.
Formation TY
Lithology SD
River Basin 5
Province 1
Type Logs E
Cuttings No
Water Analysis Yes
Aquifer Test No

Owner Observation Well # 91-L
Well Designation or Number Fentress
Address
Phone
Drilling Contractor SWCB - Creason
Address
Phone

Tax Map I.D. No.
Subdivision
Section
Block
Lot
Class Well I ____, IIA ____,
IIB ____ IIIA ____, IIIB ____
IIIC ____ IIID ____ IIIE ____

Fentress [Observation Well # 91-L]
WELL LOCATION: ____ (feet/miles ____ direction) of ____
and ____ feet/miles ____ (direction) of ____
(If possible please include map showing location marked)

Date started 9-20-88 Date completed 9-20-88 Type rig Mud Rotary

1. WELL DATA: New X Reworked ____ Deepened ____

Total depth 67' ft.
Depth to bedrock ____ ft.
Hole size (Also include reamed zones)
- 7.25 inches from 0 to 40' ft.
- 3.5 inches from 40' to 67' ft.
- ____ inches from ____ to ____ ft.

Casing size (I.D.) and material
- 4.5 inches from 0 to 40' ft.
  Material PVC
  Wt. per foot ____ or wall thickness ____ in.
- 2 inches from 37' to 57' ft.
  Material PVC
  Wt. per foot ____ or wall thickness ____ in.
- ____ inches from ____ to ____ ft.
  Material
  Wt. per foot ____ or wall thickness ____ in

Screen size and mesh for each zone (where applicable)
- 2 inches from 57' to 67' ft.
  Mesh size ____ Type ____
- ____ inches from ____ to ____ ft.
  Mesh size ____ Type ____
- ____ inches from ____ to ____ ft
  Mesh size ____ Type ____
- ____ inches from ____ to ____ ft
  Mesh size ____ Type ____

Gravel pack
From ____ to ____ ft.
From ____ to ____ ft

Grout
From 0 to 40' ft., Type Benseal/EZ Mud
From ____ to ____ ft., Type ____

2. WATER DATA Water temperature 60.8 °F
Static water level (unpumped level-measured) 8.75 TOC ft
Stabilized measured pumping water level 9.33 TOC ft.
Stabilized yield 10 gpm after 0.5 hour
Natural Flow: Yes ____ No X, flow rate ____ gpm
Comment on quality Hydrogen Sulfide Odor

3. WATER ZONES: From ____ To ____
From ____ To ____ From ____ To ____
From ____ To ____ From ____ To ____

4. USE DATA:
Type of use: Drinking ____, Livestock Watering ____,
Irrigation ____, Food processing ____, Household ____,
Manufacturing ____, Fire safety ____, Cleaning ____,
Recreation ____, Aesthetic ____, Cooling or heating ____,
Injection ____, Other Observation
Type of facility Domestic ____, Public water supply ____,
Public institution ____, Farm ____, Industry ____,
Commercial ____, Other Observaton

5. PUMP DATA: Type ____ Rated H.P. ____
Intake depth ____ Capacity ____ at ____ head

6. WELLHEAD: Type well seal ____
Pressure tank ____ gal., Loc. ____
Sample tap ____, Measurement port ____
Well vent ____, Pressure relief valve ____
Gate valve ____, Check valve (when required) ____
Electrical disconnect switch on power supply ____

7. DISINFECTION: Well disinfected ____ yes ____ no
Date ____, Disinfectant used ____
Amount ____, Hours used ____

8. ABANDONMENT (where applicable) yes ____ no ____
Casing pulled yes ____ no ____ not applicable ____
Plugging grout From ____ to ____ material ____

OVER

Sample Datetime	Time datum	Time datum reliability code	Sample Medium Code	Agency Collecting Sample, Code	Analysis Source	Hydro-logic Event	Hydro-logic Condition	Sample type
1989-03-	EST	T	WG	USGS-WRD	9	9	A	9

USGS 364227076074712 61B 18 SOW 091L

Chesapeake City, Virginia
Hydrologic Unit Code 03010205
Latitude 36°42'27", Longitude 76°07'47" NAD27
Land-surface elevation 15.00 feet above sea level NGVD29
The depth of the well is 67.00 feet below land surface.
The depth of the hole is 67.00 feet below land surface.
This well is completed in the QUATERNARY SYSTEM (110QRNR) local aquifer.

Water Quality Remark Code	Description
<	Less than.

Project Code	Temperature, water, deg C -10	Agency analyzing sample, code -28	Color, water, fltrd, Pt-Co units -80	Specific conductance, wat unf uS/cm 25 degC -95	Hydrogen ion, water, unfltrd calcd, mg/L -191	pH, water, unfltrd field, std units -400	pH, water, unfltrd lab, std units -403	Carbon dioxide water, unfltrd mg/L -405
445108900	16.0	80020	95	300	0.00032	6.5	6.9	71

ANC, wat unf fixed end pt, field, mg/L as CaCO3 -410	Ammonia water, fltrd, mg/L as N -608	Ammonia + org-N, water, unfltrd mg/L as N -625	Nitrate + nitrite water fltrd, mg/L as N -631	Phos- phorus, water, unfltrd mg/L as P -665	Organic carbon, water, unfltrd mg/L -680	Hard- ness, water, mg/L as CaCO3 -900	Calcium water, fltrd, mg/L -915	Magnes- ium, water, fltrd, mg/L -925
116	0.320	0.20	< 0.100	0.68	1.8	87	27.0	4.80

Sodium, water, fltrd, mg/L -930	Sodium adsorption ratio -931	Sodium fraction of cations percent -932	Potassium, water, fltrd, mg/L -935	Chloride, water, fltrd, mg/L -940	Sulfate water, fltrd, mg/L -945	Fluoride, water, fltrd, mg/L -950	Silica, water, fltrd, mg/L as SiO2 -955	Boron, water, fltrd, ug/L -1020
21.0	1.0	33	3.30	18.0	11.0	0.20	44.0	50

Iron, water, unfltrd recover -able, ug/L (01045)	Iron, water, fltrd, ug/L (01046)	Mangan-ese, water, unfltrd recover -able, ug/L (01055)	Mangan-ese, water, fltrd, ug/L (01056)	Zinc, water, fltrd, ug/L (01090)	Alum-inum, water, fltrd, ug/L (01106)	Depth to water level below LSD, meters (30210)	Residue on evap. at 180deg C wat flt mg/L (70300)	Residue water, fltrd, sum of consti-tuents mg/L (70301)
5000	5940	140	152	92	20	2.04	191	206

Residue water, fltrd, tons/ acre-ft (70303)	Ammonia water, fltrd, mg/L (71846)	Depth to top sample intrval feet below LSD (72015)	Depth to bot sample intrval feet below LSD (72016)	Depth to water level, feet below LSD (72019)	Specif. conduc-tance, wat unf lab, uS/cm 25 degC (90095)	ANC, wat unf fixed end pt, lab, mg/L as CaCO3 (90410)
0.26	0.41	57.00	67.00	6.70	278	112

Fo..n GW-2
1978-10,000

COMMONWEALTH OF VIRGINIA

WATER WELL COMPLETION REPORT

BWCM No 234-198

(Certification of Completion/County Permit)

State Water Control Board
O. Box 11143
11 North Hamilton St.
Richmond, Va. 23230

For Office Use	
SWCB Permit	
County Permit	
Certification of inspecting official: This well does ____ does not ____ meet code/low requirements.	
S.	
Date	

County/City Chesapeake

County/City Stamp

Virginia Plane Coordinates
N
E
Latitude & Longitude
36° 42' 27" N
76° 07' 47" W
Topo. Map No. 2B
Elevation 15 ft.
Formation QPC
Lithology SD
River Basin 5
Province 1
Type Logs E
Cuttings NO
Water Analysis Yes
Aquifer Test No

Owner Observation Well # 91-M
Well Designation or Number Fentress
Address
Phone
Drilling Contractor SWCB - Creason
Address
Phone

Tax Map I.D. No.	
Subdivision	
Section	
Block	
Lot	
Class Well I ____, IIA ____, IIB ____, IIIA ____, IIIB ____, IIIC ____, IIID ____, IIIE ____	

Fentress [Observation Well # 91 M]
WELL LOCATION: ____ (feet/miles ____ direction) of ____
and ____ feet/miles ____ (direction) of ____
(If possible please include map showing location marked)

Date started 9-21-88 Date completed 9-21-88 Type rig Mud Rotary

1. WELL DATA: New X Reworked ____ Deepened ____
Total depth 20' ft.
Depth to bedrock ____ ft.
Hole size (Also include reamed zones)
7.25 inches from 0 to 20' ft.
____ inches from ____ to ____ ft.
____ inches from ____ to ____ ft.
Casing size (I.D.) and material
4.5 inches from 0 to 10' ft.
Material PVC
Wt. per foot ____ or wall thickness ____ in.
____ inches from ____ to ____ ft.
Material
Wt. per foot ____ or wall thickness ____ in.
____ inches from ____ to ____ ft.
Material
Wt. per foot ____ or wall thickness ____ in.
Screen size and mesh for each zone (where applicable)
4 inches from 10 to 20' ft.
Mesh size .010 Type Galv. Wire Wrapped
____ inches from ____ to ____ ft.
Mesh size ____ Type ____
____ inches from ____ to ____ ft.
Mesh size ____ Type ____
____ inches from ____ to ____ ft.
Mesh size ____ Type ____
Gravel pack
From 0 to 20' ft.
From ____ to ____ ft.
Grout
From 0 to 10' ft., Type Benseal/EZ Mud
From ____ to ____ ft., Type ____

2. WATER DATA Water temperature 57.2 °F
Static water level (unpumped level-measured) 2.48 TOC ft
Stabilized measured pumping water level 8.0 TOC ft.
Stabilized yield 10 gpm after 1 hours
Natural Flow: Yes ____ No X, flow rate ____ gpm
Comment on quality Hydrogen Sulfide Odor

3. WATER ZONES: From ____ To ____
From ____ To ____ From ____ To ____
From ____ To ____ From ____ To ____

4. USE DATA:
Type of use: Drinking ____, Livestock Watering ____, Irrigation ____ Food processing ____, Household ____, Manufacturing ____, Fire safety ____, Cleaning ____, Recreation ____, Aesthetic ____, Cooling or heating ____, Injection ____, Other Observation
Type of facility Domestic ____, Public water supply ____, Public institution ____, Farm ____, Industry ____, Commercial ____, Other Observation

5. PUMP DATA: Type ____ Rated H.P. ____
Intake depth ____ Capacity ____ at ____ head

6. WELLHEAD: Type well seal ____
Pressure tank ____ gal. Loc. ____
Sample tap ____, Measurement port ____
Well vent ____, Pressure relief valve ____
Gate valve ____, Check valve (when required) ____
Electrical disconnect switch on power supply ____

7. DISINFECTION: Well disinfected ____ yes ____ no
Date ____, Disinfectant used ____
Amount ____, Hours used ____

8. ABANDONMENT (where applicable) yes ____ no ____
Casing pulled yes ____ no ____ not applicable ____
Plugging grout From ____ to ____ material ____

OVER

1

Fentress

RECORD NUMBER: 99403567 STATION NUMBER: 364227076074713 COLLECTED: 08-20-1994 AT: 1
STATION NAME: 61B 19 SOW 91-M COUNTY: 550
MEDIUM: 6 STATUS: 9 SOURCE: 9 HYD. CONDITION: 9 SAMPLE TYPE: 9 HYD.

	CODE	PARAMETER NAME	UNITS	VALUE	R	Q	M	P
	00010	WATER TEMPERATURE	(DEGREES)	19.5		I		3
	00020	AIR TEMPERATURE	DEGREES	28.0		I		3
	00025	AIR PRESSURE	(MM OF HG)	763		I		3
	00027	COLLECTING AGENCY	(CODE NUMBER)	1028		I		5
	00028	ANALYZING AGENCY	(CODE NUMBER)	80020		H		5
	00059	FLOW RATE INS. (G/M)	(GALLONS/MINUTE)	1.5		I		3
	00095	SPECIFIC CONDUCTANCE	US/CM @ 25C	326		I		3
	00300	OXYGEN DISSOLVED	(MG/L)	0.5		I		3
	00301	OXYGEN DIS. PERCENT	% OF SATURATION	5		I		3
	00400	PH, WH, FIELD	(STANDARD UNITS)	6.0		I		3
	00403	PH, WH, LABORATORY	(STANDARD UNITS)	6.7		H	A	2
	00419	ALKALINITY,WH,IT,F	(MG/L AS CACO3)	95		I		3
	00447	CARBONATE,WH,IT,F	(MG/L AS CO3)	0		I		3
	00450	BICARBONATE,WH,IT,F	(MG/L AS HCO3)	116		I		3
	00608	NITROGEN AMMONIA D.	(MG/L AS N)	0.130		H	B	3
	00613	NITROGEN,NITRITE D.	MG/L AS N	0.010	1	H	B	3
	00623	NITRO AMN & ORG DIS	(MG/L AS N)	0.20	1	H	C	2
	00631	NO2 + NO3 DISSOLVED	(MG/L AS N)	0.061		H	B	3
	00666	PHOSPHORUS DISS.	(MG/L AS P)	0.010		H	C	3
	00671	PHOSPHORUS ORTHO D.	(MG/L AS P)	0.010	1	H	B	3
	00681	CARBON ORGANIC DIS.	(MG/L AS C)	3.5		H	A	2
COMPUTED	00900	HARDNESS TOTAL	(MG/L AS CAO3)	43				
	00915	CALCIUM DISSOLVED	(MG/L AS CA)	7.0		H	D	2
	00925	MAGNESIUM DISSOLVED	(MG/L AS MG)	6.2		H	C	2
	00930	SODIUM DISSOLVED	(MG/L AS NA)	27		H	C	2
COMPUTED	00931	SODIUM ADSORPTION R.	(RATIO)	2				
COMPUTED	00932	SODIUM, PERCENT	PERCENT	57				
	00935	POTASSIUM DISSOLVED	(MG/L AS K)	1.4		H	B	2
	00940	CHLORIDE DISSOLVED	(MG/L AS CL)	24		H	J	2
	00945	SULFATE DISSOLVED	(MG/L AS SO4)	33		H	G	2
	00950	FLUORIDE DISSOLVED	(MG/L AS F)	0.10	1	H	B	2
	00955	SILICA DISSOLVED	(MG/L AS SIO2)	18		H	D	2
	01000	ARSENIC DISSOLVED	(UG/L AS AS)	8		H	B	1
	01005	BARIUM DISSOLVED	(UG/L AS BA)	71		H	G	2
	01010	BERYLLIUM DISSOLVED	(UG/L AS BE)	1	1	H	G	1
	01025	CADMIUM DISSOLVED	(UG/L AS CD)	1.0	1	H	G	2
	01030	CHROMIUM DISSOLVED	(UG/L AS CR)	6		H	G	1
	01035	COBALT DISSOLVED	(UG/L AS CO)	2		H	G	1
	01040	COPPER DISSOLVED	(UG/L AS CU)	1	1	H	G	1
	01046	IRON DISSOLVED	(UG/L AS FE)	30000		H	D	2

1

RECORD NUMBER: 99403567 -- CONTINUED

CODE	PARAMETER NAME	UNITS	VALUE	R	Q	M	P
01049	LEAD DISSOLVED	(UG/L AS PB)	1	1	H	G	1
01056	MANGANESE DISSOLVED	(UG/L AS MN)	440		H	G	2
01060	MOLYBDENUM DISSOLVED	(UG/L AS MO)	1	1	H	G	1
01065	NICKEL DISSOLVED	(UG/L AS NI)	1	1	H	G	1
01075	SILVER DISSOLVED	(UG/L AS AG)	1.0	1	H	G	2
01090	ZINC DISSOLVED	(UG/L AS ZN)	22		H	G	2
01095	ANTIMONY DISSOLVED	(UG/L AS SB)	1	1	H	G	1

01106	ALUMINUM DISSOLVED	(UG/L AS AL)	10		H	G	1
01145	SELENIUM DISSOLVED	(UG/L AS SE)	1	1	H	A	1
04024	PROPACHLOR DISS REC	(UG/L)	0.01	1	H	D	2
04028	BUTYLATE DISS REC	(UG/L)	0	1	H	D	3
04035	SIMAZINE DISS REC	(UG/L)	0	1	H	D	3
04037	PROMETON DISS REC	(UG/L)	0	1	H	D	3
04040	DEETHYL ATRAZINE D	(UG/L)	0	1	H	D	3
04041	CYANAZINE DISS REC	(UG/L)	0.01	1	H	D	2
04095	FONOFOX DISS REC	(UG/L)	0	1	H	D	3
22703	URANIUM,NATURAL,DIS	UG/L AS U	0.40	1	H	C	2
30217	DIBROMOMETHANE,W.W.R	UG/L	0.2	1	H	C	1
32101	DICHLOROBROMOMETHANE	UG/L	0.2	1	H	C	1
32102	CARBONTETRACHLORIDE	UG/L	0.2	1	H	C	1
32103	1,2-DICHLOROETHANE	UG/L	0.2	1	H	C	1
32104	BROMOFORM TOTAL	UG/L	0.2	1	H	C	1
32105	CHLORODIBROMOMETHANE	UG/L	0.2	1	H	C	1
32106	CHLOROFORM TOTAL	UG/L	0.2	1	H	C	1
34010	TOLUENE, TOTAL	UG/L	0.2	1	H	C	1
34030	BENZENE, TOTAL	UG/L	0.2	1	H	C	1
34253	ALPHA BHC	UG/L	0	1	H	D	3
34301	CHLOROBENZENE	(UG/L)	0.20	1	H	C	2
34311	CHLOROETHANE	UG/L	0.2	1	H	C	1
34371	ETHYLBENZENE TOTAL	(UG/L)	0.2	1	H	C	1
34413	METHYLBROMIDE TOTAL	(UG/L)	0.2	1	H	C	1
34418	METHYLCHLORIDE,TOT.	(UG/L)	0.4		H	C	1
34423	METHYLENECHLORIDE	(UG/L)	0.2	1	H	C	1
34475	TETRACHLOROETHYLENE	(UG/L)	3.2		H	C	2
34488	TRICH.FLUOR.METHANE	(UG/L)	0.2	1	H	C	1
34496	DICHLOROETHANE 1,1 T	(UG/L)	0.2	1	H	C	1
34501	DICHLOROETHYLENE T.	(UG/L)	0.2	1	H	C	1
34506	TRICHLOROETHANE T.	(UG/L)	0.2	1	H	C	1
34511	TRICHLOROETHANE T.	(UG/L)	0.2	1	H	C	1
34516	1122TETRACHLORO ETH	(UG/L)	0.2	1	H	C	1
34536	O-CHLORO-BENZENE U	(UG/L)	0.20	1	H	D	2

1

RECORD NUMBER: 99403567 -- CONTINUED

	CODE	PARAMETER NAME	UNITS	VALUE	R	Q	M	P
	34541	DICHLOROPROPANE TOT.	(UG/L)	0.2	1	H	C	1
	34546	TRANSDICH.ETHENE T.	(UG/L)	0.2	1	H	C	1
	34551	124TRICHLORO-BENZEN	(UG/L)	0.20	1	H	D	2
	34566	13DICHLORO-BENZENE	(UG/L)	0.20	1	H	D	2
	34571	14DICHLORO-BENZENE	(UG/L)	0.20	1	H	D	2
	34653	P,P' DDE DISSOLVED	(UG/L)	0.01	1	H	D	2
	34668	DICHL.DIFL.METHANE T	(UG/L)	0.2	1	H	C	1
	34696	NAPHTHALENE TOTAL	(UG/L)	0.2	1	H	D	1
	34699	TR1,3-DICHL.PROPENE	UG/L	0.2	1	H	C	1
	34704	CIS1,3-DICHL.PROPENE	UG/L	0.2	1	H	C	1
	38933	CHLORPYRIFOS, DISS	UG/L	0	1	H	D	3
	39175	VINYLCHLORIDE	UG/L	0.2	1	H	C	1
	39180	TRICHLOROETHYLENE	UG/L	0.2	1	H	C	1
	39341	LINDANE DISSOLVED	UG/L	0.01	1	H	D	2
	39381	DIELDRIN DISSOLVED	UG/L	0	1	H	D	3
	39415	METOLACHLOR,WAT.DIS.	UG/L	0	1	H	D	3
	39532	MALATHION DISSOLVED	UG/L	0.01	1	H	D	2
	39542	PARATHION DISSOLVED	UG/L	0.02	1	H	D	2
	39572	DIAZINON DISSOLVED	UG/L	0	1	H	D	3
	39632	ATRAZINE, DISS, REC	UG/L	0.02	1	H	D	2
	39702	HEXACHLOROBUTADIENE	UG/L	0.2	1	H	D	1
	46342	ALACHLOR, DISS, REC.	UG/L	0	1	H	D	3
	70300	RESIDUE DIS 180C	MG/L	163		H	A	3
COMPUTED	70301	DISSOLVED SOLIDS SUM	MG/L	205				

71870	BROMIDE DISSOLVED	MG/L AS BR	0.30		H	E	2
71999	SAMPLE PURPOSE	PURPOSE CODE	15.0		I		3
72000	ELEV.LSD(FT.AB.NGVD)	FT (NGVD)	15.0		I		3
72004	PUMP PERIOD (MIN))	MIN	24		I		3
72006	SAMPLING CONDITION	CODE NUMBER	8.00		I		3
72015	DEPTH TOP OF SAM.FT.	FT	10		I		3
72016	DPTH BOT. OF SAM.FT.	FT	20		I		3
72019	DEPTH BELOW LAND S.	FT	5.56		I		3
75990	URANIUM NAT PE DISS	UG/L	0		H	C	3
76000	RADIUM-228 PE DISS	PCI/L	0.4		H	C	1
77093	CIS1,2DICHL.ETHENE,T	UG/L	0.2	1	H	C	1
77128	STYRENE, TOTAL	UG/L	0.2	1	H	C	1
77168	1,1-DICHLOROPROPENE	UG/L	0.2	1	H	C	1
77170	2,2-DICHLOROPROPANE	UG/L	0.2	1	H	C	1
77173	1,3DICHLPROPANE W W	UG/L	0.2	1	H	C	1
77222	PSEUDOCUMENE UNF RE	(UG/L)	0.20	1	H	C	2
77223	ISOPROPYL-BENZENE W	(UG/L)	0.20	1	H	C	2

1

RECORD NUMBER: 99403567 -- CONTINUED

CODE	PARAMETER NAME	UNITS	VALUE	R	Q	M	P
77224	N-PROPYL-BENZENE U	(UG/L)	0.20	1	H	C	2
77226	MESITYLENE UNF REC	(UG/L)	0.20	1	H	C	2
77275	O-CHLOROTOLUENE T.	UG/L	0.2	1	H	C	1
77277	P-CHLORO-TOLUENE U	(UG/L)	0.20	1	H	C	2
77297	METHANE BROMOCHLORO	(UG/L)	0.20	1	H	C	2
77342	N-BUTYL-BENZENE U R	(UG/L)	0.20	1	H	C	2
77350	SEC-BUTYL-BENZENE U	(UG/L)	0.20	1	H	C	2
77353	TERT-BUTYL-BENZENE	(UG/L)	0.20	1	H	C	2
77356	P-ISOPROPYLTOLUENE	(UG/L)	0.20	1	H	C	2
77443	123TRICHLPROPANE,TO	UG/L	0.2	1	H	C	1
77562	1112TETRACHLORO-ETH	(UG/L)	0.2	1	H	C	1
77613	1,2,3-TRICHLORO BEN	(UG/L)	0.20	1	H	C	2
77651	1,2DIBROMOETHANE,TOT	UG/L	0.2	1	H	E	1
77652	FREON 113 UNF REC	(UG/L)	0.2	1	H	C	1
78032	TERTBUTYL METH ETHE	(UG/L)	0.2	1	H	C	1
81366	RA228 DISS	PCI/L	1.0	1	H	C	2
81551	XYLENE UNF REC	(UG/L)	0.20	1	H	C	2
81555	BROMOBENZENE WAT.WH.	UG/L	0.2	1	H	C	1
82625	DIBROMOCHLOROPROPAN	UG/L	1.0	1	H	C	2
82630	METRIBUZIN,WAT.DIS.	UG/L	0.01	1	H	D	2
82660	26DIETHYLANILINE FL	(UG/L)	0	1	H	D	3
82661	TRIFLURALIN FIL 0.7	(UG/L)	0.01	1	H	D	2
82662	DIMETHOATE FIL 0.7	(UG/L)	0.02	1	H	D	2
82663	ETHALFLURALIN FIL .	(UG/L)	0.01	1	H	D	2
82664	PHORATE FIL 0.7 REC	(UG/L)	0.01	1	H	D	2
82665	TERBACIL FIL 0.7 RE	(UG/L)	0.03	1	H	D	2
82666	LINURON FIL 0.7 REC	(UG/L)	0.04	1	H	D	2
82667	METHYL PARATHION F.	(UG/L)	0.03	1	H	D	2
82668	EPTC FIL 0.7 REC	(UG/L)	0	1	H	D	3
82669	PEBULATE FIL 0.7 RE	(UG/L)	0	1	H	D	3
82670	TEBUTHIURON FIL .7	(UG/L)	0.01	1	H	D	2
82671	MOLINATE FIL 0.7 RE	(UG/L)	0	1	H	D	3
82672	ETHOPROP FIL 0.7 RE	(UG/L)	0.01	1	H	D	2
82673	BENFLURALIN FIL .7	(UG/L)	0.01	1	H	D	2
82674	CARBOFURAN FIL .7 R	(UG/L)	0.01	1	H	D	2
82675	TERBUFOS FIL 0.7 RE	(UG/L)	0.01	1	H	D	2
82676	PRONAMIDE FIL .7 RE	(UG/L)	0	1	H	D	3
82677	DISULFOTON FIL .7 R	(UG/L)	0.06	1	H	D	2
82678	TRIALLATE FIL .7 RE	(UG/L)	0	1	H	D	3
82679	PROPANIL FIL 0.7 RE	(UG/L)	0.02	1	H	D	2
82680	CARBARYL FIL 0.7 RE	(UG/L)	0.05	1	H	D	2

1

RECORD NUMBER: 99403567 -- CONTINUED

CODE	PARAMETER NAME	UNITS	VALUE	R	Q	M	P
82681	THIOBENCARB FIL .7	(UG/L)	0	1	H	D	3
82682	DCPA FIL 0.7 REC	(UG/L)	0	1	H	D	3
82683	PENDIMETHALIN F.7 R	(UG/L)	0.02	1	H	D	2
82684	NAPROPAMIDE FIL .7	(UG/L)	0.01	1	H	D	2
82685	PROPARGITE FIL .7 R	(UG/L)	0	1	H	D	3
82686	METHYL AZINPHOS F.7	(UG/L)	0.05	1	H	D	2
82687	PERMETHRIN FIL .7 R	(UG/L)	0.02	1	H	D	2
84164	SAMPLER TYPE CODE	CODE	4040		I		3
90095	SPECIFIC CONDUCTANCE	MICROSIEMENS/CM	330		H	A	3
90410	ALKALINITY	MG/L AS CACO3	36		H	A	2
91063	DIAZINON SURROGATE	(PERCENT)	110		H	D	2
91064	TERBUTHYLAZINE SURR	(PERCENT)	120		H	D	2
91065	ALPHA D6 HCH SURROG	(PERCENT)	97		H	D	2
99856	SAMP VOL SCHED 2001	(ML)	968		H	D	3
99900	DISTRICT SPEC 99900	99900	0.10	1	A		2
99902	DISTRICT SPEC 99902	99902	0.10	1	A		2
99903	DISTRICT SPEC 99903	99903	0.10		A		2
99904	DISTRICT SPEC 99904	99904	0.10		A		2
99905	DISTRICT SPEC 99905	99905	1.00		A		3

CATION/CONDUCTANCE RATIO OUTSIDE LIMITS .92 TO 1.24

RESIDUE AT 180 C/SPECIFIC CONDUCTANCE RATIO OUTSIDE LIMITS .55 TO .81

DISSOLVED SOLIDS/CALCULATED SOLIDS RATIO OUTSIDE LIMITS .9 TO 1.12

1

RECORD NUMBER: 99403567

STATION ID: USGS 364227076074713

STATION NAME: 61B 19

COLLECTION DATE: 08-20-1994 1030 - -

CATIONS	(MG/L)	(MEQ/L)	ANIONS	(MG/L)	(MEQ/L)
CALCIUM, DISS. MG/L	7.000	0.350	CHLORIDE, DISS. MG/L	24.000	0.678
MAGNESIUM, DISS. MG/L	6.200	0.511	SULFATE, DISS. MG/L	33.000	0.688
SODIUM, DISS. MG/L	27.000	1.175	BICARB., WHL, IT, FLD	116.001	1.902
POTASSIUM, DISS. MG/L	1.401	0.036	CARB., WHL, IT, FLD	0.000	0.001

IRON,	DISS. UG/L	30000.000	1.612	NO2 + NO3, DISS. AS N	0.061	0.005
MANGANESE,	DISS. UG/L	438.000	0.016			
	TOTAL		3.698	TOTAL		3.270

PERCENT DIFFERENCE = 6.14

1

RECORD NUMBER: 99404224 STATION NUMBER: 363738076053101 COLLECTED: 08-20-1994 AT: 153
STATION NAME: 62A 17 COUNTY: 550
MEDIUM: 6 STATUS: 9 SOURCE: 9 HYD. CONDITION: 9 SAMPLE TYPE: 9 HYD.

	CODE	PARAMETER NAME	UNITS	VALUE	R	Q	M	P
	00010	WATER TEMPERATURE	(DEGREES)	26.0		I		3
	00020	AIR TEMPERATURE	DEGREES	30.0		I		3
	00025	AIR PRESSURE	(MM OF HG)	762		I		3
	00027	COLLECTING AGENCY	(CODE NUMBER)	1028		I		5
	00028	ANALYZING AGENCY	(CODE NUMBER)	80020		H		5
	00059	FLOW RATE INS. (G/M)	(GALLONS/MINUTE)	1.0		I		3
	00095	SPECIFIC CONDUCTANCE	US/CM @ 25C	381		I		3
	00300	OXYGEN DISSOLVED	(MG/L)	0.2		I		3
	00301	OXYGEN DIS. PERCENT	% OF SATURATION	3		I		3
	00400	PH, WH, FIELD	(STANDARD UNITS)	5.8		I		3
	00403	PH, WH, LABORATORY	(STANDARD UNITS)	5.7		H	A	2
	00419	ALKALINITY,WH,IT,F	(MG/L AS CACO3)	43		I		3
	00450	BICARBONATE,WH,IT,F	(MG/L AS HCO3)	52		I		3
	00608	NITROGEN AMMONIA D.	(MG/L AS N)	0.030		H	B	3
	00613	NITROGEN,NITRITE D.	MG/L AS N	0.010	1	H	B	3
	00623	NITRO AMN & ORG DIS	(MG/L AS N)	0.20		H	C	2
	00631	NO2 + NO3 DISSOLVED	(MG/L AS N)	8.00		H	B	3
	00666	PHOSPHORUS DISS.	(MG/L AS P)	0.010	1	H	C	3
	00671	PHOSPHORUS ORTHO D.	(MG/L AS P)	0.010	1	H	B	3
	00681	CARBON ORGANIC DIS.	(MG/L AS C)	1.8		H	A	2
COMPUTED	00900	HARDNESS TOTAL	(MG/L AS CAO3)	72				
	00915	CALCIUM DISSOLVED	(MG/L AS CA)	20		H	D	2
	00925	MAGNESIUM DISSOLVED	(MG/L AS MG)	5.4		H	C	2
	00930	SODIUM DISSOLVED	(MG/L AS NA)	41		H	C	2
COMPUTED	00931	SODIUM ADSORPTION R.	(RATIO)	2				
COMPUTED	00932	SODIUM, PERCENT	PERCENT	55				
	00935	POTASSIUM DISSOLVED	(MG/L AS K)	2.6		H	B	2
	00940	CHLORIDE DISSOLVED	(MG/L AS CL)	53		H	J	2
	00945	SULFATE DISSOLVED	(MG/L AS SO4)	26		H	G	2
	00950	FLUORIDE DISSOLVED	(MG/L AS F)	0.10	1	H	B	2
	00955	SILICA DISSOLVED	(MG/L AS SIO2)	6.0		H	D	2

Sample Datetime	Time datum	Time datum reliability code	Sample Medium Code	Agency Collecting Sample, Code	Analysis Source	Hydro-logic Event	Hydro-logic Condition	Sample type
1989-03-	EST	T	WG	USGS-WRD	9	9	A	9

USGS 364227076074713 61B 19 SOW 091M

Chesapeake City, Virginia
Hydrologic Unit Code 03010205
Latitude 36°42'27", Longitude 76°07'47" NAD27
Land-surface elevation 15.00 feet above sea level NGVD29
The depth of the well is 20.00 feet below land surface.
The depth of the hole is 20.00 feet below land surface.
This well is completed in the Northern Atlantic Coastal Plain aquifer system (S100NATLCP)
This well is completed in the QUATERNARY SYSTEM (110QRNR) local aquifer.

Water Quality Remark Code	**Description**
<	Less than.

Project Code	Temperature, water, deg C (00010)	Agency analyzing sample, code (00028)	Color, water, fltrd, Pt-Co units (00080)	Specific conductance, wat unf uS/cm 25 degC (00095)	Hydrogen ion, water, unfltrd calcd, mg/L (00191)	pH, water, unfltrd field, std units (00400)	pH, water, unfltrd lab, std units (00403)	Carbon dioxide water, unfltrd mg/L (00405)
445108900	14.0	80020	15	220	0.00201	5.7	6.1	238

) national aquifer.

ANC, wat unf fixed end pt, field, mg/L as CaCO3 (00410)	Ammonia water, fltrd, mg/L as N (00608)	Ammonia + org-N, water, unfltrd mg/L as N (00625)	Nitrate + nitrite water fltrd, mg/L as N (00631)	Phos-phorus, water, unfltrd mg/L as P (00665)	Organic carbon, water, unfltrd mg/L (00680)	Hard-ness, water, mg/L as CaCO3 (00900)	Calcium water, fltrd, mg/L (00915)	Magnes-ium, water, fltrd, mg/L (00925)
62	0.080	< 0.20	< 0.100	0.05	2.4	38	6.20	5.40

Sodium, water, fltrd, mg/L (00930)	Sodium adsorption ratio (00931)	Sodium fraction of cations percent (00932)	Potassium, water, fltrd, mg/L (00935)	Chloride, water, fltrd, mg/L (00940)	Sulfate water, fltrd, mg/L (00945)	Fluoride, water, fltrd, mg/L (00950)	Silica, water, fltrd, mg/L as SiO2 (00955)	Boron, water, fltrd, ug/L (01020)
17.0	1.2	49	1.10	17.0	15.0	0.10	19.0	20

Iron, water, unfltrd recover-able, ug/L (01045)	Iron, water, fltrd, ug/L (01046)	Mangan-ese, water, unfltrd recover-able, ug/L (01055)	Mangan-ese, water, fltrd, ug/L (01056)	Zinc, water, fltrd, ug/L (01090)	Alum-inum, water, fltrd, ug/L (01106)	Depth to water level below LSD, meters (30210)	Residue on evap. at 180deg C wat flt mg/L (70300)	Residue water, fltrd, sum of consti-tuents mg/L (70301)
13000	14000	240	270	2000	20	0.884	130	134

Residue water, fltrd, tons/ acre-ft (70303)	Ammonia water, fltrd, mg/L (71846)	Depth to top sample intrval feet below LSD (72015)	Depth to bot sample intrval feet below LSD (72016)	Depth to water level, feet below LSD (72019)	Specif. conduc-tance, wat unf lab, uS/cm 25 degC (90095)	ANC, wat unf fixed end pt, lab, mg/L as CaCO3 (90410)
0.18	0.10	10.00	20.00	2.90	208	60

APPENDIX I
Battlefield Golf Course
Groundwater Quality Data

TABLE 2A: SUMMARY OF ONSITE GROUNDWATER METALS ANALYSES
Battlefield Golf Club at Centerville
1001 Centerville Turnpike
Chesapeake, VA 23322

Sample ID # MW-#	Sample Date mo/dy/yr	Al (ug/L)	Sb (ug/L)	As (ug/L)	Ba (ug/L)	Be (ug/L)	B (ug/L)	Cd (ug/L)	Cr (ug/L)	Co (ug/L)	Cu (ug/L)	Fe (ug/L)	Pb (ug/L)	Mg (ug/L)	Mn (ug/L)	Hg (ug/L)	Mo (ug/L)	Ni (ug/L)	Se (ug/L)	Ag (ug/L)	Tl (ug/L)	V (ug/L)	Zn (ug/L)
MW-1	5/20/2008	86,700	MDL	64.6	284	3.8	113	MDL	187	76	9.6	157,000	67.9	31,000	1,330	0.23	MDL	166	MDL	MDL	MDL	232	510
MW-1	7/14/2008	26,800	MDL	22.7	110	0.9	37.7	MDL	58.4	33.9	5.7	48,100	26.3	19,100	416	MDL	MDL	80.2	MDL	MDL	MDL	72.4	235
MW-2	5/20/2008	99,200	MDL	79.8	444	3.4	75.2	MDL	231	90.3	33	175,000	78.7	41,500	1,300	0.24	MDL	204	MDL	MDL	MDL	297	491
MW-2	7/14/2008	16,100	MDL	21	94.1	MDL	40.1	MDL	34.2	22	4.4	32,600	15.3	22,200	284	MDL	MDL	52	MDL	MDL	MDL	45.8	91.1
MW-3	5/20/2008	130,000	MDL	103	463	5.2	75.5	MDL	302	148	44.8	229,000	106	47,700	1,540	0.31	MDL	299	MDL	MDL	MDL	384	805
MW-3	7/14/2008	69,500	MDL	71.3	265	3	56.4	MDL	158	96.3	32.5	129,000	66.8	33,700	907	0.12	MDL	187	MDL	MDL	MDL	202	524
MW-3D	7/14/2008	37,600	MDL	39.9	148	1	49.6	MDL	89	52.1	12.1	75,900	36.3	26,300	572	MDL	MDL	111	MDL	MDL	MDL	114	307
MW-3	8/25/2008	12,000	BDL	BDL	82	BDL	BDL	BDL	29	28	BDL	26,000	7	21,000	290	BDL	9.6	35	BDL	BDL	BDL	39	130
MW-3	8/25/2008	26,000	MDL	17.4	97.6	0.5	44.2	MDL	46.7	35.6	13	43,800	19.4	28,900	419	MDL	MDL	61	MDL	MDL	MDL	61.2	210
	Mean	**55,989**	**--**	**52.5**	**220.9**	**2.5**	**61.5**	**--**	**126.1**	**64.7**	**19.4**	**101,822**	**47.1**	**30,156**	**784**	**--**	**9.6**	**132.8**	**--**	**--**	**--**	**160.8**	**367.0**
	Primary MCL	**-**	**6.0**	**10.0**	**2000**	**4.0**	**-**	**5.0**	**100.0**	**-**	**-**	**-**	**15**	**-**	**-**	**2.0**	**-**	**-**	**50.0**	**-**	**2.0**	**-**	**-**
	Secondary MCL	**200**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1000**	**300**	**-**	**-**	**50**	**-**	**-**	**-**	**-**	**100**	**-**	**-**	**5000**
	WHO Guideline						**500**																
					Average per Well																		
MW-1	--	56,750		43.7	197	2.4	75.4		122.7	55.0	7.7	102,550	47.1	25,050	873			123.1				152.2	372.5
MW-2	--	57,650		50.4	269	3.4	57.7		132.6	56.2	18.7	103,800	47.0	31,850	792			128.0				171.4	291.1
MW-3	--	55,020		57.9	211	2.4	56.4		124.9	72.0	25.6	100,740	47.1	31,520	746		9.6	138.6				160.0	395.2

Note: MW-1, MW-2 and MW-3 at ~280X above primary MCL for Al.
MW-2 and MW-3 at 5X above primary MCL for As. MW-1 at 4x above primary MCL
MW-1, MW-2, MW-3 just above priimary MCL for Cr (<2X)
MW-1, MW-2, MW-3 at approximately 300X higher than Secondary MCL for Fe

MW-1, MW-2 and MW-3 at 3X above primary MCL for Pb.
MW-1, MW-2 and MW-3 at ~15X above primary MCL for Mn.

TABLE 2B: SUMMARY OF OFFSITE GROUNDWATER METALS ANALYSES
Battlefield Golf Club at Centerville
1001 Centerville Turnpike
Chesapeake, VA 23322

Sample ID # MW-#	Sample Date mo/dy/yr	Al (ug/L)	Sb (ug/L)	As (ug/L)	Ba (ug/L)	Be (ug/L)	B (ug/L)	Cd (ug/L)	Cr (ug/L)	Co (ug/L)	Cu (ug/L)	Fe (ug/L)	Pb (ug/L)	Mg (ug/L)	Mn (ug/L)	Hg (ug/L)	Mo (ug/L)	Ni (ug/L)	Se (ug/L)	Ag (ug/L)	Tl (ug/L)	V (ug/L)	Zn (ug/L)
FS-6	7/23/2008	595	MDL	MDL	68.5	MDL	33.7	MDL	MDL	9.5	106	2950	22	3560	112	MDL	MDL	9.1	MDL	MDL	MDL	MDL	55.2
MW-4	7/23/2008	5,670	MDL	MDL	33.7	8.1	17.5	MDL	MDL	132	MDL	53,600	MDL	59,400	1,190	MDL	MDL	294	MDL	MDL	MDL	MDL	485
MW-5D	7/23/2008	16,100	MDL	6.0	80.7	MDL	65.9	MDL	39.5	10.6	8.4	43,400	19.9	7,760	443	MDL	MDL	25.2	MDL	MDL	MDL	41.4	138
	Mean	7,455	MDL	6.0	61.0	8.1	39.0	MDL	39.5	50.7	57.2	33317	21.0	23,573	582	MDL	MDL	109.4	MDL	MDL	MDL	41.4	226.1
	Primary MCL	**-**	**6.0**	**10.0**	**2000**	**4.0**	**-**	**5.0**	**100.0**	**-**	**-**	**-**	**15**	**-**	**-**	**2.0**	**-**	**-**	**50.0**	**-**	**2.0**	**-**	**-**
	Secondary MCL	**200**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1000**	**300.0**	**-**	**-**	**50.0**	**-**	**-**	**-**	**-**	**100**	**-**	**-**	**5000**
	WHO Guideline						**500**																

Note: FS-6, MW-4 and MW-5D at ~3X, ~28X, ~80X above primary MCL for Al.
MW-4 at 2X above primary MCL for Be
FS-6, MW-4 and MW-5D at ~10X, ~178X, ~145X above primary MCL for Fe.
FS-6, MW-4 and MW-5D slightly above primary MCL for Pb.

FS-6, MW-4 and MW-5D at ~2+X, ~24X, ~9X above primary MCL for Mn.

TABLE 3A: SUMMARY OF ONSITE WATER CLASSICAL CHEMICAL PARAMETERS
Battlefield Golf Course at Centerville
1001 Centerville Turnpike
Chesapeake, VA 23322

Sample ID # MW-#	mo/dy/yr	Ca (u g/L)	Cl (mg/L)	F (mg/L)	N (mg/L)	P (mg/L)	K (u g/L)	Na (u g/L)	SO4 (mg/L)	Alk (mg/L)	TDS (mg/L)	TSS (mg/L)
MW-1	5/20/2008	47,800	49	0.15	0.14	1.6	9,140	15,100	76	26	290	4,800
MW-1	7/14/2008	23,700	20	0.16	0.079	0.75	3,980	11,900	79	31	230	660
MW-2	5/20/2008	69,500	50	0.28	1.1	2.1	12,600	28,500	120	28	370	2,100
MW-2	7/14/2008	58,800	36	0.26	0.19	0.99	4,350	27,300	96	89	390	180
MW-3	5/20/2008	57,700	18	0.32	0.15	2.8	14,200	22,900	140	49	360	2,100
MW-3	7/14/2008	56,900	44	0.4	MDL	MDL	10,500	22,700	130	61	380	2,600
MW-3D	7/14/2008	59,000	44	0.4	MDL	0.93	7,380	23,400	130	66	390	1,200
MW-3	8/25/2008	66,900	46	0.45	0.14	0.4	4,270	25,800	130	76	420	1400
MW-3	8/25/2008	54,000	45	0.31	BDL	0.5	4,500	24,000	130	87	420	560
	Mean	54,922	39	0.30	0.30	1.26	7,880	22,400	115	57	361	1,733
	Primary MCL	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Secondary MCL	**-**	**250**	**2.0**	**-**	**-**	**-**	**-**	**250**	**-**	**500**	**-**
					Average per Well							
MW-1	--	35,750	35	0.16	0.11	1.18	6,560	13,500	78	29	260	2,730
MW-2	--	64,150	43	0.27	0.65	1.55	8,475	27,900	108	59	380	1,140
MW-3	--	58,900	39	0.38	--	--	8,170	23,760	132	68	394	1,572

Note: All samples in Talbe 3A below primary and secondary MCLs

APPENDIX J
2007 City of Chesapeake
Water Quality Report

What's New?

EPA REGULATORY INITIATIVES

Arsenic

Arsenic is a naturally occurring mineral in soil, water, air, plants, and animals. Studies have linked long-term, chronic exposure to arsenic in drinking water to cancer. Compliance with the 10 ppb MCL was required in January, 2006. Water providers must include health information and arsenic concentrations in annual reports for water that exceed 5 ppb (one-half of the MCL). We are pleased to report that the levels of arsenic in any of Chesapeake's public water systems are well below the MCL.

Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)

This rule became final on January 5, 2006. It was developed to improve drinking water quality and provide additional protection from disease-causing microorganisms and contaminants that can form during drinking water treatment. Pathogens, such as Giardia and *Cryptosporidium*, are often found in raw water, and can cause gastro-intestinal illness and other health risks. *Cryptosporidium* is a significant concern in drinking water because it can contaminate surface water such as drinking water sources. It is resistant to chlorine and other disinfectants, and can cause waterborne disease outbreaks.

The purpose of LT2 rule is to reduce the risk associated with *Cryptosporidium* and other pathogenic microorganisms in drinking water. Northwest River Water Treatment Plant (NWRWTP) has voluntarily tested its source water quarterly since 1994. To comply with the rule NWRWTP and LGWTP started this monitoring for *Cryptosporidium*, E. coli, and turbidity in October 2006. This monitoring period will be completed by September 2008.

Stage 2 Disinfectants and Disinfection Byproduct Rule (Stage 2 D/DBPR)

This rule was developed to improve drinking water quality and to provide additional monitoring from disinfection byproducts. Disinfection is required to provide healthy drinking water. However, disinfectants like chlorine and bromate can react with naturally occurring materials in the water to form byproducts such as, Trihalomethanes (THM) and Haloacetic Acids (HAA). Under the Stage 2 D/DBPR, all drinking water systems must conduct an evaluation of their distribution systems, known as an Initial Distribution System Evaluation (IDSE), to identify the locations with higher disinfection byproduct concentrations. These locations will then be used by the systems as the sampling sites for Stage 2 D/DBPR compliance monitoring.

Compliance with the maximum contaminant levels for two groups of disinfection byproducts (TTHM and HAA5) will be calculated for <u>each monitoring location in the distribution system.</u> This approach, referred to as the <u>Locational Running Annual Average</u> (LRAA), differs from previous requirements that determined compliance by calculating the running annual average of samples from all monitoring locations across the system. Sampling all three systems every other month began in July 2007.

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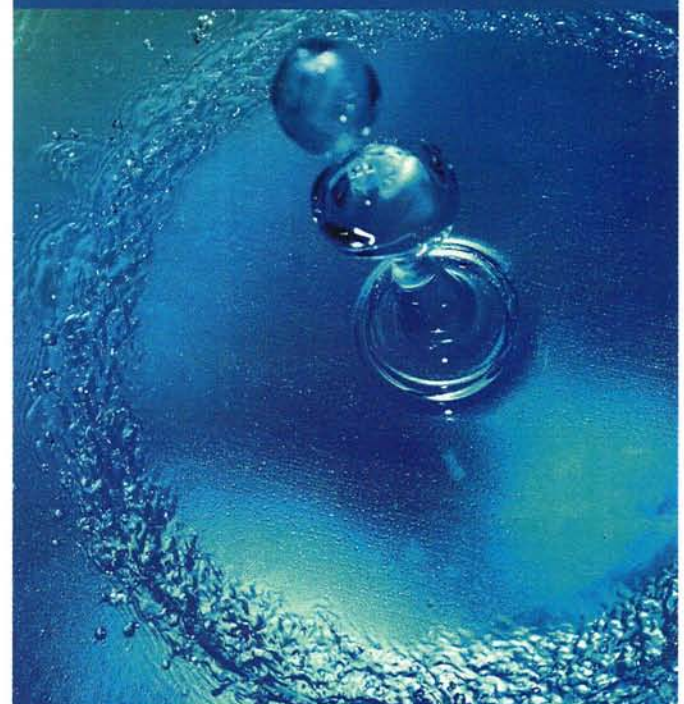
2007 WATER QUALITY REPORT

City of Chesapeake
Department of Public Utilities



Chesapeake
VIRGINIA

WATER...FOR TODAY AND TOMORROW

Want More Information?

If you have any questions about this report or need more information, please contact the Water Quality Laboratory at 757-382-3550. The following telephone numbers are provided for specific issues or questions:

Customer Service (billing)	**757-382-6352**
Laboratory (water quality)	**757-382-3550**
Water Quality Hot Line	**757-382-6360**

Visit our web site for online information at www.CityofChesapeake.net then click on Public Utilities. Contact us by E-mail at water@cityofchesapeake.net.

Our Business Office is located at City Hall, second floor, 306 Cedar Road, Chesapeake, VA 23322. It is open from 8:00 a.m. to 5:00 p.m., Monday through Friday. Address correspondence to Chesapeake Department of Public Utilities, P.O. Box 15225, Chesapeake, VA 23328.

Public Utilities Director	James K. Walski, P.E.
Public Utilities Assistant Director	William J. Meyer, Jr., P.E.
Financial/Customer Service Administrator	Markiella A. Moore
Utility Engineer	S. Dean Perry, P.E.
Water Resources Management Administrator	A. Craig Maples

Water Works Permit Identification Numbers

Northwest River System (including the Lake Gaston Water Treatment Plant) – PWSID 3550051
South Norfolk System – PWSID 3550052
Western Branch System – PWSID 3550050

Public Participation

Public Utilities is an enterprise department and is funded by customer fees, not taxes. However, it is part of the City of Chesapeake government. Our legislative body is the Chesapeake City Council, which holds hearings on budget and other financial matters, approves contracts, and considers ordinances that create or amend local laws. Some of these matters affect the operation of Public Utilities. The City Council meets on the 2nd, 3rd and 4th Tuesdays of each month at 6:30 p.m. in the City Council Chambers, First Floor of the City Hall Building, 306 Cedar Road. The meetings are televised live on WCTV Channel 48, the local government access cable channel, and on the City web site, www.CityOfChesapeake.net. Agendas for upcoming meetings are available on the City web site, or may be requested from the City Clerk's office at 757-382-6151.

INFORMATION FOR SPECIAL POPULATIONS

Some people may be more vulnerable to contaminants in drinking water than the general population. Immuno-compromised persons such as persons with cancer and undergoing chemotherapy, persons who have undergone an organ transplant, persons with HIV/AIDS or other immune system disorders, some elderly, and infants can be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. The Environmental Protection Agency/Centers for Disease Control guidelines on appropriate means to lessen the risk of infection by *Cryptosporidium* and other microbiological contaminants are available from the Safe Drinking Water Act Hotline at 1-800-426-4791.

INFORMATION ABOUT SOURCE WATER

A detailed source water assessment was conducted in 2001 by the Hampton Roads Planning District Commission. The Northwest River, like other surface water sources, was determined to have a high susceptibility to contamination. Our deep wells, like other groundwater sources, were determined to be low in susceptibility to contamination using the criteria developed by the state in its approved Source Water Assessment Program. The report consists of maps showing the source water assessment area, an inventory of known land use activities of concern, and documentation of any known contamination within the last 5 years. The report is on file at the Public Utilities Department.

The sources of drinking water (both tap water and bottled water) include rivers, lakes, streams, ponds, reservoirs, springs, and wells. As water travels over the surface of the land or through the ground, it dissolves naturally occurring minerals and, in some cases, radioactive material, and can pick up substances resulting from the presence of animals or from human activity. Substances that may be present in source water include: (1) microbial contaminants, such as viruses and bacteria, which may come from sewage treatment plants, septic systems, agricultural livestock operations, and wildlife; (2) inorganic contaminants, such as salts and metals, which can be naturally occurring or result from urban stormwater runoff, industrial or domestic wastewater discharges, oil and gas production, mining, or farming; (3) pesticides and herbicides, which may come from a variety of sources such as agriculture, urban stormwater runoff, and residential uses; (4) organic chemical contaminants, including synthetic and volatile organic chemicals, which are by-products of industrial process and petroleum production, and can also come from gas stations, urban stormwater runoff, and septic systems; (5) radioactive contaminants, which can be naturally occurring or be the result of oil and gas production and mining activities.

In order to ensure the tap water is safe to drink, the EPA prescribes regulations that limit the amount of contaminants in water provided by public water systems. Food and Drug Administration regulations establish limits for contaminants in bottled water, which must provide the similar protection for public health.

Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of contaminants does not necessarily indicate that water poses a health risk. More information about contaminants and potential health effects can be obtained by calling the Environmental Protection Agency's Safe Drinking Water Hotline at 1-800-426-4791 or accessing the EPA web site at www.epa.gov/safewater/.

2007 WATER QUALITY TABLE

The table contains the highest level and range, if available, detected by analyses performed in calendar year 2007, or the most recent testing in accordance with the regulations. An additional 180 compounds were tested for and not detected.

REGULATED SUBSTANCES

Substance (Unit)	MCL	MCLG	NWR & Range	N Highest & Range	P Highest & Range	Likely Source	Meets EPA Stds.
Antimony (ppb)	6	6	0.06 ND - 0.06	ND	ND	Discharge from petroleum refineries, fire retardants, ceramics, electronics, solders.	Yes
Arsenic (ppb)	10	NA	0.3 ND - 0.3	ND	ND	Erosion of natural deposits, runoff from orchards, glass and electronics production wastes.	Yes
Barium (ppb)	2000	2000	24 ND - 24	59 27 - 59	26 N/A	Erosion of natural deposits; discharge from metal refineries	Yes
Chlorine, Total (ppm) *highest quarter avg.	MRDL 4	MRDLG 4	2.82* 0.07 - 4.34	2.75* 0.02 - 3.90	2.62* 0.01 - 3.32	Water additive used to control microbes	Yes
Chromium (ppb)	100	100	ND	2 ND - 2	1 N/A	Erosion of natural deposits.	Yes
Dalapon (ppb)	200	200	ND	1.5 ND - 1.5	ND	Herbicide runoff.	Yes
Hexachlorocyclopentadiene (ppb)	50	50	ND	0.1 ND - 0.1	ND	Pesticide component from runoff.	Yes
Nickel (ppm)	50	50	ND	2 ND - 2	ND	Pesticide component from runoff.	Yes
Nitrate (ppm)	10	10	0.22 0.04 - 0.22	0.4 0.1 - 0.4	ND	Runoff from fertilizer use; leaching from septic tanks, sewage, erosion of natural deposits.	Yes
Total Organic Carbon [TOC] (ppm) *lowest annual average	TT (1.00 annual average removal ratio)	NA	1.20* 1.06 - 1.54 (range of individual readings)	2.7* 1.3 - 3.1	2.6 1.8 - 3.2	Naturally present in environment.	Yes
Selenium (ppb)	50	50	0.1 ND - 0.1	ND	ND	Discharge from petroleum and metal refineries, erosion of natural deposits.	Yes

Substance (Unit)	MCL / MCLG	NWR Entry Point #1	NWR Entry Point #2	N	P	Likely Source	Meets EPA Stds.
Fluoride (ppm) *highest monthly average	4	1.0* 0.6 - 1.0	1.0* 0.8 - 1.1	1.0* 0.1 - 1.6	0.79 N/A	Naturally present in environment, water additive which promotes strong teeth.	Yes

RADIONUCLIDES

Substance (Unit)	MCL	MCLG	NWR & LG EP #1	NWR & LG EP #2	N	P	Likely Source	Meets EPA Standards
Beta/photon emitters[1] (pCi/L)	50	Zero	3.48 2.3 - 4.5	N/A	3.0 2.7 - 3.0	1.8 N/A	Decay of natural and man-made deposits	Yes
Gross alpha particle (pCi/L)	15	Zero	0.28 ND - 1.1	N/A	1.3 0.3 - 1.3	ND	Erosion of natural deposits	Yes
Combined radium-226/228[2] (pCi/L) [tested every 4 years]	5	Zero	0.7 ND - 1.2	N/A	1.3 0.6 - 1.3	0.4 N/A	Erosion of natural deposits	Yes

1. EPA considers 50 pCi/L to be the level of concern for Beta particles.
2. Some people who drink water containing radium 226 or 228 in excess of the MCL over many years may have an increased risk of getting cancer.

Substance (Unit)	MCL	MCLG	NWR	LG	N	P	Likely Source	Meets EPA Stds.
Turbidity – Clarity (NTU)	Max TT, 1	N/A	0.26 0.09 - 0.26	0.13 0.05 - 0.13	0.44 N/A	0.08 0.04 - 0.08	Soil runoff	Yes
	Min. TT, less than or equal to 0.3, greater than 95%	N/A	Min. 100	Min. 100	Greater than 99.05%	Min. 100%		

Substance (Unit)	MCL	MCLG	NWR & LG Range at Sampling Sites*	NWR & LG Highest Running Average**	N Range at Sampling Sites*	N Highest Running Average**	P Range at Sampling Sites*	P Highest Running Average**	Likely Source	Meets EPA Stds.
TTHM – Total Trihalomethanes (ppb)	80*	0	ND - 66	30	33 - 83	51	35 - 48	45	By-product of drinking water chlorination	Yes
HAA – Haloacetic Acids Acids (ppb)	60*	0	1 - 27	17	4 - 40	27	13 - 26	28	By-product of drinking water chlorination	Yes

*Range of individual readings. **MCL is the highest running annual average allowed for the year.

MICROORGANISMS

Substance	MCL	MCLG	NWR & LG	N	P	Likely Source	Meets EPA Standards
Total Coliform Bacteria	5% or less of monthly samples are positive	0	0%	2% in May 0 - 2	0	Naturally present in the environment	Yes

Monitored Substance (Unit)	MCL	MCLG	NWR & LG	N	P	Likely Source
Cryptosporidium (organisms/liter)	None	None	0.01 (in source water) ND - 0.01	N/A	N/A	Warm-blooded animals living in the watershed
Giardia (organisms/liter)	TT	0	ND	N/A	N/A	Warm-blooded animals living in the watershed

LEAD AND COPPER (90TH PERCENTILE)

Substance (Unit)	MCL	MCLG	NWR & LG 90th % Range	N 90th % Range	P[2] 90th % Range	Likely Source	Meets EPA Standards
Copper (ppm) [house tap]	AL = 1.3	1.3	0.160 ND - 0.430	0.163 0.030 - 0.295	0.145 ND - 0.417	Corrosion of household plumbing	Yes
Lead (ppb) [house tap]	AL = 15	0	18[1] ND - 70	7.3 0.2 - 37	2.8 0.3 - 9.8	Corrosion of household plumbing	Yes
# of samples above AL of 1.3 ppm for copper # of samples above AL of 15 ppb for lead			0 out of 102 11 out of 102	0 out of 30 3 out of 30	0 out of 31 0 out of 31		NWR & LG - No N & P - Yes

1. **NWR/LG Lead Action Levels:** In a recent round of testing under the Lead and Copper Monitoring Program, a small percentage of the samples analyzed from homes within the City have lead levels above the EPA action level. This is the level above which a utility must initiate a public education program and provide customers with educational literature about avoiding potential exposure to lead in drinking water. The City completed the Public Education program that included the following: thoroughly investigating the corrosion control treatment and source water treatment, mailing lead information brochures to customers in the service area and placing them in public libraries and recreation centers, sending a public service announcement to the media, running an ad in the Virginian Pilot Clipper, and offering free lead testing for any customer in the service area. Free tests have been performed for over 460 customers. The City continues to collect and analyze samples per the monitoring schedule.

Lead: Infants and young children are typically more vulnerable to lead in drinking water than the general population. It is possible that lead levels at your home may be higher than at other homes in the community as a result of materials used in your home's plumbing. If you are concerned about elevated lead levels in your home's water, you may wish to have your water tested and flush your tap for 30 seconds to 2 minutes before using tap water. Additional information is available from the Safe Drinking water Hotline (800-426-4791).

2. System is on Reduced Monitoring: This means after meeting 3 consecutive years of lead and copper monitoring with results below the Action Level, EPA reduces sampling frequency to once every three years. Norfolk results are from 2005 testing, while Portsmouth results are from 2006. The next testing for Norfolk is in 2008 and Portsmouth is in 2009.

ADDITIONAL WATER QUALITY PARAMETERS

These substances are not considered harmful, but some can affect the taste and odor of drinking water.

Substance (Unit)	Suggested Limit	NWR & LG highest level and range	N highest level and range	P highest level and range
Aluminum (ppm)	0.05 - 0.2	ND	0.12 0.02 - 0.12	ND
Ammonia (ppm)	None	0.65 / 0.49 - 0.65	N/A	N/A
Chloride (ppm)	250	106 44 - 106	21 8 - 21	18 N/A
Color (CU)	15	2.5 / ND - 2.5	N/A	N/A
Hardness – total (ppm & *(grains per gallon)*)	None	30 (2) ND - 30	61 *(4)* 18 - 67	30 (2) N/A
Iron (ppm)	0.3	ND	N/A	N/A
Manganese (ppm)	0.05	ND	0.2 ND - 0.2	N/A
Nickel (ppb)	100	ND	0.2 / ND - 0.2	N/A
ph (pH units)	6.5 - 8.5	8.69 (avg.) 6.36 - 8.69	7.3 (avg.) 6.6 - 7.9	7.7 (avg.) 3.3 - 8.0
Sodium (ppm)	250	83 / 78 - 83	40 / 10 - 40	61 / N/A
Sulfate (ppm)	250	9 / ND - 9	41 / 24 - 41	61 / N/A
Zinc (ppm)	5	0.565 0.271 - 0.565	N/A	N/A

Table Definitions

Substances in your drinking water are routinely monitored by the Virginia Department of Health according to Federal and State Regulations. The 2007 Water Quality Table shows the results of our monitoring for the period of January 1st to December 31st, 2007 unless otherwise stated. In the table and elsewhere in this report you will find many terms and abbreviations you might not know. The following definitions are provided to help you better understand these terms:

Additional Water Quality Parameters – the compounds that may affect drinking water aesthetics such as taste, odor and color.

AL (Action Level) – the concentration of a contaminant which, if exceeded, triggers treatment or other requirements that a water system must follow.

CU (Color Units) – a measure of the color of water.

Detected Substances – compounds detected in Chesapeake's drinking water during calendar year 2007. The SDWA requires that the highest value detected and the range, if available, during the calendar year be provided in the report. An additional 180 compounds were tested for and not detected. A full list of these test results is available from the Chesapeake Water Quality Laboratory at 757-382-3550.

HAAs (Haloacetic Acids) – byproducts of disinfection.

IDSE (Initial Distribution System Evaluation) – sites identified in the distribution system with high disinfection byproduct concentrations.

Likely Source – the major sources of the compounds detected in finished water.

LG (Lake Gaston Water Treatment Plant) – The highest level and range, if available, of the compounds detected in the finished water processed at the Lake Gaston Water Treatment Plant (Entry Point #2), a combined surface water source, Western Branch Wells #1 and #3 and Aquifer Storage and Recovery (ASR) water sources as needed to meet heavy demand.

MCL (Maximum Contaminant Level) – the highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available treatment technology.

MCLG (Maximum Contaminant Level Goal) – the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety.

MRDL (Maximum Residual Disinfectant Level) – a level of disinfectant added for water treatment that may not be exceeded at the consumer's tap without an unacceptable possibility of adverse health effects.

MRDLG (Maximum Residual Disinfectant Level Goal) – the maximum level of a disinfectant added for water treatment at which no known or anticipated adverse effect on the health of persons would occur, and which allows an adequate margin of safety. MRDLGs are nonenforceable health goals and do not reflect the benefit of the addition of the chemical for control of waterborne microbial contaminants.

Microbial Substance – disease-causing organisms that may be harmful at certain levels. More information about *Cryptosporidium* and Giardia is supplied in this report.

mrem/year (Millirems per year) – is a measure of radiation.

N (Norfolk System Results) – the highest level and range, if available, of the compounds detected in the finished water supplied by the City of Norfolk for Chesapeake customers.

N/A – not available.

ND – not detected, lab analysis indicates that the contaminant is not present or was below the level of detection.

NTU (Nephelometric Turbidity Unit) – a measure of the clarity of water. Turbidity in excess of 5 NTU is just noticeable to the average person.

NWR (Northwest River System Results) – The highest level and range, if available, of the compounds detected in the finished water processed at the Northwest River Water Treatment Plant (Entry Point #1), a combined surface and brackish well water source.

P (Portsmouth System Results) – the highest level and range, if available, of the compounds detected in the finished water supplied by the City of Portsmouth for Chesapeake customers.

pCi/L (Picocuries per Liter) – a measure of radioactivity.

ppb (parts per billion) – One part per billion is the equivalent of one minute in 2,000 years, or one penny in $10,000,000.

ppm (parts per million) – One part per million is the equivalent of one minute in 2 years, or one penny in $10,000.

Plant Effluent – water leaving the plant after going through the treatment process.

Stage 2 D/DBPR (Disinfectants and Disinfection By-Product Rule) – rule developed to improve drinking water quality and provide additional monitoring of disinfection by-products.

TOC (Total Organic Carbon) TT – This value represents the waterwork's ability to meet TOC percent removal requirements based on an annual average of the monthly percent removal ratios. TOC percent removal requirements are met when the value is greater than or equal to 1.00.

TT (Treatment Technique) – a required process intended to reduce the level of a contaminant in drinking water.

TTHMs (Total Trihalomethanes) – compounds formed during the disinfection of drinking water.

Drinking Water of the Highest Quality

We want you to know about your drinking water: where we get your water, how it is purified and what is in it. The federal Safe Drinking Water Act (SDWA) sets the standards and this annual water quality report is one of the provisions of those standards. Please take a few minutes to review this very important information and know that reliability, quality, and affordability are at the heart of our mission in Public Utilities.

In order to produce the approximately 16.7 million gallons per day for about 61,206 accounts, more than 195,125 analyses throughout the treatment process are performed annually for treatment of drinking water. Water quality sampling in approximately 480 homes and businesses around the city tells the story of how well we are doing.

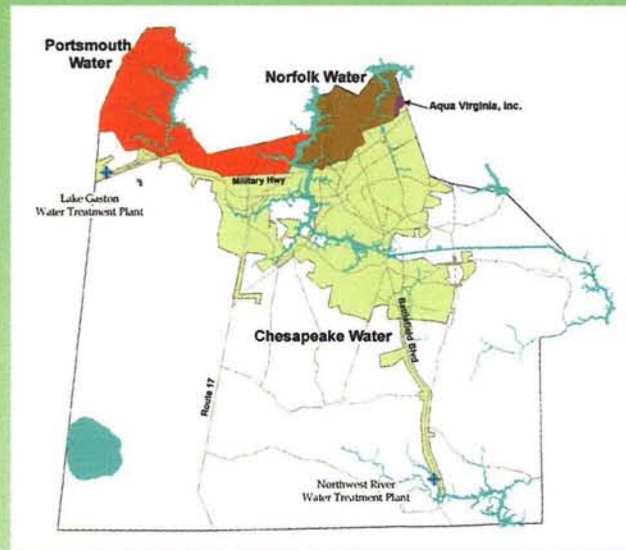
Association with world class organizations helps Public Utilities remain on the cutting edge of technology and committed to continuous improvement. We are members of the **American Water Works Association** (AWWA) and its **Partnership for Safe Water** (PSW), an association of water utilities and government entities committed to drinking water quality that is superior to that required by federal regulations. We provide financial support to the **American Water Works Association Research Foundation** (AWWARF), which funds and publishes the results of many projects every year aimed at improving management and treatment of water and wastewater facilities. We belong to the **Association of Metropolitan Water Agencies** (AMWA), whose membership is limited to utilities with at least 50,000 customer accounts. We are also members of the **American Membrane Technology Association** (AMTA), and the **Water Environment Federation** (WEF).

Locally, the City provides financial and technical support to the regional **Hampton Roads Planning District Commission** (HRPDC), which coordinates many research, public education and information programs. Some of these programs are the Hampton Roads Water Efficiency Team (HR WET), Hampton Roads Stormwater (HR Storm), Hampton Roads Clean (HR Clean), the Groundwater Committee, the Water Supply Committee, and Help 2 Others (H2O). We are members of the Hampton Roads Utility and Heavy Contractors Association (HRUHCA) and the Virginia Cross-Connection Control Association (VCCCA)

The City of Chesapeake's "The City That Cares" motto is recognized by Public Utilities in meeting the needs of both external and internal customers. In cooperation with other City departments the Customer Contact Center began operations in July 2005. It provides a new, easier way for citizens to contact us with concerns and questions. Call 382-CITY (2489) or go on line at www.CityOfChesapeake.net and click on the C3 logo. For routine turn-on or turn-off services, Public Utilities' Customer Service section stands ready at 382-6352.

Reliability Comes from Many Sources

Chesapeake is fortunate to have two treatment plants and contracts to purchase treated water from the cities of Norfolk and Portsmouth. Additional water is available from an auxiliary well source that is used during peak demands. These sources are described below.



The City's Northwest River Water Treatment Plant, located at 3550 South Battlefield Boulevard, treats up to 10 million gallons a day (MGD) from the Northwest River. The plant also treats brackish ground water from four wells located along South Battlefield Boulevard. The plant's capabilities include both the conventional processes of coagulation, sedimentation, and filtration as well as reverse osmosis (RO) membrane treatment. This supply generally serves customers south of Military Highway, but is subject to periodic adjustment depending on consumption patterns.

In April 2006, the Lake Gaston Water Treatment Plant was dedicated. It provides 8 MGD of new water for the City. The plant is located west of the Hampton Roads Airport on Virginia Route 58. The plant is currently treating raw water purchased from Norfolk. Treatment is provided using ultrafiltration technology with low pressure. Upgrades to the Lake Gaston plant will allow treatment of the 1/6 portion of Lake Gaston raw water in the future. With this added source, we expect to meet our projected water demands to the year 2040.

Customers in the Indian River and South Norfolk areas, north of Military Highway, receive treated water from the city of Norfolk. Water customers in Western Branch and Deep Creek, north of Military Highway, receive treated water from the city of Portsmouth. These sources are of excellent quality and also meet or exceed the SDWA standards.

The Western Branch Auxiliary Source is located near the Hampton Roads Airport. This source consists of groundwater from Wells #1 and #3 and the Aquifer Storage and Recovery (ASR) well. These wells serve a dual purpose. Fluoride occurs naturally in the native water; so the wells are used to provide natural fluoridation to the treated water. In addition, the Auxiliary Source is used to meet peak demand when necessary. When in use this water is blended with Lake Gaston treated water before entering the distribution system.

A private water company, Aqua Virginia, Inc., has a franchise area in the Norfolk Highlands neighborhood, which serves approximately 450 customers. The Aqua Virginia, Inc. customer service number is 1-800-537-4865 .

Spotlight Water-Saving Tips – Help Yourself to Savings

Using our drinking water responsibly and in smart ways will lead to preserving supplies and possibly save you money. When you use less hot water you will save on the costs to heat the water. You may be surprised at the results of knowing how and where you use this precious natural resource. Here are some easy water-wise tips:

- Fix leaks
- Wash only full loads of laundry and dishes
- Take shorter showers
- Turn the water off while brushing teeth or shaving
- Slow the flow to what you really need for the job
- Install water-saving aerators on faucets and tank dams on toilets
- Mulch around plants and shrubs
- Lawns need only 1" of water a week; if nature provides, turn off the sprinklers
- Water the lawn and garden in the early morning or evening

APPENDIX K
Water Storage Requirement for Alternative 2

Community System Flows

	# of Homes (ERC[1])	Per Diem Water Use Gallons
Fentress	1	400
Blue Ridge	3	400
Centerville	15	400
Murray	42	400
Whittamore	34	400
Unaccounted Additional	5	400
Summation	100	400

Year	Service Connections	Daily Pumpage		
2009	100	400 00	(Gallons/connection/day) typ	
		40,000	avg gpd	
		27 78	avg gpm	
		120,000	(max day) gpd	(Using Peak Factor of 3 00)
		83 33	(max day) gpm	(Using Peak Factor of 3 00)
		240,000	(peak hour) gpd	(Using Peak Factor of 6 00)
		166 67	(peak hour) gpm	(Using Peak Factor of 6 00)
		139 61	(peak hour) gpm	Using VDH equation (below)

$$= 11.4 \times N^{0.554}$$

Peaking Factors	
Max Day Avg Day 1 2 to 3	3
Peaking Factors Peak Hour Avg Day 3 to 6	6

Year	Projected Daily Pumpage		
Future	40,000	avg gpd	(Existing average day demand summed with projected growth demand)
	120,000	(max day) gpd	(Using Peak Factor of 3 0)
	201,033	(peak hour) gpd	Using VDH Equation

Fire Protection	120,000	gallons	1000 gpm @ 120 minutes City of Chesapeake

Peak Hour Equalization Reserve

Method 1	200/ERC	20,000	gallons -equalization storage reserve -VDH Requirement
			Peak Hour is satisfied by Fire Reserve, 1000 gpm > 139 6 gpm Thus not necessary

Emergency Reserve [2]

Method 1a) hours of average day storage[2]	12	20,000	gallons	
Method 1b) 60% of average day demand[2]	0 6	24,000	gallons	√ (Not Required)
Method 2 25% of total storage capacit		30,000	gallons	

Total Storage Required	120,000	gallons	(sum of check marked entries)
Total Storage Presently Available	0	gallons	
Additional Storage Needed	120,000	gallons	

[1] Equivalent Residential Connection

[2] The amount of emergency storage included within a particular water distribution system is an owner option based on an assessment of risk and the desired degree of system dependability An assessment must be made of the type and nature of emergency conditions, including their frequency, intensity, and duration

APPENDIX L
City of Chesapeake
Public Utility Charges

Public Utilties Charges

A. Monthly Minimum Charges:

The minimum monthly charges includes 300 cubic feet (ccf)* of water.

	WATER			SEWER			COMBINED		
meter size	*Effective* 1/1/2007	*Effective* 7/1/2008	*Effective* 7/1/2010	*Effective* 1/1/2007	*Effective* 1/1/2008	*Effective* 1/1/2010	*Effective* 1/1/2007	*Effective* 1/1/2008	*Effective* 1/1/2010
5/8	$16.50	$17.50	$18.50	$6.95	$7.95	$8.95	$23.45	$25.45	$27.45
3/4	$18.15	$19.25	$20.35	$7.95	$8.75	$9.85	$26.10	$28.00	$30.20
1	$23.10	$24.50	$25.90	$9.73	$11.13	$12.53	$32.83	$35.63	$38.43
1 1/2	$29.70	$31.50	$33.30	$12.51	$14.31	$16.11	$42.21	$45.81	$49.41
2	$47.85	$50.75	$53.65	$20.16	$23.06	$25.96	$68.01	$73.81	$79.61
3	$181.50	$192.50	$203.50	$76.45	$87.45	$98.45	$257.95	$279.95	$301.95
4	$231.00	$245.00	$259.00	$97.30	$111.30	$125.30	$328.30	$356.30	$384.30
6	$346.50	$367.50	$388.50	$145.95	$166.95	$187.95	$492.45	$534.45	$576.45
8	$478.50	$507.50	$536.50	$201.55	$230.55	$259.55	$680.05	$738.05	$796.05
10	$627.00	$665.00	$703.00	$264.10	$302.10	$340.10	$891.10	$967.10	$1,043.10

B. Charges for usage over 300 ccf:

$3.578	$3.878	$4.178	$1.789	$2.554	$3.971	$5.367	$6.432	$8.149

* 100 ccf = 748 gallons
300 ccf = 2,244 gallons

C. How is the bill calculated?

RESIDENTIAL:

Most residential homes have a 5/8 inch water meter and are billed every two months.

Example 1

A customer uses 6 ccf. In two months

$46.90 - The combined minimum monthly bill for water and sewer services is $23.45; multiply by 2 (the bill covers 2 months) = $46.90
- The minimum charge includes 3 ccf a month. A bill for two months would include 6 ccf.

Example 2

A customer uses 18 ccf. in two months

$46.90 - The combined minimum monthly bill for water and sewer services is $23.45; multiply by 2 = $46.90

<u>$64.40</u> - The minimum charge includes 3 ccf a month. A bill for two months would include 6ccf. The remaining 12 ccf (18ccf - 6ccf) would be charged at $5.367 per ccf.

$111.30

COMMERCIAL:

Many commercial customers have larger meters and are billed every month.

Example 1

The customer has a 2 inch meter and uses 18 ccf in one month

$68.01 - The combined minimum monthly bill for water and sewer services for a 2 inch meter

<u>$80.51</u> - The minimum charge includes 3ccf a month. The remaining 15 ccf (18 ccf - 3 ccf) would be charged at $5.367 per ccf.

$148.52

5/16/2007 MAM

APPENDIX M
Reverse Osmosis for Community Water System

SIEMENS

January 21, 2009

Riordan Materials Corporation
8712 Inwood Road
Baltimore, MD 21244

Attn: Mr. Thomas Rainier

Reference: URS Confidential Client
Reverse Osmosis/Nanofiltration Application
Equipment: Vantage M84-024RO
Vantage M83-006RO
Pretreatment for Iron and Manganese
Quote #: 09PS4202GFM

Dear Mr. Rainier:

This letter includes budgetary pricing and information for the proposed application using reverse osmosis (RO) submitted by URS Engineers for a confidential client. Our recommendations are based on water quality data that we received from you via email.

We have attached computer models of the NF/RO system performance. Overall, this system would be very effective at removing dissolved contaminants with a recovery of approximately 92% for the primary and secondary RO.

Vantage M84 System

The following is the budgetary pricing and information offered regarding the above referenced project:

Equipment	Capacity (permeate, gpm)	Budget Price
One (1) Vantage M84-024RO - Primary	100	$137,600.00
One (1) Vantage M83-006RO - Secondary	24	$ 90,100.00

Estimated Delivery: 12-14 weeks after receipt of approval drawings

Equipment Furnished:
Vantage M units are pre-piped and skid mounted on a painted steel skid with the following with each system:

- Membrane elements as manufactured by DOW FILMTEC™, either NF90-400 (primary) or LE400 (secondary). **MEMBRANE ELEMENTS ARE FIELD INSTALLED.**
- FRP membrane housings adequate for above membranes.
- Control panel with Siemens PLC controller and Siemens touch screen Human Machine Interface (HMI).
- Schedule 10 316L Stainless Steel high pressure piping.
- Schedule 80 PVC low pressure piping.
- Stainless steel pre-filter housing with first 2 sets of cartridge filters (about 1 month worth).
- Booster pump.
- Manual and automatic control valves.
- Instrumentation including flow meters/transmitters, pH and ORP meters, conductivity and pressure gauges.
- Product water divert line for wasting of below-quality water during startup.
- Reject flush line for flushing of system with raw water for shutdown.
- Raw water blend line including diaphragm valve and rotameter (on primary unit only).
- Air compressor with receiver and starter panel for automatic valve operation.
- Polyethylene CIP makeup tank with CIP hose kit (included with first skid only, additional skids will share the same tank and hose kit).
- Freight to the jobsite.
- Technical direction during plant installation, membrane loading, start-up and training. See table above for std. time.
- Antiscalant Feed System includes 16 gallon day tank, Grundfos DME series digital pump, rigid suction tubing with low level switch, priming aid, injection valve, alarm cable, communication cable and wall bracket for pump.

Refer to Equipment Lists for exact scope of supply.

Equipment Not Furnished:
Installation and field assembly, interconnecting piping, interconnecting wiring, backwash pumps, motor starters not specifically called out, and finished water storage.

Pretreatment for Iron and Manganese
The client also requested information on pretreatment options for iron and manganese. Per our correspondence, iron and manganese have been detected at 5.0 mg/L and 0.35 mg/L, respectively. Our recommendation for this application is our vertical pressure filter with oxidative media. We have provided pricing and information on a three-tank system. This provides redundancy and reduces the amount of backwash flow required on an instantaneous basis. Due to the relatively high levels of iron and manganese, we recommend running the filters at 2 gpm per square foot loading rate.

Budgetary pricing and information are as follows:

Equipment	Capacity (gpm)	Budget Price
Three (3) 84"-dia. vertical pressure filter vessels with Manganese ANTHRA/SAND Media	135	$187,900.00

Estimated Delivery: 12-14 weeks after receipt of approval drawings

Equipment Furnished:
Scope: (3) tanks, each includes 100 psi working pressure filter tank with supporting legs. Top side inlet connection with overdrain and bottom head effluent connection. Shop installed steel plate underdrain with gravel retaining strainers. Screwed air release connection. One 14" x 18" manhole in top head. One coat of interior and exterior primer, and one coat of interior finish paint. Sch. 40 steel filter face piping with exterior primer coat. Automatic backwash control panel, NEMA 12 rated. Pneumatically operated butterfly valves for inlet, backwash waste and effluent. Automatic air release valve and piping. Airwash grid and air blower. 10" of support gravel and 24" of 1.0-1.2 mm LO-d:C Manganese ANTHRA/SAND media. GFC #4879 loss of head gauge and #1639 backwash rate of flow indicator.

Equipment Not Furnished:
Installation, concrete slab work including waste sump, interconnecting piping, chemical feeds, and overall plant operation and controls.

Notes:
- Prices include technical direction, commission and freight.
- Filter tank size is outside diameter. Straight side shell height is 5'-0".
- Unit capacity ranges based on 2 to 3 gpm/sq.ft. of filter area.

We look forward to working with you on this exciting project. Should you have any questions or require further information, please contact me at (215)712-7040.

Best Regards,

Richard Ross, P.E.
Technical Sales Manager, East

Attachments: Equipment lists, sales drawings, brochure, ROSA projections, and specification.

cc: Dave Lucey, Siemens Water Technologies

SIEMENS

Vantage™ M83 Reverse Osmosis System Operating Cost Estimate

Note: This operating cost estimate is provided as a courtesy for Siemen Water Technologies customers and is an estimate only. No warrantees are expressed or implied.

Project Name: Confidential URS, VA Secondary System
Location: Confidential, Virginia
Date: January 21, 2009

System Configuration

Number of Vantage™ Skids:	1
Vantage Model Number:	M83-006
Membrane Type:	Reverse Osmosis
Array Configuration:	1:1 3M
Number of Pressure Vessels:	2 per skid
Total Number of Elements:	6 per skid
Number of Cartridge Filters:	4 - 30" per skid

System Flow Rates

Feed Flow per Skid:	33 GPM
Permeate Flow per Skid:	25 GPM
Total Feed Flow:	33 GPM
Total Permeate Flow:	25 GPM
RO System Recovery:	75%
Acid Dose Rate:	0 mg/l H2SO4
Antiscalant Feed Rate:	8 mg/l

Operating Times

System Operating Time:	24 hrs/day
Percent Online:	100%
Water Temperature:	70 ºF
CIP Interval:	90 days

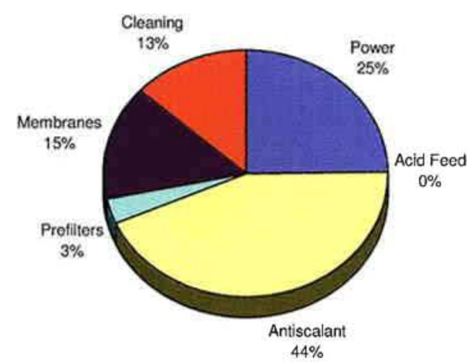
Cost Assumptions

Power Cost:	$0.06/kwhr
Acid Cost:	$3.27/gallon
Antiscalant Cost:	$3.22/gallon
Membrane Element Cost:	$650/element
Low pH Clean Solution:	$39.00/gallon
High pH Clean Solution:	$45.00/gallon

Operating Cost Summary

PERMEATE PRODUCED	13,140,000 gallons/year
Power	$2453/year ($0.187/kgal)
Acid Feed	$0/year ($0/kgal)
Antiscalant	$4329/year ($0.329/kgal)
Prefilters	$333/year ($0.025/kgal)
Membranes	$1495/year ($0.114/kgal)
Cleaning	$1332/year ($0.101/kgal)
EST ANNUAL OP COST $9942/year ($0.757/kgal)	

Estimated Operating Costs do not include labor, water and sewer charges, CIP pumping costs, or disposal costs.



Revision 3
8/13/2008

SIEMENS

Vantage™ M84 Reverse Osmosis System Operating Cost Estimate

Note: This operating cost estimate is provided as a courtesy for Siemen Water Technologies customers and is an estimate only. No warrantees are expressed or implied.

Project Name: Confidential URS, VA

Location: Confidential, Virginia

Date: January 21, 2009

System Configuration

Number of Vantage™ Skids:	1
Vantage Model Number:	M84-024
Membrane Type:	Reverse Osmosis
Array Configuration:	3:2:1 4M
Number of Pressure Vessels:	6 per skid
Total Number of Elements:	24 per skid
Number of Cartridge Filters:	7 - 40" per skid

System Flow Rates

Feed Flow per Skid:	133 GPM
Permeate Flow per Skid:	100 GPM
Total Feed Flow:	133 GPM
Total Permeate Flow:	100 GPM
RO System Recovery:	75%
Acid Dose Rate:	0 mg/l H2SO4
Antiscalant Feed Rate:	2 mg/l

Operating Times

System Operating Time:	24 hrs/day
Percent Online:	100%
Water Temperature:	50 ºF
CIP Interval:	90 days

Cost Assumptions

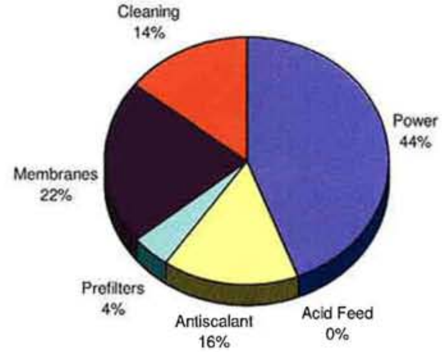
Power Cost:	$0.06/kwhr
Acid Cost:	$3.27/gallon
Antiscalant Cost:	$3.22/gallon
Membrane Element Cost:	$650/element
Low pH Clean Solution:	$39.00/gallon
High pH Clean Solution:	$45.00/gallon

Operating Cost Summary

PERMEATE PRODUCED	**52,560,000 gallons/year**
Power	**$12264/year ($0.233/kgal)**
Acid Feed	**$0/year ($0/kgal)**
Antiscalant	**$4329/year ($0.082/kgal)**
Prefilters	**$1199/year ($0.023/kgal)**
Membranes	**$5980/year ($0.114/kgal)**
Cleaning	**$3996/year ($0.076/kgal)**
EST ANNUAL OP COST $27768/year ($0.528/kgal)	

Estimated Operating Costs do not include labor, water and sewer charges, CIP pumping costs, or disposal costs.

Operating Cost Breakdown



Revision 3
8/13/2008

Reverse Osmosis System Analysis for FILMTEC™ Membranes | ROSA v6.1.5 ConfigDB U238786_55
Project: Confidential URSV2 | Case: 3
AFZ, Siemens Water Technologies | 1/12/2009

Project Information: Municipal groundwater source with high levels of Boron. URS would like projections done for a confidential client.

System Details

Feed Flow to Stage 1	34.00 gpm	Pass 1 Permeate Flow	23.80 gpm	Osmotic Pressure:	
Raw Water Flow to System	34.00 gpm	Pass 1 Recovery	70.00 %	Feed	27.09 psig
Feed Pressure	272.00 psig	Feed Temperature	62.6 F	Concentrate	86.60 psig
Fouling Factor	0.85	Feed TDS	3089.11 mg/l	Average	56.84 psig
Chem. Dose	None	Number of Elements	6	Average NDP	208.95 psig
Total Active Area	2400.00 ft²	Average Pass 1 Flux	14.28 gfd	Power	5.03 kW
Water Classification: Well Water SDI < 3				Specific Energy	3.52 kWh/kgal

Stage	Element	#PV	#Ele	Feed Flow (gpm)	Feed Press (psig)	Recirc Flow (gpm)	Conc Flow (gpm)	Conc Press (psig)	Perm Flow (gpm)	Avg Flux (gfd)	Perm Press (psig)	Boost Press (psig)	Perm TDS (mg/l)
1	BW30-400/34i	1	3	34.00	267.00	0.00	19.16	262.43	14.84	17.80	0.00	0.00	17.64
2	BW30-400/34i	1	3	19.16	257.43	0.00	10.20	255.61	8.96	10.76	50.00	0.00	51.07

Pass Streams (mg/l as Ion)							
Name	Feed	Adjusted Feed	Concentrate		Permeate		
			Stage 1	Stage 2	Stage 1	Stage 2	Total
NH4	3.30	3.30	5.83	10.88	0.03	0.08	0.05
K	58.40	58.40	103.32	193.14	0.37	1.10	0.64
Na	668.50	668.50	1182.73	2211.01	4.23	12.43	7.32
Mg	83.20	83.20	147.36	276.04	0.32	0.91	0.54
Ca	169.40	169.40	300.06	562.12	0.62	1.80	1.07
Sr	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	0.10	0.10	0.18	0.33	0.00	0.00	0.00
CO3	5.29	5.29	16.19	49.07	0.00	0.00	0.00
HCO3	868.10	868.10	1521.48	2804.83	6.32	17.79	10.63
NO3	0.20	0.20	0.34	0.58	0.02	0.06	0.04
Cl	1079.90	1080.71	1913.27	3580.68	5.24	15.55	9.12
F	0.80	0.80	1.41	2.64	0.01	0.02	0.01
SO4	53.70	53.70	95.17	178.48	0.13	0.36	0.21
SiO2	97.40	97.40	172.53	323.28	0.35	0.96	0.58
Boron	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	20.11	20.11	24.38	35.84	20.95	26.85	23.18
TDS	3088.29	3089.11	5459.89	10193.09	17.64	51.07	30.22
pH	7.70	7.70	7.81	7.85	5.74	6.06	5.91

Design Warnings

WARNING: Maximum element recovery has been exceeded. Please change your system design to reduce the element recoveries. (Product: BW30-400/34i, Limit: 19.00%)

CAUTION: The concentrate flow rate is less than the recommended minimum flow. Please change your system design to increase concentrate flow rates. (Product: BW30-400/34i, Limit: 13.00gpm)

Solubility Warnings

Langelier Saturation Index > 0
Stiff & Davis Stability Index > 0
$BaSO_4$ (% Saturation) > 100%
CaF_2 (% Saturation) > 100%
SiO_2 (% Saturation) > 100%
Antiscalants may be required. Consult your antiscalant manufacturer for dosing and maximum allowable system recovery.

Stage Details

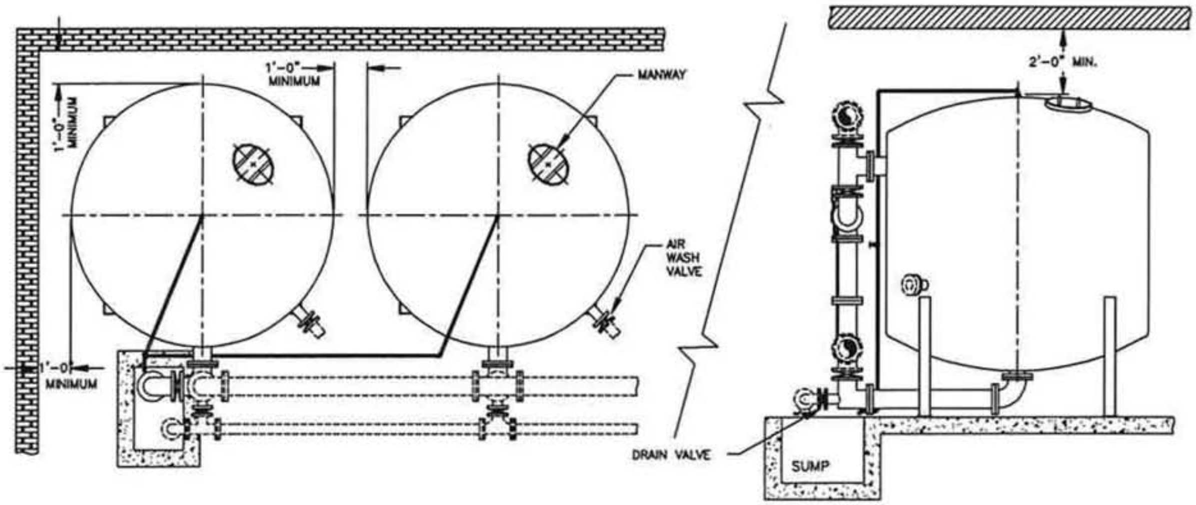
Stage 1 Element	Recovery	Perm Flow (gpm)	Perm TDS (mg/l)	Feed Flow (gpm)	Feed TDS (mg/l)	Feed Press (psig)
1	0.15	5.17	13.46	34.00	3089.11	267.00
2	0.17	4.96	17.17	28.83	3640.06	265.04
3	0.20	4.70	22.76	23.86	4392.09	263.54
Stage 2 Element	Recovery	Perm Flow (gpm)	Perm TDS (mg/l)	Feed Flow (gpm)	Feed TDS (mg/l)	Feed Press (psig)
1	0.18	3.37	36.61	19.16	5459.89	257.43
2	0.19	3.02	49.85	15.80	6611.76	256.63
3	0.20	2.58	71.36	12.78	8154.64	256.03

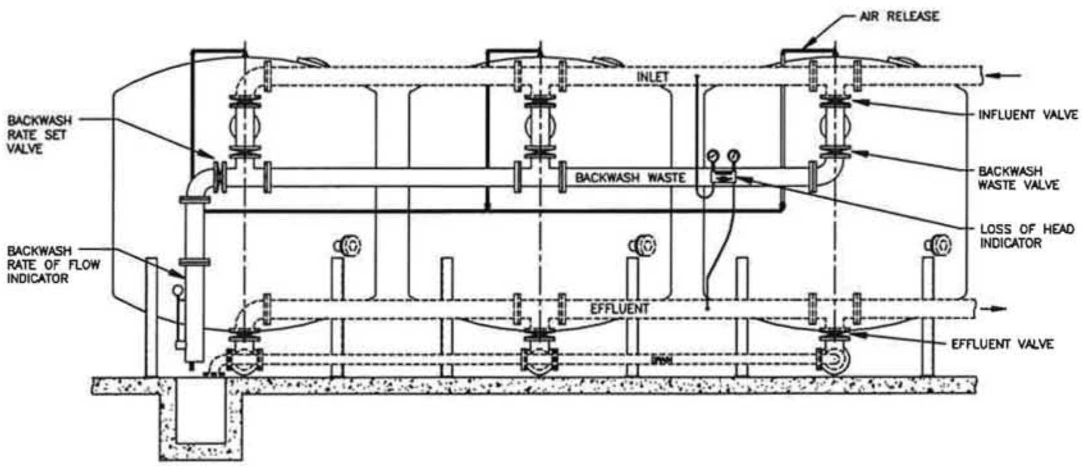
Scaling Calculations

	Raw Water	Adjusted Feed	Concentrate
pH	7.70	7.70	7.85
Langelier Saturation Index	1.04	1.04	2.19
Stiff & Davis Stability Index	1.07	1.07	1.76
Ionic Strength (Molal)	0.05	0.05	0.18
TDS (mg/l)	3088.29	3089.11	10193.09
HCO3	868.10	868.10	2804.83
CO2	20.11	20.11	35.82
CO3	5.29	5.29	49.07
CaSO4 (% Saturation)	1.19	1.19	5.57
BaSO4 (% Saturation)	80.00	80.00	260.06
SrSO4 (% Saturation)	0.00	0.00	0.00
CaF2 (% Saturation)	14.41	14.41	520.66
SiO2 (% Saturation)	89.36	89.36	297.86
Mg(OH)2 (% Saturation)	0.01	0.01	0.05

To balance: 0.81 mg/l Cl added to feed.

GENERAL FILTER
THREE UNIT MANGANESE GREENSAND VERTICAL FILTER BATTERY
STANDARD FLANGED PIPING





NOTE: ON JOBS WHERE PRESSURE AERATION OCCURS BEFORE FILTRATION, THERE NEEDS TO BE A PROVISION MADE FOR AIR RELEASE IN THE HIGHEST POINT OF THE INLET PIPING.

NOTE: FILTER PIPING SHOWN DASHED IS PROVIDED BY OTHERS UNLESS SPECIFICALLY QUOTED.

NOTE: CONFIGURATION SHOWN IS STANDARD   REF. DATA SHEET D–22.00A,B

FILTER DIAMETER	INFLUENT VALVE	EFFLUENT VALVE	BACKWASH WASTE VALVE	DRAIN VALVE	AIR WASH VALVE	BACKWASH RATE SET VALVE
84"	6"	6"	6"	3"	2.5"	6"

SIEMENS *Water Technologies*
Ames, IA
515–268–8400

A–28512–2
REV. 1–3–07

Reverse Osmosis System Analysis for FILMTEC™ Membranes
Project: Confidential URSV2
AFZ, Siemens Water Technologies

ROSA v6.1.5 ConfigDB U238786_55
Case: 2
1/12/2009

Project Information: Municipal groundwater source with high levels of Boron. URS would like projections done for a confidential client.

System Details

Feed Flow to Stage 1	133.33 gpm	Pass 1 Permeate Flow	100.01 gpm	Osmotic Pressure:	
Raw Water Flow to System	133.33 gpm	Pass 1 Recovery	75.01 %	Feed	10.72 psig
Feed Pressure	105.22 psig	Feed Temperature	62.6 F	Concentrate	38.82 psig
Fouling Factor	0.85	Feed TDS	1188.35 mg/l	Average	24.77 psig
Chem. Dose	None	Number of Elements	24	Average NDP	58.91 psig
Total Active Area	9600.00 ft²	Average Pass 1 Flux	15.00 gfd	Power	7.63 kW
Water Classification: Well Water SDI < 3				Specific Energy	1.27 kWh/kgal

Stage	Element	#PV	#Ele	Feed Flow (gpm)	Feed Press (psig)	Recirc Flow (gpm)	Conc Flow (gpm)	Conc Press (psig)	Perm Flow (gpm)	Avg Flux (gfd)	Perm Press (psig)	Boost Press (psig)	Perm TDS (mg/l)
1	NF90-400	3	4	133.33	100.22	0.00	66.98	85.06	66.35	19.90	0.00	0.00	48.13
2	NF90-400	2	4	66.98	80.06	0.00	39.64	69.14	27.35	12.31	0.00	0.00	127.70
3	NF90-400	1	4	39.64	64.14	0.00	33.32	46.96	6.32	5.69	0.00	0.00	329.14

Pass Streams (mg/l as Ion)

Name	Feed	Adjusted Feed	Concentrate			Permeate			
			Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Total
NH4	1.30	1.30	2.49	4.04	4.70	0.10	0.24	0.58	0.17
K	22.74	22.74	44.05	72.14	84.17	1.23	3.32	8.71	2.27
Na	259.88	259.89	503.70	826.03	965.00	13.73	36.47	93.68	25.00
Mg	31.40	31.40	61.84	103.27	122.00	0.67	1.78	4.56	1.22
Ca	63.89	63.89	125.85	210.23	248.38	1.33	3.54	9.21	2.43
Sr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	0.03	0.03	0.05	0.09	0.10	0.00	0.00	0.00	0.00
CO3	0.69	0.69	2.94	8.37	11.60	0.00	0.00	0.01	0.00
HCO3	331.00	331.00	648.43	1075.34	1266.37	7.40	19.59	51.22	13.48
NO3	0.11	0.11	0.14	0.16	0.17	0.08	0.11	0.14	0.09
Cl	420.00	420.00	813.84	1334.34	1558.67	22.37	59.34	152.20	40.68
F	0.30	0.30	0.58	0.93	1.09	0.02	0.06	0.14	0.04
SO4	20.00	20.00	39.66	66.73	79.19	0.15	0.41	1.07	0.28
SiO2	37.00	37.00	72.61	120.73	142.20	1.05	2.85	7.62	1.96
Boron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	17.70	17.70	18.65	20.81	21.98	17.82	19.12	20.92	18.38
TDS	1188.34	1188.35	2316.16	3822.42	4483.65	48.13	127.70	329.14	87.63
pH	7.40	7.40	7.63	7.76	7.79	5.86	6.23	6.58	6.09

Reverse Osmosis System Analysis for FILMTEC™ Membranes
Project: Confidential URSV2
AFZ, Siemens Water Technologies

ROSA v6.1.5 ConfigDB U238786_55
Case: 2
1/12/2009

Design Warnings

-None-

Solubility Warnings

Langelier Saturation Index > 0
Stiff & Davis Stability Index > 0
SiO2 (% Saturation) > 100%
Antiscalants may be required. Consult your antiscalant manufacturer for dosing and maximum allowable system recovery.

Stage Details

Stage 1 Element	Recovery	Perm Flow (gpm)	Perm TDS (mg/l)	Feed Flow (gpm)	Feed TDS (mg/l)	Feed Press (psig)
1	0.14	6.25	33.15	44.44	1188.35	100.22
2	0.15	5.75	41.70	38.20	1377.09	95.02
3	0.16	5.29	53.27	32.45	1613.62	90.85
4	0.18	4.83	69.55	27.16	1917.13	87.58
Stage 2 Element	Recovery	Perm Flow (gpm)	Perm TDS (mg/l)	Feed Flow (gpm)	Feed TDS (mg/l)	Feed Press (psig)
1	0.12	4.10	89.86	33.49	2316.16	80.06
2	0.12	3.64	113.14	29.39	2626.23	76.53
3	0.12	3.19	143.84	25.76	2980.39	73.59
4	0.12	2.75	184.71	22.57	3380.01	71.16
Stage 3 Element	Recovery	Perm Flow (gpm)	Perm TDS (mg/l)	Feed Flow (gpm)	Feed TDS (mg/l)	Feed Press (psig)
1	0.05	2.12	241.64	39.64	3822.42	64.14
2	0.05	1.73	302.07	37.52	4024.37	59.41
3	0.04	1.38	379.29	35.79	4203.52	55.02
4	0.03	1.09	478.47	34.41	4356.98	50.89

Scaling Calculations

	Raw Water	Adjusted Feed	Concentrate
pH	7.40	7.40	7.79
Langelier Saturation Index	-0.07	-0.07	1.46
Stiff & Davis Stability Index	0.31	0.31	1.34
Ionic Strength (Molal)	0.02	0.02	0.08
TDS (mg/l)	1188.34	1188.35	4483.65
HCO3	331.00	331.00	1266.37
CO2	17.70	17.70	21.98
CO3	0.69	0.69	11.60
CaSO4 (% Saturation)	0.26	0.26	2.03
BaSO4 (% Saturation)	17.14	17.14	80.78
SrSO4 (% Saturation)	0.00	0.00	0.00
CaF2 (% Saturation)	0.76	0.76	38.93
SiO2 (% Saturation)	33.94	33.94	130.46
Mg(OH)2 (% Saturation)	0.00	0.00	0.02

To balance: 0.01 mg/l Na added to feed.

Water Technologies

Vantage™ M84 Reverse Osmosis Units

The Clear Advantage
In Membrane Systems

SIEMENS

Vantage™ M84 units are packaged single-pass 8-inch reverse osmosis units designed for a variety of applications requiring high quality equipment with a fast delivery and competitive price.These pre-engineered, pre-assembled and factory tested units minimize installation and start-up time. With simple utility connections and easy to set up controls, the unit is ready for quick on-line service.

The Vantage™ M84 unit comes with a user friendly touch screen Human Machine Interface (HMI), Variable Frequency Drive (VFD) for flow control, built in Clean In Place (CIP) function, and pH/ORP monitoring.

The unit features an "On-Board" integrated cleaning system (CIP) initiated through the HMI. The CIP system includes plumbing to the on-skid RO cartridge filter housing and VFD controlled pump along with the factory supplied valves, hoses, and a polyethylene CIP tank (off-skid).

VANTAGE™ M84 UNIT BENEFITS:

- Compact footprint saves valuable floor space
- Quick equipment delivery keeps project moving fast
- Clean in place connections maximize system serviceability
- Comprehensive factory testing performed at our ISO9001 certified facility
- FilmTec's iLEC® interlocking endcaps, an innovative element coupling technology that significantly enhances the performance of RO systems

STANDARD M84 UNIT FEATURES:

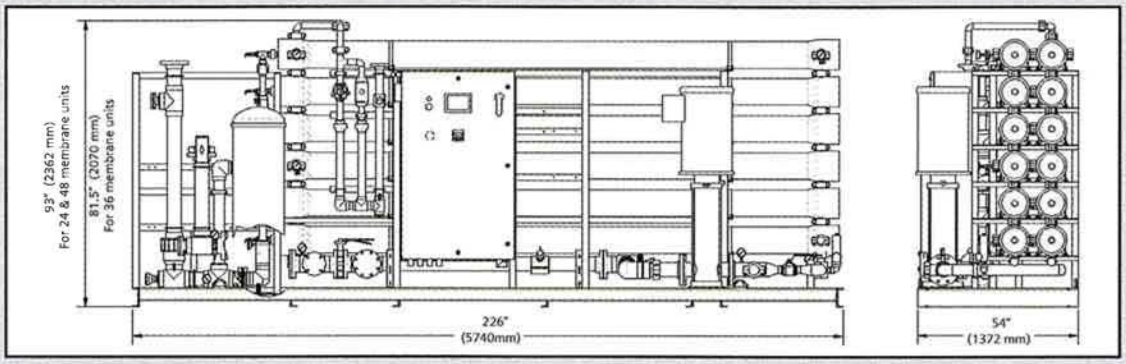
- Choice of brackish water or low energy TFC membranes (400 ft^2) to ensure optimum water quality
- High pressure 316 stainless steel vertical multi-stage feed pump
- ASME Code FRP, RO pressure vessels with ASME pressure relief protection
- PVC low pressure feed, product and reject piping, 316L stainless steel high pressure piping
- Urethane coated carbon steel frame rated for Seismic Zone 4 anchorage
- Dry contacts are provided for chemical feed, pre-treatment equipment, storage tank levels, and pressure switches
- All alarm and shut down conditions are indicated on the control interface

Specifications

Model No**	Flow Rate Specifications GPM Nominal (m^3/hr)			Vessel Staging	Membrane/ Vessel	Membrane Quantity	Customer Connection Specifications			Utility Requirements***			Approx. Shipping Weight lb (kg)
	Product*	Feed	Reject				Feed	Product	Reject	High Voltage Service	High Voltage FLA	Pump HP	
M84R024	100(22.7)	134(30.4)	34(7.7)	3:2:1	4	24	3"	3"	2"	480 VAC 3 ph	36	25	5400 (2449)
M84R036	150(34.1)	200(45.4)	50(11.4)	4:3:2	4	36	4"	4"	2"	480 VAC 3 ph	67	50	5750 (2608)
M84R048	200(45.4)	267(60.6)	67(15.2)	6:4:2	4	48	4"	4"	2"	480 VAC 3 ph	67	50	6100 (2767)

*Product flow rates are based on a flux rate of 15 GFD and equipment design parameters listed below. Product flow rates may not be appropriate for other feed waters.
**The 8 designates 8" housing, the 4 designates 4 elements in length, and the -RXXX designates the number of membranes.
***Additional voltage options are available. Refer to equipment specifications.

Dimensions



Model Features

Component	Description
Controls	Siemens PLC
HMI	6" Color Touch Screen
Inputs/Outputs	Discrete 24 point (14 input/ 10 output)
I/O Expansion Capability	Yes
Communication Port	PLC-RS485/HMI-Ethernet
Remote Monitoring/Communications*	Optional Modules
Flow Monitoring	Paddlewheel to PLC (feed/reject)
Conductivity	Signet Multiparameter
Auto-Flush (Standby)	Yes
Visual/Audible Alarm	Yes
Single Power Drop (460/575 VAC)	Yes
304LSS Pre-Filter Housing	Yes
Product Divert Kit	Yes
Variable Frequency Drive (VFD) Pump	Yes
On-Board CIP (Tank off-skid)	Yes
ORP/pH with alarms	Yes
Product Blend Kit	Yes
Low Energy Membranes (Cold Water)	Optional

*Additional communication modules and remote monitoring capabilities available upon request.

Design Parameters:

Feed Water Source	Well or Pretreated
Maximum Turbidity	1 NTU
Maximum Free Chlorine and/or chloramine	<0.1 PPM
Feed Water Fouling Index	Silt Density Index (SDI) <3
Design Feed Water Temperature	65°F (18.3°C)
Inlet Pressure Requirements	30-60 PSIG
Product Pressure Available	10 PSIG
System Recovery (Nominal)	75%
Performance Basis	A specific computer projection must be run for each individual application.

*Lower temperature may require larger booster pump or use of low energy membranes.

If any of the feed water parameters are not within the limits given, contact Siemens Water Technologies Technical Support.

The information provided in this brochure contains merely general descriptions or characteristics of performance which in actual case of use do not always apply as described or which may change as a result of further development of the products. An obligation to provide the respective characteristics shall only exist if expressly agreed in the terms of contract.

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EQUIPMENT LIST
VANTAGE™ M84 REVERSE OSMOSIS SYSTEM

Confidential URS, VA

Equipment Supplied by Siemens Water Technologies

One (1) Vantage M84 Reverse Osmosis Membrane Skid: Model M84-024, rated for 100 GPM permeate. The skid would be in the 3:2:1 configuration using 8" diameter x 4 membrane long 4M FRP pressure vessels. The operating weight of the skid is approximately 7,200 lbs. The skid measures 18 feet 10 inches long by 4 feet 6 inches wide by 7 feet 9 inches high, outside dimensions. The skid is painted steel construction and has the following prepiped and installed on the skid:

FRP Membrane Vessels: Six (6) Protec model PRO-8-300 FRP membrane vessels arranged in a 3:2:1 configuration for housing the membrane elements. The vessels are rated for 300 psi, are ASME code stamped and are NSF 61 approved for contact with potable water. Connections to the vessels are stainless steel grooved side entry type for feed and concentrate connections.

Piping: High pressure skid piping will be constructed from welded, schedule 10 Type 316L stainless steel. Low pressure piping will be constructed from schedule 80 PVC.

Prefilter Housing: One (1) prefilter housing constructed of 304L stainless steel. The size of the prefilter shall be 7Rx4H.

Booster Pump: One (1) with stainless steel housing and 25 hp, 460V, 3ph, 60 Hz TEFC motor. The pump is a Grundfos CRN Series.

Automatic Control Valves:

Inlet Valve: One (1) per skid, butterfly type with pneumatic actuator.

Auto Flush Valve: One (1) per skid, ball type, 316 SS, with pneumatic actuator.

Product Isolation Valve: One (1) per skid, butterfly type, with fail-to-close pneumatic actuator.

Product to Drain Valve: One (1) per skid, butterfly type, with fail-to-open pneumatic actuator.

Manual Valves:

Pump Throttling Valve: One (1) per skid, ball type, 316 SS, with locking manual actuator.

Reject Throttling Valve: One (1) per skid, globe valve, 316 SS, with manual actuator.

Blend Line Valve: One (1) per skid, diaphragm type, PVC construction with manual handwheel actuator.

Miscellaneous Valves:

Sample Valves: One (1) set ¼" PVC sample valves for feed water, product connections on each pressure vessel and a combined product sample.

Sample Valve: One (1) ¼" 316 stainless steel plug valve for high pressure feed sampling.

Pressure Relief: One (1) per skid, relief valve with ASME certified carbon steel body with stainless steel trim and Viton soft seat.

Controls:

Skid Control Panel: One (1) skid mounted NEMA 12 enclosure per skid, with Siemens operator interface terminal, relays, lights, and switches controlled by a Siemens programmable controller. The panel will have discrete interlocks for integration with additional skids, chemical prefeed and external run and stop signals. An HMI will be provided consisting of a Siemens model TP177B with 6" diagonal color touch screen. In addition, the PLC will have an Ethernet connection module that will allow remote communication with the skid.

Variable Frequency Drive (VFD): One (1) solid state variable frequency motor drive for the booster pump continuously adjustable over a range of 10 to 1. The VFD shall be mounted in the instrument control panel.

Pressure Gauges: Pressure gauges are 316 stainless steel bourdon tube and socket type with glycerin filled dial. Pressure gauges shall be provided for:

- cartridge prefilter inlet
- prefilter outlet
- booster pump discharge
- membrane housing inlet
- first stage permeate pressure prior to orifice plate
- concentrate outlet from each of stage 1, 2 and 3
- combined permeate

Pressure Switches: Two (2) per skid, one low pressure and one high pressure. The low pressure switch is adjustable between 4 and 50 psig. The high pressure switch is adjustable between 30 and 600 psig. Units have a BUNA N primary wetted diaphragm and a 1/4" 316 stainless steel wrought casing.

Conductivity Sensor: One (1) per skid, panel mounted in a NEMA 12 housing, monitor will be Signet 8900 Series Multi-parameter.

Conductivity Probe: Two (2) per skid, with 316 stainless steel electrodes, and PFM O-rings, rated to 100 psig. Probes will be Signet 2850 Series.

Flow Sensors: Two (2) per skid, for feed and reject flow monitoring and control. The sensors are paddlewheel style, polypropylene construction, and mount in a T fitting in the process piping. The flow sensor is Signet 2536 series.

Flow Indicating Rotameter: One (1) per skid, for blend line flow determination. The rotameter will be acrylic construction and have 316 stainless steel end connections.

pH and ORP Monitor: One (1) per skid, panel mounted in a NEMA 12 housing. Monitor will be Signet 8900 Series Multi-parameter.

pH Probe: One (1) per skid, pH probe is Signet model 2774

ORP Probe: One (1) per skid, ORP probe is Signet model 2775.

The Following Items are Shipped Loose for Field Assembly:

Twenty Four (24) – Membrane Elements: Model LE-400 Reverse Osmosis membrane elements as manufactured by DOW FILMTEC™.

Fourteen (14) – Cartridge Prefilters: 40" long for field installation in the prefilter housing. This quantity is sufficient for two complete sets of cartridge filters.

One (1) – Chemical Clean-in-Place (CIP) Tank: The CIP will be constructed of polyethylene and will be 36" diameter with a nominal capacity of 200 gallons. The tank will be supplied with four (4) PVC bulkhead fittings with PVC connections to allow flow into and out of the tank from the Vantage skid during cleaning. An additional bulkhead fitting and PVC ball valve will be supplied for tank draining.

One (1) – CIP Hose and Recirculation Valve Kit: for connection of above tank to the Vantage skid during CIP operation. The hoses shall be reinforced flexible hose with appropriate end connections for attachment to the skid.

One (1) – Set Antiscalant Feed Equipment: consisting of the following:

Chemical Feed Pump: One (1) per skid high-precision diaphragm type, on/off control by control panel with rate set from integral interface on pump. Pump will be Grundfos DME series with maximum capacity of 0.66 gph. Pump will be 120V, 1ph, 60 Hz service. Pump will be supplied with alarm wire and communication wire. Dose rate will be manually set from the pump, the pump will be turned on and off from skid control panel.

Chemical Day Storage Tank: One (1) 53 gallon Polyethylene Tank.

Suction Line: One (1) rigid suction tube with low level switch assembly.

Miscellaneous Hardware: Additional hardware consisting of pump wall mounting bracket, priming kit, inlet valve and pulsation dampener will be provided.

One (1) Air Compressor Pack: For Operation of the filter function valves consisting of two Quincy air compressors set for lead/lag, 4.4 CFM FAD @ 80 psig with ½ hp, 230 VAC, 3 ph, 60 Hz, 1750 rpm,

open drip proof drive motors, mounted on a common 30 gallon ASME code receiver (optional for additional cost: TEFC with NEMA 4 enclosure).
Accessories include:

- V-belt drive
- enclosed belt guard
- inlet filter/silencer air filter with spare cartridge
- automatic adjustable pressure switches
- ASME safety relief valve on air receiver
- in-tank type check valve
- compressor vibration mounts
- manual tank drain
- 120V (mounted) electronic type automatic tank drain (contractor to provide wall outlet at proper location)
- 120V (mounted) refrigerated air dryer (contractor to provide wall outlet at proper location)
- compressed air filter with spare filter cartridge
- single-supply alternator/starter panel with control circuit transformer and test-off-auto selector switches in a NEMA 1 enclosure with IEC magnetic starters.
- vibration isolation pads
- manufacturer's standard paint system

(Note to Proposals Specialist: Additional items requiring an air supply, such as modulating valves, may require a larger compressor.)

Owners Manuals: six (6), with installation, operating, and maintenance instructions, drawings and manufacturers' bulletins. Information contained on CD's.

Technical Direction: Six (6) days, for installation supervision, plant start-up, and operator training in a total of three (3) trips to the jobsite.

NOTE: Availability of equipment components specified may dictate substitutions of equal quality at the discretion of Siemens Water Technologies. Interconnecting wiring and piping is not included in the equipment supplied. Chemicals for startup are not included.

Installation is by others.

Equipment Specifications

Vantage™ M84 Series Reverse Osmosis Water Treatment System

Confidential URS, VA

Section 1 - GENERAL

1.01 WORK INCLUDED:

A. This section of the specification covers the furnishing and installation of a Vantage M84 Series Reverse Osmosis treatment skid and appurtenances as shown on the drawings and as specified herein.

B. The following items are a part of this section and shall be furnished by one manufacturer to ensure a properly designed and integrated water treatment system.

1. Factory built structural carbon steel skid with urethane coating.

2. Membrane elements in fiberglass pressure vessels, high pressure pump, prefilter housing, stainless steel high pressure piping, PVC low pressure piping, automatic process valves, and the system control panel all mounted on the above skid.

3. Cleaning solution tank and clean-in-place (CIP) hose kit.

4. Instrumentation and control system designed to automatically control flow to the membranes based on a product flow setpoint input by the operator, automatically control CIP flow, prevent unacceptable water from being directed to downstream unit operations and to prevent damage to the membranes from over pressure or low reject flow rates.

5. Raw water blend line built into the skid with rate set valve and flow meter.

1.02 QUALITY ASSURANCE:

A. The treatment system shall be furnished by a single manufacturer who shall comply with the following:

The manufacturer supplying equipment for this specification shall furnish proof of a minimum of 100 installations and 10 years of manufacturing treatment systems similar to the specified system.

In addition to normal start-up service, the systems detailed above shall be fully operational including the demonstration of a fully automated control sequence for the flush of the system and prevention of over-pressure of the membranes.

Membrane elements, housings and piping of the packaged treatment system shall be certified to NSF® Standard 61.

1.03 SUBSTITUTIONS:

A. Manufacturers other than that which is specified and/or not meeting EVERY provision of the specification shall be required to submit a complete and detailed PRE-QUALIFICATION PACKAGE to the engineer at least fifteen (15) days prior to the bid. Any PRE-QUALIFICATION PACKAGE must contain as a minimum:

1 Detailed Layout Drawings.
2. Detailed component specifications and catalog cut sheets.
3. Process P&ID Drawing.
4. Detailed list of variations required from original design, referencing appropriate sections of the specifications and locations on the drawings.
5. History of the process offered, including pilot data and experience.
6. Installation list including actual scale-up data from pilot testing to full scale plant operation, also including plant contact names and telephone numbers.
7. All other data as required in Quality Assurance section above.
8. A detailed System Performance Guarantee with appropriate remedies for non-performance.

B. Manufacturers qualifying will be recognized by addendum a minimum of five (5) days prior to the bid. Contractors shall include all costs associated with any redesign required with their bid.

C. Manufacturers not meeting this specification in EVERY WAY or are not PRE-QUALIFIED and approved by the engineer as outlined above will not be considered for use on this project.

Section 2 - PRODUCTS

2.01 GENERAL

A. All component parts and equipment utilized in the pre-engineered water treatment system shall be furnished as a complete integrated system by one manufacturer. This specification describes a Vantage Series M84 Water Treatment System as manufactured by Siemens Water Technologies.

Furnish and install one (1) identical skid capable of producing 100 GPM* permeate. Total plant design flow rate is 100 GPM. The pre-engineered treatment system shall be Vantage Model M84-024.

*** This is based on a nominal design flux of 15 gfd, which is typical for well water or pretreated surface water with an SDI of less than 5.**

2.02 REVERSE OSMOSIS SKID

A. The configuration of the system shall be multi-stage, single pass, with a design system recovery of 75%. The skid shall be staged in a 3:2:1 configuration and shall utilize 4M vessels.

B. Influent temperature shall be greater than 50ºF, have an SDI less than 5 and have undetectable free chlorine and/or chloramines.

C. Skid Fabrication

The Vantage Series Reverse Osmosis System shall be mounted on a rectangular steel skid. Major components shall be of the size and configuration shown on the drawings and fabricated of ASTM A36 structural carbon steel and ASTM A500 structural carbon steel tubing. Surface shall be prepared using an SSPC SP-6 commercial blast and coated with 6-9 mils DFT urethane. The skid frame shall extend to the full footprint of the skid.

All external connections shall be provided as flanged connections as shown in the drawings.

1. High pressure piping on the skid (greater than 90 psi) shall be welded Schedule 10, 316L stainless steel.

2. Low pressure piping shall be Schedule 80 PVC conforming to ASTM-D-1784, socket welded and flanged (threaded for instrumentation).

3. Gaskets shall be 1/8" thick EPDM, ring or full face.

D. Membrane and Pressure Vessels

1. Membranes shall be thin film composite, 8" spiral wound and shall come in a standard 40" length. The membranes shall be DOW FILMTEC™ LE-400.

2. Each membrane element shall have an active surface area of 400 ft^2.

3. The system shall be designed for a flux of 15 gallons/ft^2/day (GFD).

4. Membrane elements shall be housed in a fiberglass reinforced plastic (FRP) pressure vessel rated to 300 psig. Each housing shall be 8" diameter, and have grooved 1 ½" side entry connections. Housings shall be ASME code stamped. Membrane housings shall be Protec™ Pro-8-300 Series. Pressure relief must also be provided, as per ASME and the code stamped housing.

E. Booster Pump

1. A multistage centrifugal pump shall be mounted on each skid for pressurizing the water to the RO system. Each pump will be designed to provide 133 gpm of water at a pressure of 250 psig.

2. Pump housing shall be constructed of 316 stainless steel. Pump impellers shall be 316 stainless steel.

3. Pump motor shall be 25 hp, TEFC, 460 volt, 3 phase, 60 hz. Motor shall have Class F insulation, be UL recognized, and have a service factor of 1.15.

4. Pump shall be Grundfos CRN series.

F. Plant Process Valves

The treatment plant manufacturer shall provide all process control valves in sizes shown on the drawings.

1. There shall be automatic control valves with pneumatic actuators for the skid including:

   One inlet valve, wafer butterfly style, with EPDM seats.

   One auto flush valve, which shall be a ball valve with 316 stainless steel body, ball and stem.

   One product isolation valve, wafer butterfly style, with EPDM seats. Actuator shall be fail-to-close.

   One product to drain valve, wafer butterfly style, with EPDM seats. Actuator shall be fail-to-open.

2. There shall be adequate manual valves on the skid as follows:

   One pump throttling valve, which shall be a ball valve with 316 stainless steel body, ball and stem and locking manual actuator.

   One reject throttling valve, which shall be a 316 stainless steel globe valve with manual actuator.

   One lot ¼" PVC sample valves for feed water, product connections on each pressure vessel and a combined product sample.

   One ¼" 316 stainless steel plug valve for high pressure feed sampling.

   One ¼" PVC valve for low pressure feed sampling

3. There shall be a pressure relief valve with ASME certified carbon steel body with stainless steel trim and Viton soft seat on the skid on both the feed to the membrane housings and on the product piping.

   Gauges shall be isolated from the process stream by ¼" stainless steel threaded plug valves.

G. System Prefilters

1. The skid shall be provided with one multi-element prefilter for removal of suspended solids in the influent water.

2. The filter elements shall be non-shedding polypropylene with a nominal opening of 5 microns.

3. The filter housing shall be 304L stainless steel and shall have a 150 psig non-code pressure rating. The housing shall be sized for no more than 5 gpm per 10" filter equivalent.

H. Blend Line

1. Each membrane skid shall be equipped with a raw water blend line that allows a portion of raw water to be blended with the membrane permeate to reach a desired finished water quality goal.

2. The blend line shall consist of a diaphragm valve, check valve and rotameter to allow the operator to manually adjust the desired raw water bypass rate.

2.03 CLEAN-IN-PLACE SYSTEM

A. The cleaning system pump, filter and controls will be fully integrated into the Reverse Osmosis skid. The only additional CIP components that shall be required will consist of a chemical makeup tank and a hose kit.

1. The CIP Chemical Makeup Tank shall have a capacity of 200 gallons and shall be 36" diameter. The tank will be installed by the contractor near the membrane skid as shown on the project plans. It shall be polyethylene construction and use PVC bulkhead fittings for the connection points.

2. A hose kit shall be provided by the manufacturer with sufficient hoses and connection hardware to make the CIP system operational when required. The hose kit shall also be supplied with a bypass valve for mixing of CIP solution.

2.04 AIR COMPRESSOR

A. Manufacturer shall furnish one compressor pack consisting of two (2) single stage automatic air compressors with one ASME code, 30 gallon horizontal receiver, motor, load-less starting, pressure gauge, safety valve, crankcase drain, intake air filter, pressure switch, manual and automatic receiver blowdown, continuously running refrigeration type air dryer, dryer moisture trap with manual and automatic blowdown, shut off valve and compressed air filter with spare cartridge. Compressor pack to be completely shop assembled with dryer. Refrigeration dryer shall be 120 volt single phase, contractor to provide wall outlet at proper location for dryer. Compressors shall have a piston displacement of 4.4 cfm FAD and driven by ½ hp, 230 volt, 3 phase, 60 Hz drive motors. Compressors shall be alternating with lead compressor switch setting 70 - 90 psig, lag compressor switch setting 60 - 80 psig. Capacity of a single compressor shall be sufficient for normal operation of pneumatic valves. An IEC specific purpose motor starter assembly is to be provided as part of the compressor pack and is to be installed by the contractor.

2.05 ANTISCALANT FEED SYSTEM

A. Manufacturer shall furnish chemical dosing equipment for the introduction of antiscalant to the system feedwater. It shall consist of a metering pump, calibration column, tubing and injection quill.

1. The pump will be field mounted by others on the chemical storage container for the antiscalant. The pump will be Grundfos DME series, capable of a maximum of 0.66 gph, with a turndown capability of 1000:1. The pump rate shall be manually set by the operator, but pump run status will be controlled by the skid control system.

Section 3 - PLANT CONTROL

3.01 PLANT CONTROL - GENERAL

A PLC based control panel shall be supplied to monitor and control the Vantage Series System. The PLC based system shall be capable of operating in an automatic mode completely autonomously. The control panel shall provide automatic starting and stopping of the Treatment System, based on clearwell level or device failure.

A. The control system shall be supplied complete including all necessary equipment to provide a complete and functioning system. The components shall include PLC, human machine interface (HMI), control relays, push-buttons & selector switches, indicating lights, power supplies, fuses and terminal strips. The PLC shall have an Ethernet™ port, enabling interface to a SCADA System or, Master Control Panel or to other membrane skids.

3.02 TREATMENT SYSTEM CONTROL PANEL

A. The treatment system controls shall consist of Local Control Panel (LCP) on the skid. The control panel shall be supplied in a NEMA 4/12 steel enclosure suitable for indoor use. The front panel of the cabinet shall contain all push buttons, and Human Machine Interface as detailed within this specification. The internal portion of the cabinet shall contain all rail-mounted PLC equipment, power supply, processor, and interface cards. Relays and terminals shall also be contained within the cabinet. The PLC subsystem shall be Siemens S7/200 model CPU224XP. Terminal strips for all field wiring shall be furnished within the panel.

B. Fuses and simplex outlet shall be provided within the panel.

C. All digital outputs shall be provided with relay contacts.

3.03 VARIABLE FREQUENCY DRIVE (VFD)

A. The drive for the booster pump shall consist of an adjustable frequency AC motor controller.

B. The VFD shall provide continuously adjustable settings over a range of not less than 10 to 1. The controller shall be solid state.

C. The VFD shall be mounted in the instrument control panel.

3.04 DEVICES FOR OPERATOR INTERFACE

External face mounted devices for operator interface shall be as follows:

A. Human Machine Interface

The HMI shall be touch screen type with 6 in. diagonal full color display. The HMI shall be fully programmed with shall allow the operator to view and modify system variables within the PLC. It shall allow the operator to set process flow rate, run status and CIP operation through the use of virtual switches/pushbuttons. The HMI shall have an Ethernet port to allow interfacing with other membrane skids, pretreatment devices or other control devices. The HMI shall be Siemens model TP177B DP/PN with Ethernet.

B. Pushbuttons

1. Pushbuttons shall be Siemens. Panel Mounted Pushbuttons shall be provided to perform the following functionality:

   a. Emergency Stop

3.05 PROCESS CONTROL SYSTEM FUNCTIONS

A. The LCP shall automatically control the treatment process.

B. The HMI shall provide operator adjustable set points for the following parameters:

1. RO selector Man/Auto
2. RO selector Start/Stop
3. Permeate Flow Rate Setpoint
4. Auto flush selector On/Off
5. Alarm silence
6. Alarm reset
7. CIP Start/Stop
8. CIP Flow rate set

C. The PLC shall, via the HMI, provide the following status indicators at a minimum:

1. Feed flow, reject flow, product flow, % recovery
2. Total run time
3. RO operating mode
4. Pump status
5. Inlet, reject, product to tank, product to drain valve status
6. Pretreatment lockout
7. Storage tank full (Standby – no call for water)

D. The following alarm conditions shall be monitored by LCP. All alarms shall be visible via the HMI Display.

1. Low quality product
2. Low feed pressure
3. Low reject flow
4. High product flow
5. Low feed flow
6. High pump discharge pressure
7. High feed water temperature
8. ORP alarm
9. Emergency Stop
10. VFD fault
11. CIP low flow

E. The following additional features shall be provided in the LCP.

1. Alarm horn and alarm pilot light
2. Chemical injection pump terminals
3. Auxiliary contacts for pump running & fault

3.06 INSTRUMENTS

A. Pressure Sensors and Gauges

1. Pressure gauges shall be 316 stainless steel bourdon tube and socket with a 63mm glycerin filled dial. Pressure gauges shall be Ashcroft series 1009.

2. Pressure switches shall be provided for low feed pressure and high discharge pressure. The pressure switches shall have a 15 amp switching power at 120 volts. The low pressure switch shall have an adjustable range between 4 and 50 psig. The high pressure switch shall have an adjustable range between 30 and 600 psig. Units shall have a BUNA N primary wetted diaphragm and a 1/8" 316 stainless steel wrought casing.

B. Conductivity Sensors

1. Conductivity shall be continuously monitored by the control system. The monitor shall be NEMA 4 and be panel mounted. Conductivity monitors shall be Signet 8900 Series Multi-parameter.

2. Conductivity probes shall have 316 stainless steel electrodes, 316 stainless steel body, and FPM O-rings. Units shall thread into a ¾" NPT connection and be rated to 100 psig. Probes shall be Signet 2850 Series.

C. Flow Sensors/Indicators

1. Each skid will be equipped with two flow sensors for feed and reject flow monitoring and control. The sensors shall be paddlewheel style and shall be polypropylene and mount in a T fitting in the process piping. The flow sensor will be Signet 2536 series.

2. Each skid shall have an acrylic rotameter for flow determination in the product blend line. The rotameter shall have 316 stainless steel end connections. The rotameter shall be manufactured by King Products.

D. PH/ORP Sensors

1. PH and ORP of the raw water shall be continuously monitored by the control system. A sample shall be taken from a high pressure point, fed to the sensors, and returned to a low pressure point so that no waste stream is generated from the sampling. The monitor shall be NEMA 4 and be panel mounted. The monitor shall be Signet 8900 Series Multi-parameter.

2. PH probe shall be Signet model 2774 and ORP probe shall be Signet model 2775.

Section 4 - Execution

4.01 DELIVERY OF EQUIPMENT

A. The membrane skids shall be shipped to site as a complete unit with the exception of the blend line and membrane elements, which will be installed on-site by the contractor.

B. The CIP tank and hose kit shall be shipped loose for placement and field installation by others.

4.02 INSTALLATION AND TRAINING

The Vantage Series Reverse Osmosis System shall be installed as shown on the Contract Drawings and specified herein.

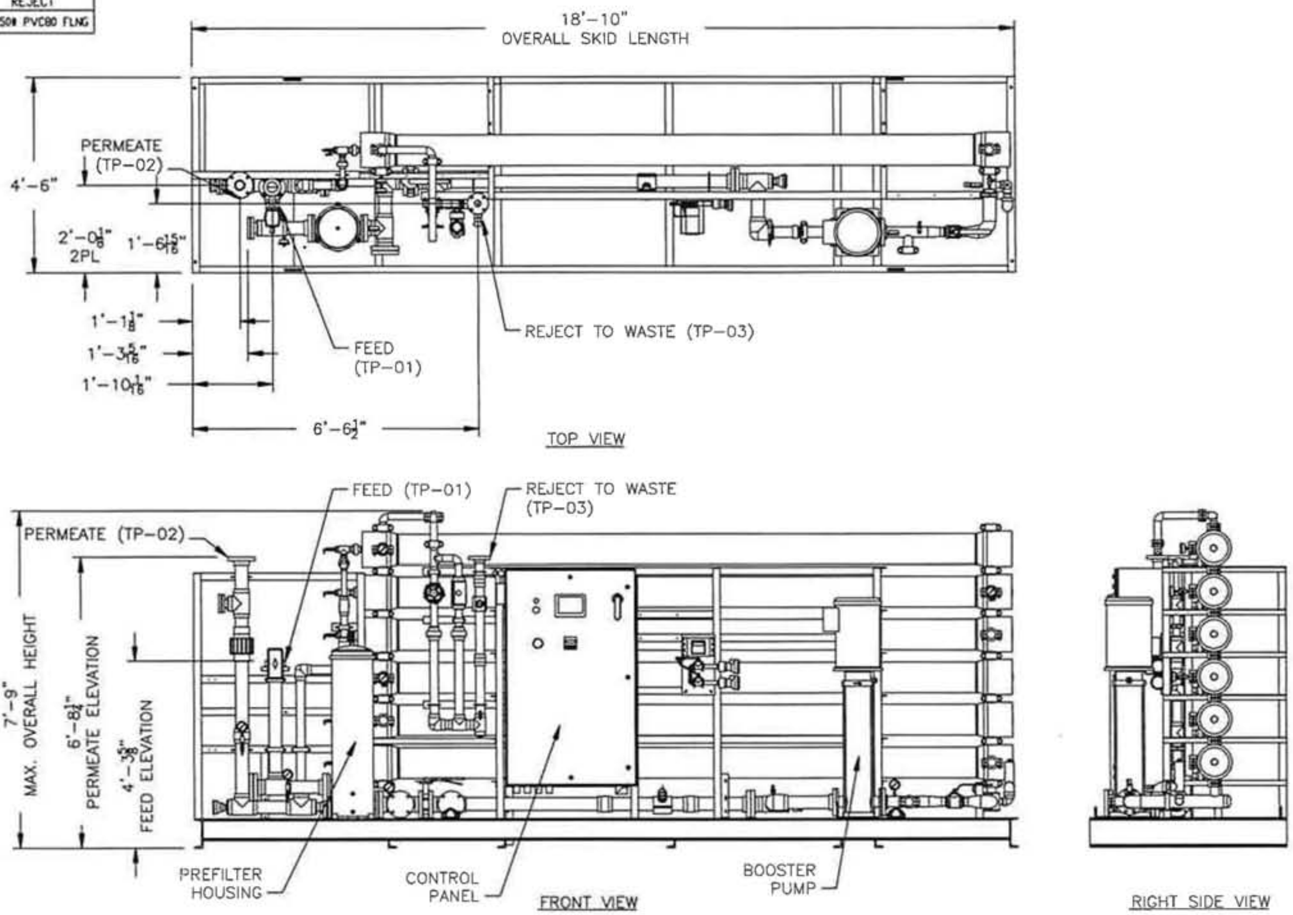
The Manufacturer shall inspect the installation of all equipment in this section prior to start-up in order to verify that the equipment has been properly installed and operates properly as a system and individually.

After the equipment has been properly installed, the Manufacturer shall calibrate the equipment with the Owner's operator present.

The Manufacturer shall furnish the service of a competent technical service representative after Contractor's start-up to instruct the Owner's personnel in the operation and maintenance of the equipment.

The Manufacturer's representative shall be present for six (6) days in three (3) trips total to provide services described above.

CONNECTION TABLE			
MEMBRANES	TP-01 FEED	TP-02 PRODUCT	TP-03 REJECT
24	3" 150# PVC80 FLNG	3" 150# PVC80 FLNG	2" 150# PVC80 FLNG



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COS	4-16-07
CHECKER	DATE
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FILE:	
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TITLE VANTAGE MB4 MEMBRANE SYSTEM
NANOFILTRATION/REVERSE OSMOSIS
MODEL: MB4–024 3:2:1 4M ARRAY

CLIENT

SIEMENS Water Technologies
Ames, IA
515–268–8400

PROJECT	CODE	DRAWING	SHEET	REV
		MB4–024–01	1 OF 1	

REV	DESCRIPTION	DATE	DWN	CHKD	APVD	ECN

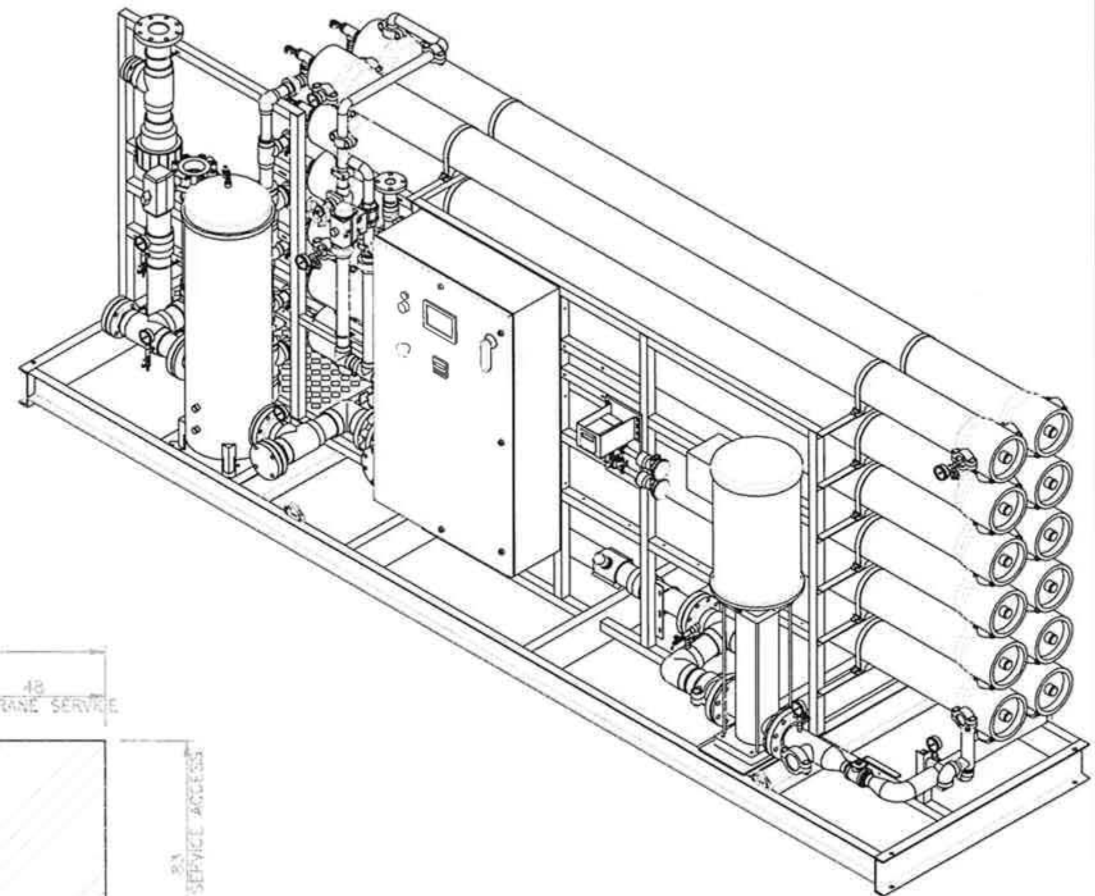
COMPANY CONFIDENTIAL

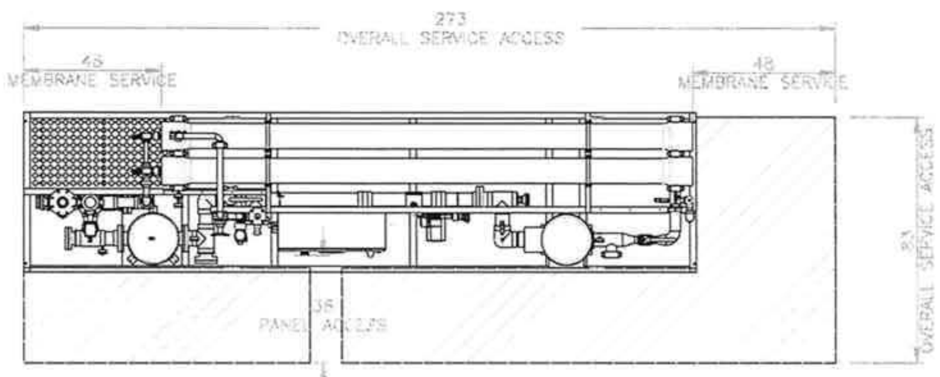
STD: BORDER–1101–11X17B

INTL REF:

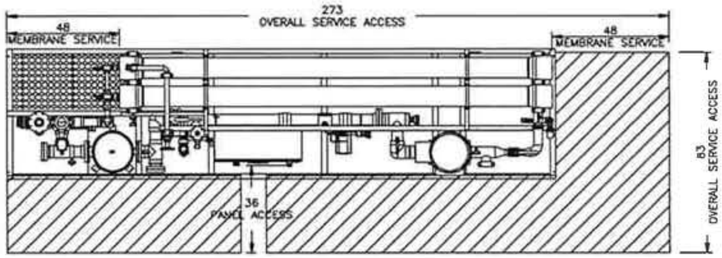
= 1" AT PLOT SCALE

STD: BORDER-1101-11X17B | INTL REF: | = 1" AT PLOT SCALE

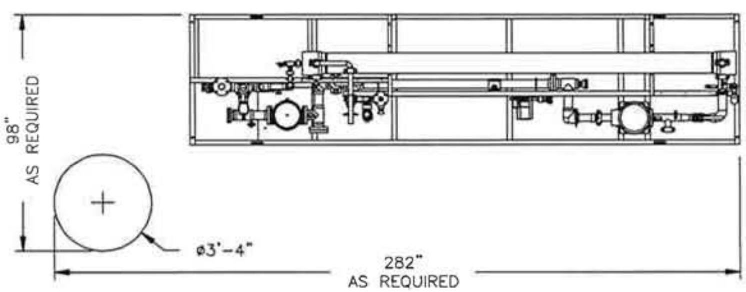




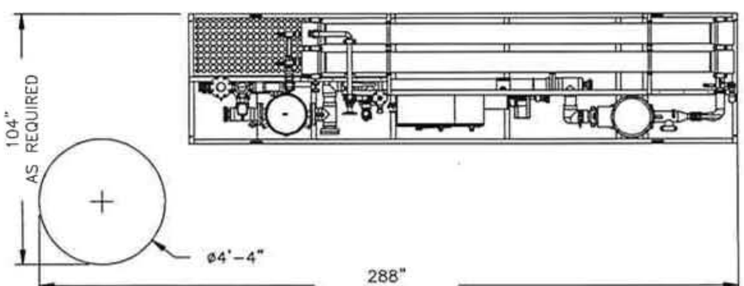
SIEMENS



NORMAL SERVICE ACCESS REQUIREMENT
(ALL MODELS)



M84-024 CIP ACCESS REQUIREMENT



M84-036 & M84-048 CIP ACCESS REQUIREMENT

STD: BORDER-1101-11X17B

INTL REF:

= 1" AT PLOT SCALE

REV	DESCRIPTION	DATE	DWN	CHKD	APVD	ECN

DESIGNER	DATE
COS	4-16-07
CHECKER	DATE
ENGINEER	DATE
MANAGER	DATE
FILE:	
SCALE: NTS	

TITLE VANTAGE M84 MEMBRANE SYSTEM
NANOFILTRATION/REVERSE OSMOSIS
GENERAL ACCESS REQUIREMENTS

CLIENT

SIEMENS Water Technologies
Ames, IA
515-268-8400

PROJECT	CODE	DRAWING	SHEET	REV
		M84-CIP-01	1 OF 1	

Water Technologies

Vantage™ M83 Reverse Osmosis Units

The Clear Advantage In Membrane Systems

SIEMENS

Vantage™ M83 units are packaged single-pass 8-inch reverse osmosis units are designed for a variety of applications requiring high quality equipment with a fast delivery and competitive price. These pre-engineered, pre-assembled and factory tested units minimize installation and start-up time. With simple utility connections and easy to set up controls, the unit is ready for quick on-line service.

The Vantage™ M83 unit comes with a user friendly touch screen Human Machine Interface (HMI), Variable Frequency Drive (VFD) for flow control, built in Clean In Place (CIP) function, and pH/ORP monitoring.

The system features an "On-Board" integrated cleaning system (CIP) initiated through the HMI. The CIP system includes plumbing to the on-skid RO cartridge filter housing and VFD controlled pump along with the factory supplied valves, hoses, and a polyethylene CIP tank (off-skid).

VANTAGE™ M83 UNIT BENEFITS:

- Compact footprint saves valuable floor space
- Quick equipment delivery keeps project moving fast
- Clean in place connections maximize system serviceability
- Comprehensive factory testing performed at our ISO9001 certified facility
- Optional Filmtec's iLEC® interlocking endcaps, an innovative element coupling technology that significantly enhances the performance of RO systems

STANDARD M83 UNIT FEATURES:

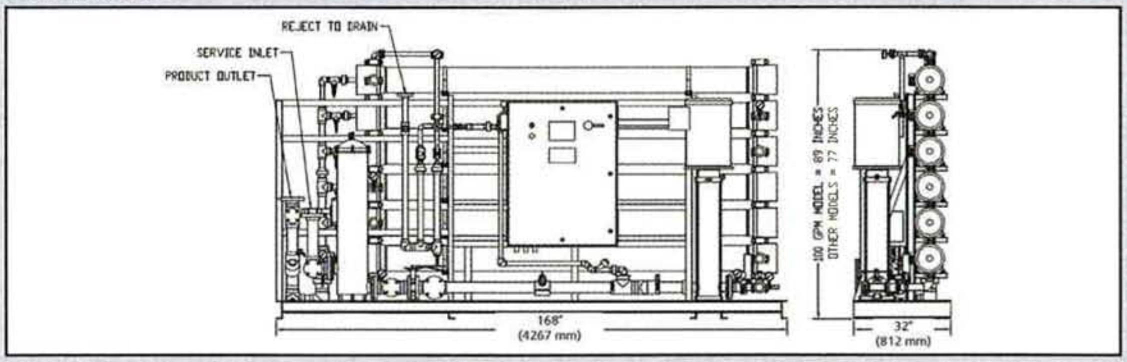
- Choice of *brackish water, low energy* TFC, or nanofilteration membranes (400 ft^2) to ensure optimum water quality
- High pressure 316 stainless steel vertical multi-stage feed pump
- ASME Code FRP, RO pressure vessels with pressure relief protection
- PVC low pressure feed, product and reject piping, 316L stainless steel high pressure piping
- Urethane coated carbon steel frame rated for Seismic Zone 4 anchorage
- Dry contacts are provided for chemical feed, pre-treatment equipment, storage tank levels, and pressure switches
- All alarm and shut down conditions are indicated on the control interface

Specifications

Model No.**	Flow Rate Specifications GPM Nominal (m³/hr)				Vessel Staging	Membrane/ Vessel	Membrane Quantity	Customer Connection Specifications			Utility Requirements***			Approx. Shipping Weight lb (kg)
	Product*	Feed	Reject	Recycle				Feed	Product	Reject	High Voltage Service	High Voltage FLA	Pump HP	
M83R006	25(5.7)	33(7.5)	8(1.8)	10(2.3)	1:1	3	6	2"	1.5"	1.5"	480 VAC 3ph	16	10	2900 (1315)
M83R009	37(8.4)	49(11.1)	12(2.7)	5(1.1)	1:1:1	3	9	2"	1.5"	1.5"	480 VAC 3ph	29	20	3175 (1440)
M83R012	50(11.4)	67(15.2)	17(3.9)	5(1.1)	2:1:1	3	12	2"	2"	1.5"	480 VAC 3ph	36	20	3450 (1565)
M83R015	62(14.1)	83(18.9)	21(4.8)	3(0.7)	2:2:1	3	15	3"	2"	1.5"	480 VAC 3ph	36	25	3725 (1690)
M83R018	75(17.0)	100(27.7)	25(5.7)	3(0.7)	3:2:1	3	18	3"	3"	1.5"	480 VAC 3ph	42	30	4000 (1814)

*Product flow rates are based on equipment design parameters listed below. Product flow rates may not be appropriate for other feed waters.
**The 8 designates 8" housing, the 3 designates 3 elements in length, and the R0XX designates the nominal design product flow rate at 65°F (18.3°C).
***Additional voltage options are available. Refer to equipment specifications.

Dimensions



Model Features

Component	Description
Controls	Siemens PLC & HMI
Inputs/Outputs	Discrete 24 point (14 input/ 10 output)
I/O Expansion Capability	Yes
Communication Port	RS485
Remote Monitoring/Communications*	Optional Modules
Flow Monitoring	Paddlewheel (feed/reject) Rotometer (recycle)
Conductivity	Signet Multiparameter
Auto-Flush (Standby)	Yes
Visual/Audible Alarm	Yes
Single Power Drop (480 VAC)	Yes
304LSS Pre-Filter Housing	Yes
Variable Frequency Drive (VFD) Pump	Yes
On-Board CIP (Tank off-skid)	Yes
ORP/pH with alarms	Yes
Low Energy Membranes (Cold Water)	Optional
Product Divert Kit	Optional

*Additional communication modules and remote monitoring capabilities available upon request.

Design Parameters:

Feed Water Source	Well or pretreated
Maximum Turbidity	1 NTU
Maximum Free Chlorine and/or chloramine	<0.1 PPM
Feed Water Fouling Index	Silt Density Index (SDI) <3
Design Feed Water Temperature	65°F (18.3°C)
Inlet Pressure Requirements	30-60 PSIG
Product Pressure Available	10 PSIG
System Recovery (Nominal)	75%
Performance Basis	A specific computer projection must be run for each individual application.

*Lower temperature may require larger booster pump or use of low energy membranes.
If any of the feed water parameters are not within the limits given, contact Siemens Water Technologies Technical Support.

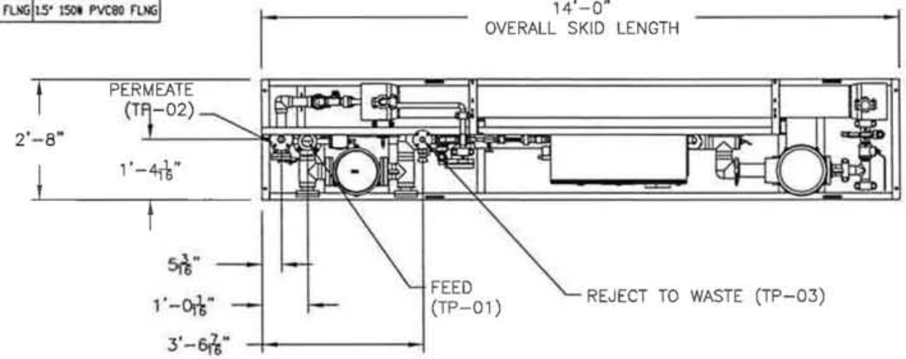
The information provided in this brochure contains merely general descriptions or characteristics of performance which in actual case of use do not always apply as described or which may change as a result of further development of the products. An obligation to provide the respective characteristics shall only exist if expressly agreed in the terms of contract.

Vantage is a trademark of Siemens, its subsidiaries or affiliates.
iLEC is a trademark of FilmTec Corporation, a wholly owned subsidiary of The Dow Chemical Company.

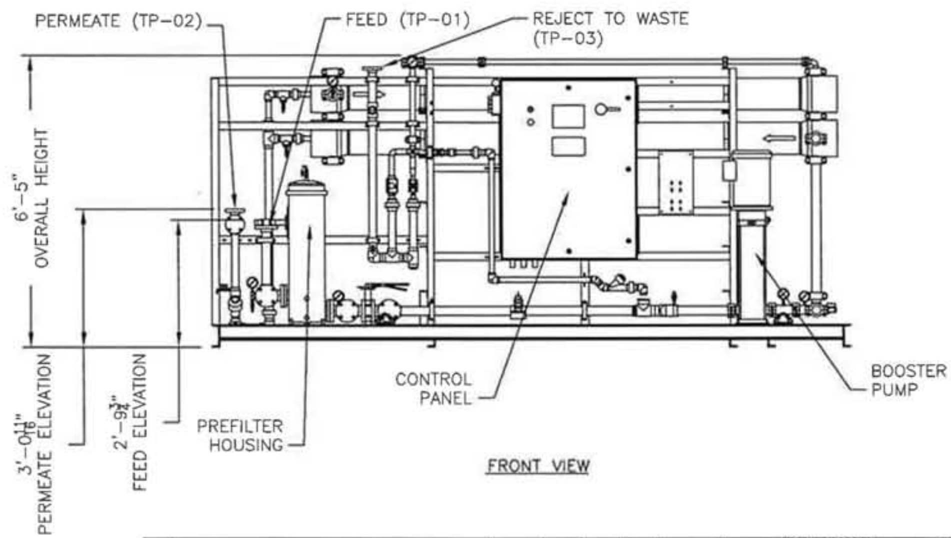
Siemens
Water Technologies
600 Arrasmith Trail
Ames, IA 50010
Phone: 515-268-8400
Fax: 515-268-8500
www.siemens.com/water

CONNECTION TABLE

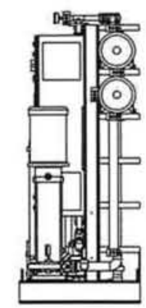
MEMBRANES	TP-01 FEED	TP-02 PRODUCT	TP-03 REJECT
6	2" 150# PVC80 FLNG	1.5" 150# PVC80 FLNG	1.5" 150# PVC80 FLNG



TOP VIEW



FRONT VIEW



RIGHT SIDE VIEW

= 1" AT PLOT SCALE

INTL REF:

STD: BORDER-1101-11X17B

REV	DESCRIPTION	DATE	DWN	CHKD	APVD	ECN

COMPANY CONFIDENTIAL

DESIGNER: CDS DATE: 4-16-07
CHECKER DATE
ENGINEER DATE
MANAGER DATE
FILE:
SCALE: 3/8"-1'-0"

TITLE: VANTAGE M83 MEMBRANE SYSTEM
NANOFILTRATION/REVERSE OSMOSIS
MODEL: M83-006 1:1 3M ARRAY

CLIENT

SIEMENS Water Technologies
Ames, IA
515-268-8400

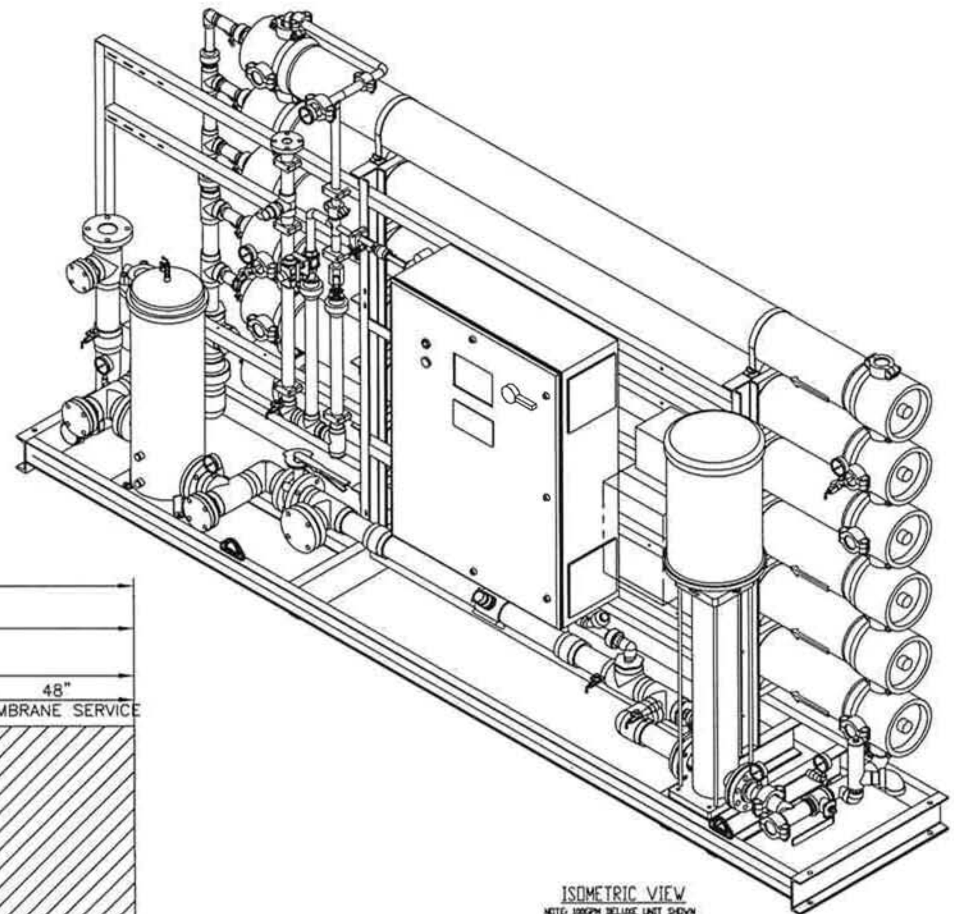
PROJECT	CODE	DRAWING	SHEET	REV
		M83-006-01	1 OF 1	

NOTES:

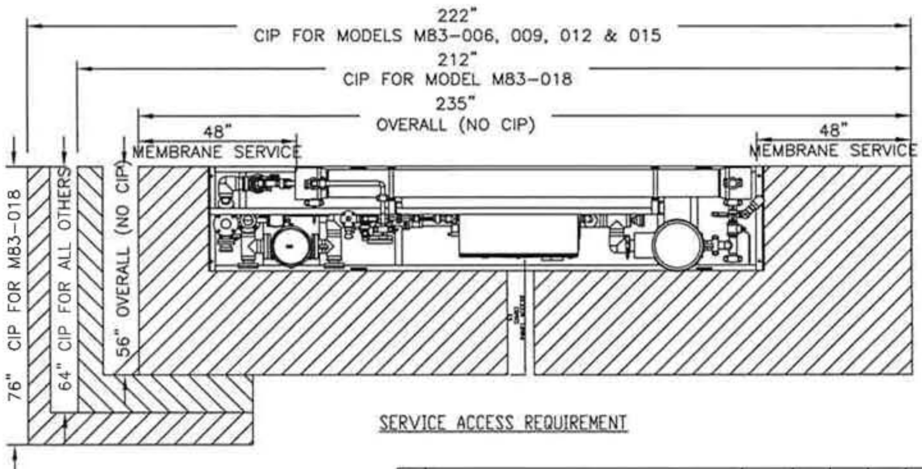
1. ALL DIMENSIONS ARE IN INCHES +/- 1/2"
2. ALL WEIGHTS ASSOCIATED WITH GENERAL ARRANGEMENT DRAWINGS ARE NOMINAL.
3. TAGS TO BE LAMICOID. HANG WITH TIE-WRAPS.
4. BOLT HOLE PATTERN OF FLANGES TO STRADDLE PRINCIPLE CENTERLINE OF PIPE.
5. ALL TUBING TO BE PE.
6. ALL FLANGE GASKETS TO BE EPDM UNLESS OTHERWISE NOTED.
7. ALL MOUNTING HARDWARE TO BE ZINC PLATED CARBON STEEL.
8. FLEXIBLE CONDUIT TO BE USED BETWEEN PUMP AND PANEL, S.O. CABLE FOR ALL OTHER.
9. PRESSURE TEST ALL PNEUMATIC TUBING TO 90psi.
10. STATICALLY LEAK TEST TO 100psi.

GENERAL ARRANGEMENT
M83
REVERSE OSMOSIS SYSTEMS

	30 GPM	45 GPM	60 GPM	75 GPM	100 GPM
SKID LENGTH	168 inches				
SKID WIDTH	32 inches				
SKID HEIGHT	77 inches				89 inches
DELUXE (DRY WEIGHT INCLUDES CIP)					
WEIGHT DRY	2,950 lbs	3,050 lbs	3,250 lbs	3,500 lbs	3,700 lbs
WEIGHT WET OPERATING	4,400 lbs	4,600lbs	4,800 lbs	5,000 lbs	5,200 lbs



ISOMETRIC VIEW



SERVICE ACCESS REQUIREMENT

REV	DESCRIPTION	DATE	DWN	CHKD	APVD	ECN

DESIGNER: COS | DATE: 4-16-07
CHECKER | DATE
ENGINEER | DATE
MANAGER | DATE
FILE:
SCALE: NTS

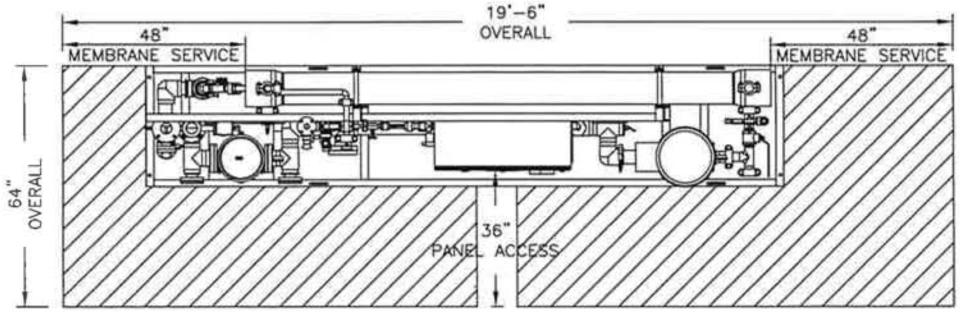
TITLE: VANTAGE M83 MEMBRANE SYSTEM NANOFILTRATION/REVERSE OSMOSIS GENERAL INFORMATION

CLIENT

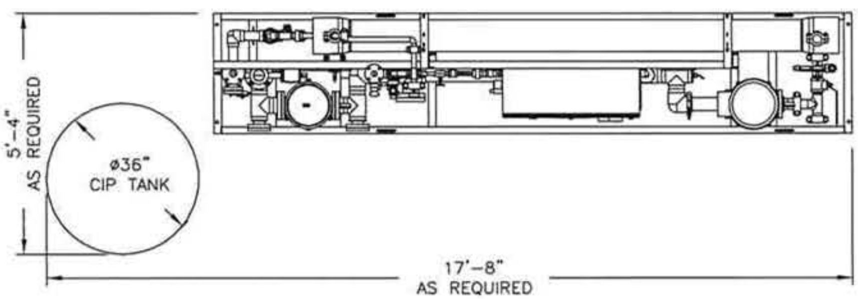
SIEMENS Water Technologies
Ames, IA
515-268-8400

PROJECT	CODE	DRAWING	SHEET	REV
		M83-GEN-01	1 OF 1	

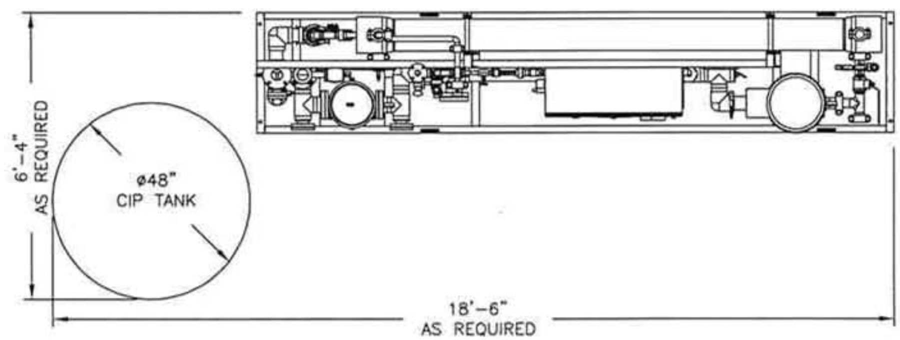
STD: BORDER-1101-11X17B | INTL REF: | = 1" AT PLOT SCALE



SERVICE ACCESS REQUIREMENT
(ALL MODELS)



M83-006, M83-009, M83-012 & M83-015 CIP ACCESS REQUIREMENT



M83-018 CIP ACCESS REQUIREMENT

REV	DESCRIPTION	DATE	DWN	CHKD	APVD	ECN

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CHECKER	DATE
ENGINEER	DATE
MANAGER	DATE
FILE:	
SCALE: 3/8"=1'-0"	

TITLE VANTAGE M83 MEMBRANE SYSTEM
NANOFILTRATION/REVERSE OSMOSIS
GENERAL ACCESS REQUIREMENTS

CLIENT

SIEMENS Water Technologies
Ames, IA
515-268-8400

PROJECT	CODE	DRAWING	SHEET	REV
		M83-CIP-01	1 OF 1	

STD: BORDER-1101-11X17B

INTL REF:

= 1" AT PLOT SCALE

EQUIPMENT LIST
VANTAGE™ M83 REVERSE OSMOSIS SYSTEM

Confidential URS, VA Secondary System

Equipment Supplied by Siemens Water Technologies

One (1) Vantage M83 Reverse Osmosis Membrane Skid: Model M83-006, rated for 25 GPM permeate. The skid would be in the 1:1 configuration using 8" diameter x 3 membrane long 3M FRP pressure vessels. The operating weight of the skid is approximately 4,400 lbs. The skid measures 14 feet 0 inches long by 2 feet 8 inches wide by 6 feet 5 inches high, outside dimensions. The skid is painted steel construction and has the following prepiped and installed on the skid:

FRP Membrane Vessels: Two (2) Protec model PRO-8-300 FRP membrane vessels arranged in a 1:1 configuration for housing the membrane elements. The vessels are rated for 300 psi, are ASME code stamped and are NSF 61 approved for contact with potable water. Connections to the vessels are stainless steel grooved side entry type for feed and concentrate connections.

Piping: High pressure skid piping will be constructed from welded, schedule 10 Type 316L stainless steel. Low pressure piping will be constructed from schedule 80 PVC.

Prefilter Housing: One (1) prefilter housing constructed of 304L stainless steel. The size of the prefilter shall be 4Rx3H.

Booster Pump: One (1) with stainless steel housing and 10 hp, 460V, 3ph, 60 Hz TEFC motor. The pump is a Grundfos CRN Series.

Automatic Control Valves:

Inlet Valve: One (1) per skid, butterfly type with pneumatic actuator.

Auto Flush Valve: One (1) per skid, ball type, 316 SS, with pneumatic actuator.

Product Isolation Valve: One (1) per skid, butterfly type, with fail-to-close pneumatic actuator.

Product to Drain Valve: One (1) per skid, butterfly type, with fail-to-open pneumatic actuator.

Manual Valves:

Pump Throttling Valve: One (1) per skid, ball type, 316 SS, with locking manual actuator.

Reject Throttling Valve: One (1) per skid, globe valve, 316 SS, with manual actuator.

Reject Recycle Valve: One (1) per skid, globe type, 316 SS, with manual actuator.

Miscellaneous Valves:

Sample Valves: One (1) set ¼" PVC sample valves for feed water, product connections on each pressure vessel and a combined product sample.

Sample Valve: One (1) ¼" 316 stainless steel plug valve for high pressure feed sampling.

Pressure Relief: One (1) per skid, relief valve with ASME certified carbon steel body with stainless steel trim and Viton soft seat.

Controls:

Skid Control Panel: One (1) skid mounted NEMA 12 enclosure per skid, with Siemens operator interface terminal, relays, lights, and switches controlled by a Siemens programmable controller. The panel will have discrete interlocks for integration with additional skids, chemical prefeed and external run and stop signals. An HMI will be provided consisting of a Siemens model TP177A with 6" diagonal touch screen.

Variable Frequency Drive (VFD): One (1) solid state variable frequency motor drive for the booster pump continuously adjustable over a range of 10 to 1. The VFD shall be mounted in the instrument control panel.

Pressure Gauges: Pressure gauges are 316 stainless steel bourdon tube and socket type with glycerin filled dial. Pressure gauges shall be provided for:

- cartridge prefilter inlet
- prefilter outlet
- booster pump discharge
- membrane housing inlet
- first stage permeate pressure prior to orifice plate
- concentrate outlet from each of stage 1, 2 and 3
- combined permeate

Pressure Switches: Two (2) per skid, one low pressure and one high pressure. The low pressure switch is adjustable between 4 and 50 psig. The high pressure switch is adjustable between 30 and 600 psig. Units have a BUNA N primary wetted diaphragm and a 1/4" 316 stainless steel wrought casing.

Conductivity Sensor: One (1) per skid, panel mounted in a NEMA 12 housing, monitor will be Signet 8900 Series Multi-parameter.

Conductivity Probe: Two (2) per skid, with 316 stainless steel electrodes, and PFM O-rings, rated to 100 psig. Probes will be Signet 2850 Series.

Flow Sensors: Two (2) per skid, for feed and reject flow monitoring and control. The sensors are paddlewheel style, polypropylene construction, and mount in a T fitting in the process piping. The flow sensor is Signet 2536 series.

pH and ORP Monitor: One (1) per skid, panel mounted in a NEMA 12 housing. Monitor will be Signet 8900 Series Multi-parameter.

pH Probe: One (1) per skid, pH probe is Signet model 2774

ORP Probe: One (1) per skid, ORP probe is Signet model 2775.

The Following Items are Shipped Loose for Field Assembly:

Seventy Two (72) – Membrane Elements: Model BW30-400/34i Reverse Osmosis membrane elements as manufactured by DOW FILMTEC™.

Eight (8) – Cartridge Prefilters: 30" long for field installation in the prefilter housing. This quantity is sufficient for two complete sets of cartridge filters.

One (1) – Chemical Clean-in-Place (CIP) Tank: The CIP will be constructed of polyethylene and will be 36" diameter with a nominal capacity of 200 gallons. The tank will be supplied with four (4) PVC bulkhead fittings with PVC connections to allow flow into and out of the tank from the Vantage skid during cleaning. An additional bulkhead fitting and PVC ball valve will be supplied for tank draining.

One (1) – CIP Hose and Recirculation Valve Kit: for connection of above tank to the Vantage skid during CIP operation. The hoses shall be reinforced flexible hose with appropriate end connections for attachment to the skid.

One (1) – Set Antiscalant Feed Equipment: consisting of the following:

Chemical Feed Pump: One (1) per skid high-precision diaphragm type, on/off control by control panel with rate set from integral interface on pump. Pump will be Grundfos DME series with maximum capacity of 0.66 gph. Pump will be 120V, 1ph, 60 Hz service. Pump will be supplied with alarm wire and communication wire. Dose rate will be manually set from the pump, the pump will be turned on and off from skid control panel.

Chemical Day Storage Tank: One (1) 53 gallon Polyethylene Tank.

Suction Line: One (1) rigid suction tube with low level switch assembly.

Miscellaneous Hardware: Additional hardware consisting of pump wall mounting bracket, priming kit, inlet valve and pulsation dampener will be provided.

One (1) Air Compressor Pack: For Operation of the filter function valves consisting of two Quincy air compressors set for lead/lag, 4.4 CFM FAD @ 80 psig with ½ hp, 230 VAC, 3 ph, 60 Hz, 1750 rpm, open drip proof drive motors, mounted on a common 30 gallon ASME code receiver (optional for additional cost: TEFC with NEMA 4 enclosure).
Accessories include:

- V-belt drive
- enclosed belt guard
- inlet filter/silencer air filter with spare cartridge

- automatic adjustable pressure switches
- ASME safety relief valve on air receiver
- in-tank type check valve
- compressor vibration mounts
- manual tank drain
- 120V (mounted) electronic type automatic tank drain (contractor to provide wall outlet at proper location)
- 120V (mounted) refrigerated air dryer (contractor to provide wall outlet at proper location)
- compressed air filter with spare filter cartridge
- single-supply alternator/starter panel with control circuit transformer and test-off-auto selector switches in a NEMA 1 enclosure with IEC magnetic starters.
- vibration isolation pads
- manufacturer's standard paint system

(Note to Proposals Specialist: Additional items requiring an air supply, such as modulating valves, may require a larger compressor.)

Owners Manuals: six (6), with installation, operating, and maintenance instructions, drawings and manufacturers' bulletins. Information contained on CD's.

Technical Direction: Six (6) days, for installation supervision, plant start-up, and operator training in a total of three (3) trips to the jobsite.

NOTE: Availability of equipment components specified may dictate substitutions of equal quality at the discretion of Siemens Water Technologies. Interconnecting wiring and piping is not included in the equipment supplied. Chemicals for startup are not included.

Installation is by others.

Equipment Specifications

Vantage™ M83 Series Reverse Osmosis Water Treatment System

Confidential URS, VA Secondary System

Section 1 - GENERAL

1.01 WORK INCLUDED:

A. This section of the specification covers the furnishing and installation of a Vantage M83 Series Reverse Osmosis treatment skid and appurtenances as shown on the drawings and as specified herein.

B. The following items are a part of this section and shall be furnished by one manufacturer to ensure a properly designed and integrated water treatment system.

1. Factory built structural carbon steel skid with urethane coating.

2. Membrane elements in fiberglass pressure vessels, high pressure pump, prefilter housing, stainless steel high pressure piping, PVC low pressure piping, automatic process valves, and the system control panel all mounted on the above skid.

3. Cleaning solution tank and clean-in-place (CIP) hose kit.

4. Instrumentation and control system designed to automatically control flow to the membranes based on a product flow setpoint input by the operator, automatically control CIP flow, prevent unacceptable water from being directed to downstream unit operations and to prevent damage to the membranes from over pressure or low reject flow rates.

1.02 QUALITY ASSURANCE:

A. The treatment system shall be furnished by a single manufacturer who shall comply with the following:

The manufacturer supplying equipment for this specification shall furnish proof of a minimum of 100 installations and 10 years of manufacturing treatment systems similar to the specified system.

In addition to normal start-up service, the systems detailed above shall be fully operational including the demonstration of a fully automated control sequence for the flush of the system and prevention of over-pressure of the membranes.

Membrane elements, housings and piping of the packaged treatment system shall be certified to NSF® Standard 61.

1.03 SUBSTITUTIONS:

A. Manufacturers other than that which is specified and/or not meeting EVERY provision of the specification shall be required to submit a complete and detailed PRE-QUALIFICATION PACKAGE to the engineer at least fifteen (15) days prior to the bid. Any PRE-QUALIFICATION PACKAGE must contain as a minimum:

1 Detailed Layout Drawings.
2. Detailed component specifications and catalog cut sheets.
3. Process P&ID Drawing.
4. Detailed list of variations required from original design, referencing appropriate sections of the specifications and locations on the drawings.
5. History of the process offered, including pilot data and experience.
6. Installation list including actual scale-up data from pilot testing to full scale plant operation, also including plant contact names and telephone numbers.
7. All other data as required in Quality Assurance section above.
8. A detailed System Performance Guarantee with appropriate remedies for non-performance.

B. Manufacturers qualifying will be recognized by addendum a minimum of five (5) days prior to the bid. Contractors shall include all costs associated with any redesign required with their bid.

C. Manufacturers not meeting this specification in EVERY WAY or are not PRE-QUALIFIED and approved by the engineer as outlined above will not be considered for use on this project.

Section 2 - PRODUCTS

2.01 GENERAL

A. All component parts and equipment utilized in the pre-engineered water treatment system shall be furnished as a complete integrated system by one manufacturer. This specification describes a Vantage Series M83 Water Treatment System as manufactured by Siemens Water Technologies.

Furnish and install one (1) identical skid capable of producing 25 GPM* permeate. Total plant design flow rate is 25 GPM. The pre-engineered treatment system shall be Vantage Model M83-006.

*** This is based on a nominal design flux of 15 gfd, which is typical for well water or pretreated surface water with an SDI of less than 5.**

2.02 REVERSE OSMOSIS SKID

A. The configuration of the system shall be multi-stage, single pass, with a design system recovery of 75%. The skid shall be staged in a 1:1 configuration and shall utilize 3M vessels.

B. Influent temperature shall be greater than 70°F, have an SDI less than 5 and have undetectable free chlorine and/or chloramines.

C. Skid Fabrication

The Vantage Series Reverse Osmosis System shall be mounted on a rectangular steel skid. Major components shall be of the size and configuration shown on the drawings and fabricated of ASTM A36 structural carbon steel and ASTM A500 structural carbon steel tubing. Surface shall be prepared using an SSPC SP-6 commercial blast and coated with 6-9 mils DFT urethane. The skid frame shall extend to the full footprint of the skid.

All external connections shall be provided as flanged connections as shown in the drawings.

1. High pressure piping on the skid (greater than 90 psi) shall be welded Schedule 10, 316L stainless steel.
2. Low pressure piping shall be Schedule 80 PVC conforming to ASTM-D-1784, socket welded and flanged (threaded for instrumentation).
3. Gaskets shall be 1/8" thick EPDM, ring or full face.

D. Membrane and Pressure Vessels

1. Membranes shall be thin film composite, 8" spiral wound and shall come in a standard 40" length. The membranes shall be DOW FILMTEC™ BW30-400/34i.
2. Each membrane element shall have an active surface area of 400 ft^2.
3. The system shall be designed for a flux of 15 gallons/ft^2/day (GFD).
4. Membrane elements shall be housed in a fiberglass reinforced plastic (FRP) pressure vessel rated to 300 psig. Each housing shall be 8" diameter, and have grooved 1 ½" side entry connections. Housings shall be ASME code stamped. Membrane housings shall be Protec™ Pro-8-300 Series. Pressure relief must also be provided, as per ASME and the code stamped housing.

E. Booster Pump

1. A multistage centrifugal pump shall be mounted on each skid for pressurizing the water to the RO system. Each pump will be designed to provide 33 gpm of water at a pressure of 200 psig.
2. Pump housing shall be constructed of 316 stainless steel. Pump impellers shall be 316 stainless steel.
3. Pump motor shall be 10 hp, TEFC, 460 volt, 3 phase, 60 hz. Motor shall have Class F insulation, be UL recognized, and have a service factor of 1.15.

4. Pump shall be Grundfos CRN series.

F. Plant Process Valves

The treatment plant manufacturer shall provide all process control valves in sizes shown on the drawings.

1. There shall be automatic control valves with pneumatic actuators for the skid including:

   One inlet valve, wafer butterfly style, with EPDM seats.

   One auto flush valve, which shall be a ball valve with 316 stainless steel body, ball and stem.

   One product isolation valve, wafer butterfly style, with EPDM seats. Actuator shall be fail-to-close.

   One product to drain valve, wafer butterfly style, with EPDM seats. Actuator shall be fail-to-open.

2. There shall be adequate manual valves on the skid as follows:

   One pump throttling valve, which shall be a ball valve with 316 stainless steel body, ball and stem and locking manual actuator.

   One reject throttling valve, which shall be a 316 stainless steel globe valve with manual actuator.

   One lot ¼" PVC sample valves for feed water, product connections on each pressure vessel and a combined product sample.

   One ¼" 316 stainless steel plug valve for high pressure feed sampling.

   One ¼" PVC valve for low pressure feed sampling

3. There shall be a pressure relief valve with ASME certified carbon steel body with stainless steel trim and Viton soft seat on the skid on both the feed to the membrane housings and on the product piping.

   Gauges shall be isolated from the process stream by ¼" stainless steel threaded plug valves.

G. System Prefilters

1. The skid shall be provided with one multi-element prefilter for removal of suspended solids in the influent water.

2. The filter elements shall be non-shedding polypropylene with a nominal opening of 5 microns.

3. The filter housing shall be 304L stainless steel and shall have a 150 psig non-code pressure rating. The housing shall be sized for no more than 5 gpm per 10" filter equivalent.

2.03 CLEAN-IN-PLACE SYSTEM

A. The cleaning system pump, filter and controls will be fully integrated into the Reverse Osmosis skid. The only additional CIP components that shall be required will consist of a chemical makeup tank and a hose kit.

1. The CIP Chemical Makeup Tank shall have a capacity of 200 gallons and shall be 36" diameter. The tank will be installed by the contractor near the membrane skid as shown on the project plans. It shall be polyethylene construction and use PVC bulkhead fittings for the connection points.

2. A hose kit shall be provided by the manufacturer with sufficient hoses and connection hardware to make the CIP system operational when required. The hose kit shall also be supplied with a bypass valve for mixing of CIP solution.

2.04 AIR COMPRESSOR

A. Manufacturer shall furnish one compressor pack consisting of two (2) single stage automatic air compressors with one ASME code, 30 gallon horizontal receiver, motor, load-less starting, pressure gauge, safety valve, crankcase drain, intake air filter, pressure switch, manual and automatic receiver blowdown, continuously running refrigeration type air dryer, dryer moisture trap with manual and automatic blowdown, shut off valve and compressed air filter with spare cartridge. Compressor pack to be completely shop assembled with dryer. Refrigeration dryer shall be 120 volt single phase, contractor to provide wall outlet at proper location for dryer. Compressors shall have a piston displacement of 4.4 cfm FAD and driven by ½ hp, 230 volt, 3 phase, 60 Hz drive motors. Compressors shall be alternating with lead compressor switch setting 70 - 90 psig, lag compressor switch setting 60 - 80 psig. Capacity of a single compressor shall be sufficient for normal operation of pneumatic valves. An IEC specific purpose motor starter assembly is to be provided as part of the compressor pack and is to be installed by the contractor.

2.05 ANTISCALANT FEED SYSTEM

A. Manufacturer shall furnish chemical dosing equipment for the introduction of antiscalant to the system feedwater. It shall consist of a metering pump, calibration column, tubing and injection quill.

1. The pump will be field mounted by others on the chemical storage container for the antiscalant. The pump will be Grundfos DME series, capable of a maximum of 0.66 gph, with a turndown capability of 1000:1. The pump rate shall be manually set by the operator, but pump run status will be controlled by the skid control system.

Section 3 - PLANT CONTROL

3.01 PLANT CONTROL - GENERAL

A PLC based control panel shall be supplied to monitor and control the Vantage Series System. The PLC based system shall be capable of operating in an automatic mode completely autonomously. The control panel shall provide automatic starting and stopping of the Treatment System, based on clearwell level or device failure.

A. The control system shall be supplied complete including all necessary equipment to provide a complete and functioning system. The components shall include PLC, human machine interface (HMI), control relays, push-buttons & selector switches, indicating lights, power supplies, fuses and terminal strips. The PLC shall have an Ethernet™ port, enabling interface to a SCADA System or, Master Control Panel or to other membrane skids.

3.02 TREATMENT SYSTEM CONTROL PANEL

A. The treatment system controls shall consist of Local Control Panel (LCP) on the skid. The control panel shall be supplied in a NEMA 4/12 steel enclosure suitable for indoor use. The front panel of the cabinet shall contain all push buttons, and Human Machine Interface as detailed within this specification. The internal portion of the cabinet shall contain all rail-mounted PLC equipment, power supply, processor, and interface cards. Relays and terminals shall also be contained within the cabinet. The PLC subsystem shall be Siemens S7/200 model CPU224XP. Terminal strips for all field wiring shall be furnished within the panel.

B. Fuses and simplex outlet shall be provided within the panel.

C. All digital outputs shall be provided with relay contacts.

3.03 VARIABLE FREQUENCY DRIVE (VFD)

A. The drive for the booster pump shall consist of an adjustable frequency AC motor controller.

B. The VFD shall provide continuously adjustable settings over a range of not less than 10 to 1. The controller shall be solid state.

C. The VFD shall be mounted in the instrument control panel.

3.04 DEVICES FOR OPERATOR INTERFACE

External face mounted devices for operator interface shall be as follows:

A. Human Machine Interface

The HMI shall be touch screen type with 6 in. diagonal monochrome display. The HMI shall be fully programmed with shall allow the operator to view and modify system variables within the PLC. It shall allow the operator to set process flow rate, run status and CIP operation through the use of virtual switches/pushbuttons. The HMI shall be Siemens model TP177A.

B. Pushbuttons

1. Pushbuttons shall be Siemens. Panel Mounted Pushbuttons shall be provided to perform the following functionality:

    a. Emergency Stop

3.05 PROCESS CONTROL SYSTEM FUNCTIONS

A. The LCP shall automatically control the treatment process.

B. The HMI shall provide operator adjustable set points for the following parameters:

1. RO selector Man/Auto
2. RO selector Start/Stop
3. Permeate Flow Rate Setpoint
4. Auto flush selector On/Off
5. Alarm silence
6. Alarm reset
7. CIP Start/Stop
8. CIP Flow rate set

C. The PLC shall, via the HMI, provide the following status indicators at a minimum:

1. Feed flow, reject flow, product flow, % recovery
2. Total run time
3. RO operating mode
4. Pump status
5. Inlet, reject, product to tank, product to drain valve status
6. Pretreatment lockout
7. Storage tank full (Standby – no call for water)

D. The following alarm conditions shall be monitored by LCP. All alarms shall be visible via the HMI Display.

1. Low quality product
2. Low feed pressure
3. Low reject flow
4. High product flow
5. Low feed flow
6. High pump discharge pressure
7. High feed water temperature
8. ORP alarm
9. Emergency Stop
10. VFD fault
11. CIP low flow

E. The following additional features shall be provided in the LCP.

1. Alarm horn and alarm pilot light
2. Chemical injection pump terminals
3. Auxiliary contacts for pump running & fault

3.06 INSTRUMENTS

A. Pressure Sensors and Gauges

1. Pressure gauges shall be 316 stainless steel bourdon tube and socket with a 63mm glycerin filled dial. Pressure gauges shall be Ashcroft series 1009.

2. Pressure switches shall be provided for low feed pressure and high discharge pressure. The pressure switches shall have a 15 amp switching power at 120 volts. The low pressure switch shall have an adjustable range between 4 and 50 psig. The high pressure switch shall have an adjustable range between 30 and 600 psig. Units shall have a BUNA N primary wetted diaphragm and a 1/8" 316 stainless steel wrought casing.

B. Conductivity Sensors

1. Conductivity shall be continuously monitored by the control system. The monitor shall be NEMA 4 and be panel mounted. Conductivity monitors shall be Signet 8900 Series Multi-parameter.

2. Conductivity probes shall have 316 stainless steel electrodes, 316 stainless steel body, and FPM O-rings. Units shall thread into a ¾" NPT connection and be rated to 100 psig. Probes shall be Signet 2850 Series.

C. Flow Sensors/Indicators

1. Each skid will be equipped with two flow sensors for feed and reject flow monitoring and control. The sensors shall be paddlewheel style and shall be polypropylene and mount in a T fitting in the process piping. The flow sensor will be Signet 2536 series.

2. Each skid shall have an acrylic rotameter for flow determination in the product blend line. The rotameter shall have 316 stainless steel end connections. The rotameter shall be manufactured by King Products.

D. PH/ORP Sensors

1. PH and ORP of the raw water shall be continuously monitored by the control system. A sample shall be taken from a high pressure point, fed to the sensors, and returned to a low pressure point so that no waste stream is generated from the sampling. The monitor shall be NEMA 4 and be panel mounted. The monitor shall be Signet 8900 Series Multi-parameter.

2. PH probe shall be Signet model 2774 and ORP probe shall be Signet model 2775.

Section 4 - Execution

4.01 DELIVERY OF EQUIPMENT

A. The membrane skids shall be shipped to site as a complete unit with the exception of the blend line and membrane elements, which will be installed on-site by the contractor.

B. The CIP tank and hose kit shall be shipped loose for placement and field installation by others.

4.02 INSTALLATION AND TRAINING

The Vantage Series Reverse Osmosis System shall be installed as shown on the Contract Drawings and specified herein.

The Manufacturer shall inspect the installation of all equipment in this section prior to start-up in order to verify that the equipment has been properly installed and operates properly as a system and individually.

After the equipment has been properly installed, the Manufacturer shall calibrate the equipment with the Owner's operator present.

The Manufacturer shall furnish the service of a competent technical service representative after Contractor's start-up to instruct the Owner's personnel in the operation and maintenance of the equipment.

The Manufacturer's representative shall be present for six (6) days in three (3) trips total to provide services described above.

APPENDIX N
Point of Entry Reverse Osmosis System

APPLIED® SYSTEMS

SERIES AA – 350 TO 1,000 GPD SYSTEMS

STANDARD EQUIPMENT

- Thin Film Composite Membranes
- Stainless Steel Pressure Vessels
- Rotary Vane Brass Pump
- Motor
- 5 Micron Pre-Filter (1)
- 10 Micron Carbon Filters (2)
- Polypropylene Filter Housings (3)
- Automatic inlet feed solenoid valve
- Heavy duty powder coated frame
- Liquid Filled System Pressure Gauges
- Low Pressure Switch
- System control valve
- Recycle control valve
- Polyethylene High Pressure Tubing
- Product Tank Pressure Control ***(Required to turn system on/off with pressurized tank - tank sold separately)***

OPTIONAL EQUIPMENT

- * Pressurized Product Water Storage Tank 40 or 88 Gallon Size
- Stainless Steel Pump
- *Pre-treatment equipment:
  Softener
  Carbon filter
  Multi-media filter

**Recommended Minimum Options*

Model	Capacity		Elements*		Line Sizes (In/Cm)			Dimensions (In/cm)			Approx Shipping Weight (lb/kg)
	GPD	m^3/day	Qty.	Length (In/cm)	Inlet	Perm.	Conc.	Length	Width	Height	
AA-12521-116	350	1.3	1	21/54	.375/1	.375/1	0.25/1	14/36	26/66	20/51	60/26
AA-22521-116	700	2.7	2	21/54	.375/1	.375/1	0.25/1	14/36	26/66	20/51	70/30
AA-32521-116	1000	3.8	3	21/54	.375/1	.375/1	0.25/1	14/36	26/66	20/51	65/21

**Elements are 2.5" (6.4 cm) Diameter*

NOTES

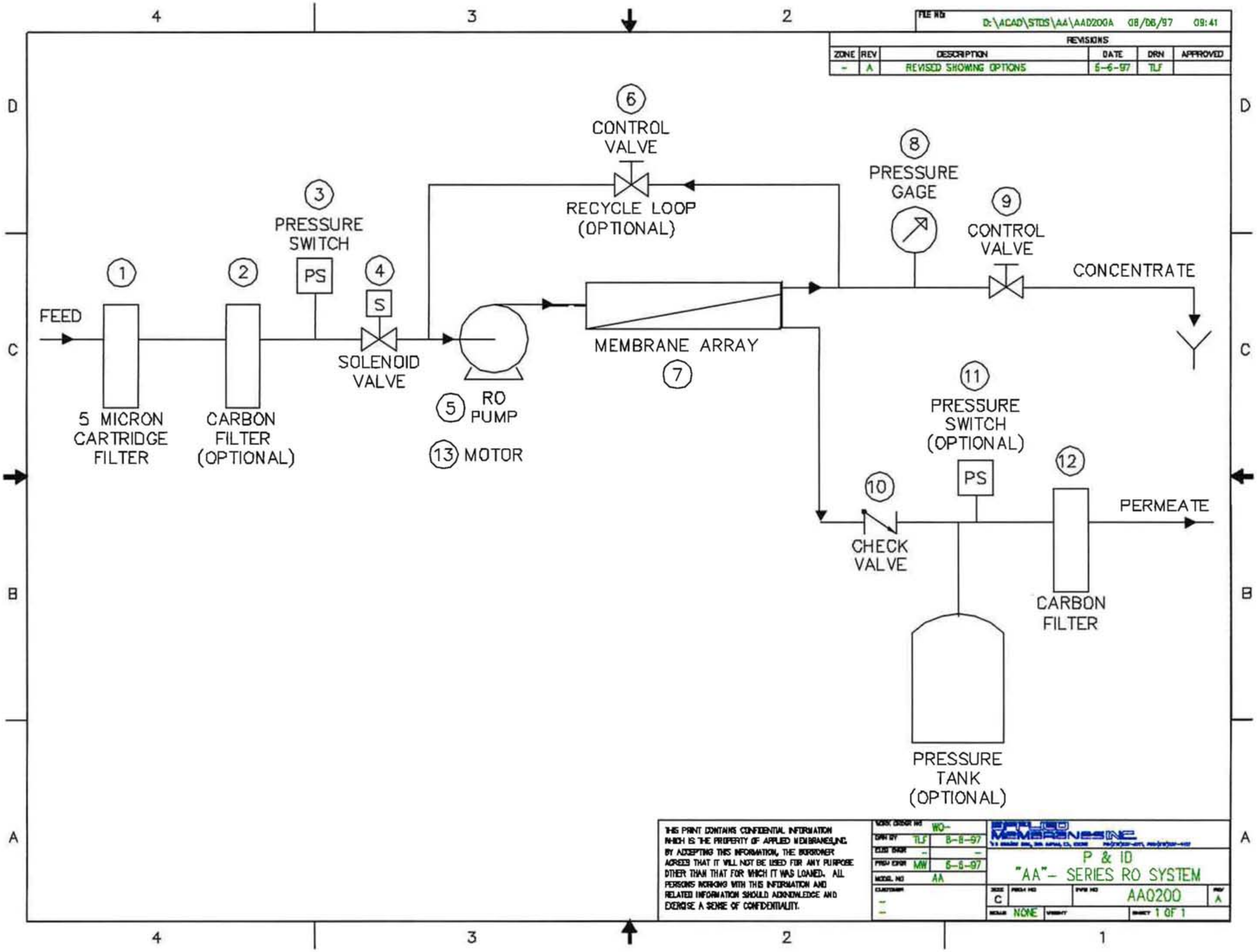
- All dimensions and weights are approximate.
- System must operate with a pressurized storage tank to turn system on/off (quoted separately).
- Systems rated at 77°F (25°C) using 1000 ppm sodium chloride solution and 200 psi pressure. System capacity changes significantly with water temperature. For higher TDS, a water analysis must be supplied and could result in modifications to the system.
- Chlorine must be removed prior to RO system if present in the feed water.
- Water must be pretreated by a softener or antiscalant to avoid scaling the membranes.
- Standard packaging is boxed, crating optional.

ORDERING INFORMATION

Please add our voltage codes to the end of the model number when ordering.
Example: AA-12521-**116** = 110v / 1 ph / 60 hz.

Voltage Codes:
116 = 110v/ 1ph/ 60hz
215 = 220/230v, 1ph, 50hz

Three Phase Not Available



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REVISED SHOWING OPTIONS
6-6-97
TLF
FEED
1
5 MICRON CARTRIDGE FILTER
2
CARBON FILTER (OPTIONAL)
3
PRESSURE SWITCH
PS
4
S
SOLENOID VALVE
5
RO PUMP
13
MOTOR
6
CONTROL VALVE
RECYCLE LOOP (OPTIONAL)
MEMBRANE ARRAY
7
8
PRESSURE GAGE
9
CONTROL VALVE
CONCENTRATE
11
PRESSURE SWITCH (OPTIONAL)
PS
10
CHECK VALVE
12
CARBON FILTER
PERMEATE
PRESSURE TANK (OPTIONAL)
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Industry Leader in RO Expertise and Membrane Applications Since 1983™

APPLIED® SYSTEMS

Complete Reverse Osmosis RO Systems

Series AA

220 to 700 Gallons/Day (0.8 to 2.7m³/Day)

Designed to produce low dissolved solids water from tap or well water, these Reverse Osmosis RO systems use high efficiency reverse osmosis membranes. The product water is used in applications such as restaurants, aquariums, small manufacturing, and a wide variety of other applications.

Series AA RO systems offer a compact design. These economically priced systems are simple to install and operate. When combined with a water softener as pretreatment, they offer a reliable water purification solution.

Scroll to the bottom for additional photographs

Key Features:

- Over 20 years of experience is reflected in our quality
- Compact, Heavy Duty, Powder Coated Frame
- Proven components used throughout the system
- Conservatively engineered for reliable long term performance
- Factory tested to ensure trouble-free operation

STANDARD EQUIPMENT AA RO Systems

- Thin Film Composite Membranes
- Stainless Steel Pressure Vessels
- Rotary Vane Brass Pump
- Motor
- 5 Micron Pre-Filter (1)
- 10 Micron Carbon Filters (2)
- Polypropylene Filter Housings (3)
- Brass Auto Feed Shut-Off
- Heavy duty powder coated frame
- Liquid Filled System Pressure Gauges
- Low Pressure Switch
- Brass Pressure Regulator
- Polyethylene High Pressure Tubing
- Product Tank Pressure Control (turns system off with pressurized tank - tank sold separately)

OPTIONAL EQUIPMENT

- Stainless Steel Pump
- Stainless Steel Back Pressure Regulator
- Pressurized Product Water Storage Tank*
- Tank Level Control for Atmospheric Tank
- Softener*
- Backwashable Pretreatment* – Carbon or Media

in 10, 30, 40 or 88 Gallon Size
- Recycle Loop with Brass Valve
- Crating

**Recommended Minimum Options*

Model	Capacity		Elements (2.5" Dia)		Line sizes (in/cm)			Dimensions, in.(cm)			Approx. Weight (lb/kg)
	GPD	m3/day	Qty	Length (in/cm)	Inlet	Perm	Conc	Length	Width	Height	
AA-12514	220	0.8	1	14/36	.375/1	.375/1	0.25/1	14/36	26/66	20/51	55/24
AA-12521	350	1.3	1	21/54	.375/1	.375/1	0.25/1	14/36	26/66	20/51	60/26
AA-32514	525	2.0	3	14/36	.375/1	.375/1	0.25/1	14/36	26/66	20/51	6521
AA-22521	700	2.7	2	21/54	.375/1	.375/1	0.25/1	14/36	26/66	20/51	70/30

NOTES

- All dimensions and weights are approximate.
- System must operate with a pressurized storage tank to turn system on/off (quoted separately).
- Systems rated at 77°F (25°C) using 1000 ppm sodium chloride solution and 200 psi pressure. System capacity changes significantly with water temperature. For higher TDS, a water analysis must be supplied and could result in modifications to the system.
- Chlorine must be removed prior to RO system if present in the feed water.
- Water must be pretreated by a Water Softener or antiscalant to avoid scaling the membranes.
- Standard packaging is boxed, crating optional.

ORDERING INFORMATION

Please add our voltage codes to the end of the model number when ordering.
Example: AA-12521-**116** = 110V/1 ph/ 60 hz

Voltage Codes: *Three Phase Not Available*

215 = 220/230, 1 ph, 50 Hz **216 =** 220/230, 1 ph, 60 hz **116 =** 110v/1 ph/60 hz

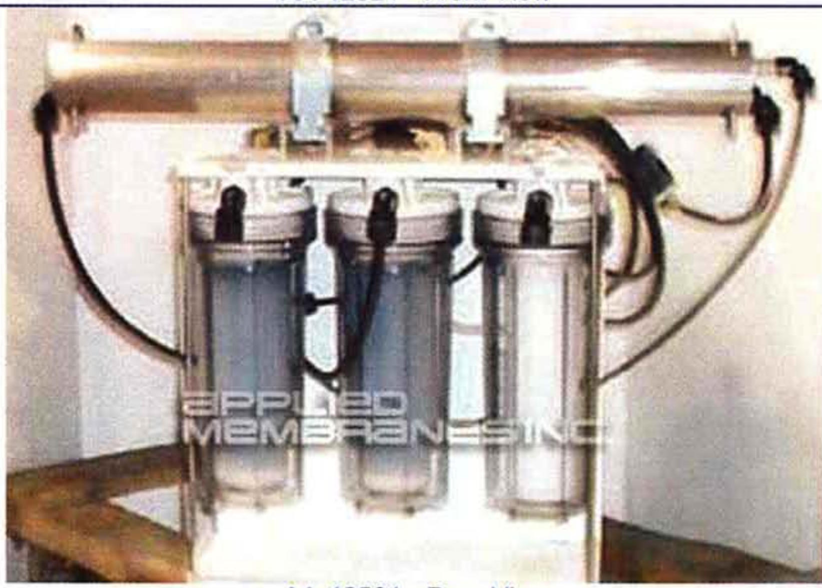
Replacement Parts and Consumables for AA Reverse Osmosis Systems

- Click here for replacement Reverse Osmosis Membranes
- Click here for replacement Membrane Pressure Vessels
- Click here for replacement Sediment filters
- Click here for replacement Carbon Filters
- Click here for replacement Filter Housings
- Click here for replacement Components
- Click here for Membrane Cleaning Cartridges

PHOTOGRAPHS of AA Series RO Systems

AA-12521 - Front View

AA-22521 - Front View



AA-12521 - Rear View

AA-22521 - Rear View

'This page was last updated 06/30/08

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APPLIED® FILTERS

PYROLOX FILTERS FOR IRON REMOVAL

About Pyrolox:

A mined ore, Pyrolox effectively reduces iron, sulfur and manganese from problem water.

A Naturally mined ore, Pyrolox is a mineral form of manganese dioxide which has been used in water treatment for more than 75 years. Pyrolox is a granular filtration media for hydrogen sulfide, iron and manganese reduction. Pyrolox functions as a catalyst, but itself remains relatively unchanged. Pyrolox works on a principle whereby the hydrogen sulfide, iron and manganese are oxidized and trapped on the media while simple backwashing cleans the bed. No chemical regeneration is required, nothing is imparted into the drinking water and Pyrolox has a high capacity for low contaminant concentrations. Pyrolox can be used in conjunction with aeration, chlorination, ozone or other pretreatment methods for difficult applications. Chlorine or other oxidants accelerate the catalytic reaction.

With SS Jacket***

With No Jacket

Advantages of Pyrolox:

- Effective reduction of iron, sulfur and manganese
- Durable material with long service life and low annual attrition of bed
- No chemical regeneration required, only periodic backwashing

Conditions for Operation:

- pH: 6.5 - 9.0
- Because of its heavy weight, it is very important that Pyrolox filters are backwashed properly to insure adequate bed expansion and continued service life.

Iron Filters (Pyrolox)

Model No.*	Media (Cu.Ft.)	Service Flow Rate** (GPM)	Backwash** (GPM)	Fleck Valve Head	Tank Size (Dia." × H.")	Pipe Size (in.)	Approx. Ship. Wt. (lbs)
W-MFI744P	0.3	1.3	7	5600	7 × 44	¾	75
W-MFI844P	0.5	1.7	7	2510	8 × 44	1	95
W-MFI940P	0.6	2.2	12	2510	9 × 40	1	100
W-MFI1040P	1.0	2.7	15	2510	10 × 40	1	155
W-MFI1054P	1.0	2.7	15	2510	10 × 54	1	165
W-MFI1252P	1.5	3.9	15	2510	12 × 52	1	245
W-MFI1354P	2.0	4.6	25	2750	13 × 54	1	285
W-MFI1465P	2.5	5.3	25	2750	14 × 65	1	435
W-MFI1665P	3.0	7.0	30	2850	16 × 65	1.5	465
W-MFI2162P	4.0	12.0	49	2850	21 × 62	1.5	635
W-MFI2472P	6.0	15.7	60	3150	24 × 72	2	905

System Shown with Optional Skid Mounting & Control Panel

Notes:

* Please add the appropriate voltage code to the end of the model no. when ordering.
110v/60Hz = 116, 220v/60Hz = 216, 220v/50Hz = 215 *Example: W-MFI744P-116*

** 5 gpm per sq. ft. of media is the best design condition for filtration. Backwash flow rate based on 25 psi pressure drop.

*** Stainless Steel Jacket available for 9-16" Diameter as an additional option.

Specifications

- Vessel is rated at 150 psi maximum operating pressure, 120°F maximum operating temperature.
- All Systems Automatic
- Fleck Control Valve
- Standard Valve Configuration Below. Metered Valve, Electronic Valve, or change to 7/12-Day timer are available as options.
  • 7"-14" Diameter: 7-Day Timer. • 16"-48" Diameter: 12-Day Timer.

Also check our Filtration Media, listed on Page 7-11.

APPLIED® FILTERS
CARBON FILTERS – GRANULAR ACTIVATED (GAC)

About Carbon Filters:
These filters are used to reduce chlorine, organics, color, tannin, and objectionable tastes and odors from water. Automatic backwashing system removes the trapped contaminants within the filter bed and washes them down the drain. Our Household Carbon Filters (10"-12" Diameter) use NSF approved coconut shell based carbon.

Advantages of Carbon Filtration:
- **Significantly reduce the following contaminants:**
  - Chlorine
  - Chlorine By-Products such as Trihalomethanes (THMs)
  - Bad Tastes and Odors
  - Turbidity
  - Herbicides, Pesticides & Insecticides
  - Volatile Organic Chemicals (VOCs)

With SS Jacket***

With No Jacket

Model No.*	Volume of Media (Cu.Ft.)	Flow Rate (GPM)** 5gpm/ft.^{2}	Flow Rate (GPM)** 15gpm/ft.^{2}	Backwash Flow (GPM)**	Fleck Valve Head	Tank Size (Dia"×H")	In/Out Conn. (in.)	Approx. Ship. Wt. (lbs)
W-G744	0.4	1	4	2	5600	7 × 44	¾	60
W-G844	0.5	2	5	3	5600	8 × 44	¾	62
W-G940	0.7	2	6	3.5	5600	9 × 40	¾	65
W-G1040	1.0	2	7	4	5600	10 × 40	¾	70
W-G1054	1.4	2	7	4	5600	10 × 54	¾	80
W-G1252	1.9	4	12	6	2510	12 × 52	1	100
W-G1354	2.4	4	14	7	2510	13 × 54	1	135
W-G1465	3.0	5	16	7	2510	14 × 65	1	185
W-G1665	4.0	7	21	15	2510	16 × 65	1	235
W-G2162	8.0	13	36	25	2850	21 × 62	1.5	335
W-G2472	10.0	15	47	40	2850	24 × 72	1.5	410
W-G3072	15.0	24	74	55	3150	30 × 72	2	485
W-G3672	20.0	35	106	75	3150	36 × 72	2	785
W-G4272	30.0	48	144	100	3900	42 × 72	3	935
W-G4872	40.0	60	188	100	3900	48 × 72	3	1,535

Notes:
* Please add the appropriate voltage code to the end of the model no. when ordering.
110v/60Hz = 116, 220v/60Hz = 216, 220v/50Hz = 215 *Example: W-G744-116*
** 5 gpm per sq. ft. of media is the best design condition for filtration. For relatively clean water, you may go up to design criteria of 15 gpm per sq. ft. Backwash flow rate based on 25 psi pressure drop.
*** Stainless Steel Jacket available for 9-16" Diameter as an additional option.

Specifications
- Vessel rated at 150 psi max. operating pressure, 120°F max. operating temp.
- All Systems Automatic
- Fleck Control Valve
- Standard Valve Configuration Below. Metered Valve, Electronic Valve, or change to 7/12-Day timer are available as options.
  - 7"-14" Diameter: 7-Day Timer.
  - 16"-48" Diameter: 12-Day Timer.



Systems Shown with Optional Skid Mounting and Control Panel

Also check our Filtration Media, listed on Page 7-11.

APPENDIX O
Present Worth Comparison of Alternative Evaluation

Battlefield Golf Club Water Project
PRESENT WORTH OPINION OF COST EVALUATIONS

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Expected System Life (yr)	30	30	30	30
Capital Cost	$ 7,221,756	$ 8,411,704	$ 2,770,149	$ 803,000
O&M Costs/yr	$ 3,000	$ 187,227	$ 460,879	$ 10,000
Present Worth Costs	$ 7,267,873	$ 11,289,844	$ 9,854,989	$ 956,725

Alternative 1 Provide City Of Chesapeake Water via a Water Main Extension
Alternative 2 Installation of Community System
Alternative 3 Installation of Point of Entry (POE) Treatment Systems on Existing Private W
Alternative 4 Development and Installation of New Individual Home Owner Supply Wells

Assumptions

Cost Opinions do not consider Engineering Time required for alternatives
Cost Opinions do not consider Permitting Time and Constraints
Cost Opinions make assumptions for market value of land acquistion
Cost Opinions are not actual determinations of project costs and are strictly for comparison
Cost Opinions do not consider cost of brine disposal

Battlefield Golf Club Water Project
Centerville Turnpike Water Main - Alternative 1

ITEM NO.	ITEM DESCRIPTION	UNIT	QTY	UNIT COST	LINE ITEM COST
1	Mobilization	LS	1	$92,000.00	$100,000.00
2	16" Water Main - Ductile Iron Pipe	LF	8439	$108.25	$913,521.75
3	10" Water Main - Ductile Iron Pipe	LF	384	$74.66	$28,669.44
4	6" Water Main - Ductile Iron Pipe	LF	160	$58.00	$9,280.00
5	Water Main Undercut Excavation & Replacement with Bedding Stone	CY	1009	$32.00	$32,288.00
6	Select Backfill , CBR 15 - Pipe	CY	3844	$20.00	$76,880.00
7	Pipe Bedding	CY	570	$54.00	$30,780.00
8	Course Aggregate	TON	1976	$50.00	$98,800.00
9	16" Cross	EA	1	$2,000.00	$2,000.00
10	16" x 10"Tee	EA	2	$1,836.00	$3,672.00
11	16" x 6"Tee	EA	16	$1,661.00	$26,576.00
12	16" 45° Bend - Ductile Iron Pipe	EA	28	$1,177.00	$32,956.00
13	16" 22-1/2° Bend - Ductile Iron Pipe	EA	24	$1,193.00	$28,632.00
14	16" Butterfly Valve - Ductile Iron Pipe	EA	11	$4,500.00	$49,500.00
15	Fire Hydrant Assembly	EA	17	$3,000.00	$51,000.00
16	Crusher Run - Fire Hydrant Only	TON	299	$25.00	$7,475.00
17	Connect to Existing Water Main	EA	2	$3,500.00	$7,000.00
18	Service Connections	EA	30	$2,500.00	$75,000.00
	Utility Trench Pavement Patching	LF	1410		
19	2" SM-2A	Ton	130	$90.00	$11,700.00
20	7" BM-2	Ton	455	$90.00	$40,950.00
21	10" Aggregate Base	Ton	630	$35.00	$22,050.00
22	Traffic Control	LS	1	$5,000.00	$5,000.00
23	Erosion and Sediment Control Pipe line	LS	1	$25,000.00	$25,000.00
24	Curb and Gutter Replacement	LF	60	$45.00	$2,700.00
25	Storm Drain Pipe - 15" RCP	LF	330	$44.00	$14,520.00
26	Storm Drain Pipe - 18" RCP	LF	50	$62.00	$3,100.00
27	Storm Drain Pipe - 24" RCP	LF	442	$77.00	$34,034.00
28	Storm Drain Pipe - 30" RCP	LF	20	$160.00	$3,200.00
29	Flared End Section - 15" RCP	EA	19	$750.00	$14,250.00
30	Flared End Section - 18" RCP	EA	2	$780.00	$1,560.00
31	Flared End Section - 24" RCP	EA	17	$800.00	$13,600.00
32	Flared End Section - 30" RCP	EA	2	$1,000.00	$2,000.00
33	Drop Inlet	EA	1	$5,000.00	$5,000.00
34	Manhole	EA	2	$4,000.00	$8,000.00
35	Connect to Existing Storm Struct.	EA	2	$1,000.00	$2,000.00
36	Select Tree Removal	EA	10	$585.00	$5,850.00
37	Seeding, Fertilizing and Lime	LS	1	$10,000.00	$10,000.00
38	Sawcut and Remove Pavement	LF	1410	$3.85	$5,428.50
	Pavement Milling & Overlay for Utility Patch				
39	2" Mill	SY	3506	$15.00	$52,590.00
40	Asphalt Overlay	Ton	385	$125.00	$48,125.00
41	Traffic Control	LS	1	$5,000.00	$5,000.00
	Pavement Repair Along Centerville Tpk.				
42	2"-Mill 12'wide X 7831' long	SY	10441	$15.00	$156,615.00
43	Asphalt Overlay	Ton	1722	$90.00	$154,980.00
44	Traffic Control	LS	1	$9,000.00	$9,000.00
45	Isolated Pavement Repair	SY	1000	$80.00	$80,000.00
46	VDOT EC-1 For Ditch Stabalization	SY	12229	$2.25	$27,515.25
47	Excavation For Ditch	CY	4489	$5.45	$24,465.05
48	Topsoil	CY	2232	$25.00	$55,800.00
49	Select Borrow, CBR 15 - Ditch fill Only	CY	3707	$20.00	$74,140.00
50	Fine Grade Shoulder	SY	9166	$1.50	$13,749.00
51	Concrete Driveway Replacement	EA	3	$2,800.00	$8,400.00
52	Asphalt Driveway Replacement	EA	4	$3,000.00	$12,000.00
53	Gravel Driveway Replacement	EA	4	$1,000.00	$4,000.00

Battlefield Golf Club Water Project
Centerville Turnpike Water Main - Alternative 1

ITEM NO.	***ITEM DESCRIPTION***	***UNIT***	***QTY***	***UNIT COST***	***LINE ITEM COST***
54	Traffic Control Non paving operations	LS	1	$40,000.00	$40,000.00
	Subtotal				$2,570,351.99
	Contengency 10%				$257,035.20
	Easement Acquisition				
55	Business	SF	10500	$ 15.00	$157,500.00
56	Other	SF	55380	$ 8.00	$443,040.00
	TOTAL				$3,427,927.19

Battlefield Golf Club Water Project

Murray Drive & Whittamore Road Water Main - Alternative 1

ITEM NO.	ITEM DESCRIPTION	UNIT	QTY	UNIT COST	LINE ITEM COST
1	Mobilization	LS	1	$ 100,000.00	$ 150,000.00
	Whittamore Road				
2	10" DI Pipe	LF	2250	$ 68.00	$ 153,000.00
3	8" DI Pipe	LF	5685	$ 58.00	$ 329,730.00
4	6" DI Pipe	LF	370	$ 50.00	$ 18,500.00
5	Hydrants & Appurtenances	EA	17	$ 3,000.00	$ 51,000.00
6	10" Gate Valve & Box	EA	2	$ 2,500.00	$ 5,000.00
7	8" Gate Valve & Box	EA	5	$ 1,300.00	$ 6,500.00
8	6" Gate Valve & Box	EA	17	$ 931.00	$ 15,827.00
9	Connect to existing Water Main	LA	1	$ 3,500.00	$ 3,500.00
10	Service Connections	EA	30	$ 1,600.00	$ 48,000.00
11	Water Main Undercut Excavation & Replacement with Bedding Stone	LF/6" depth	4000	$ 7.43	$ 29,720.00
12	Select Backfill, CBR 15 - Pipe Install	CY	7164	$ 20.00	$ 143,280.00
13	Temporary Pavement Patch Water Main	SY	5373	$ 27.00	$ 145,071.00
14	Sawcut Pavement	LF	16120	$ 1.00	$ 16,120.00
15	Erosion and Sed. Control	LS	1	$ 10,000.00	$ 10,000.00
16	Storm Drain Pipe-24" RCP	LF	376	$ 130.00	$ 48,880.00
17	Flared End Section 24" RCP	EA	47	$ 2,350.00	$ 110,450.00
18	Crusher Run Fill at Culverts	CY	47	$ 50.00	$ 2,350.00
19	Traffic Control	LS	1	$ 15,000.00	$ 15,000.00
	Water Line Sub Total				$ 1,151,928.00
	Rebuild Entire Roadway				
20	Demolition and removal of pavement and subgrade. Haul off	CY	12935	$ 20.00	$ 258,700.00
21	24" Select Material, CBR=15, Sand Blanket	CY	11940	$ 19.00	$ 226,860.00
22	Grade/compact Subgrade	SY	17911	$ 1.50	$ 26,866.50
23	Subgrade Undercut & replacement W/ select material	CY	1000	$ 40.00	$ 40,000.00
24	8" Aggregate Base Material	Ton	7630	$35.00	$267,050.00
25	Grade Aggregate Base Material	SY	17911	$2.00	$35,822.00
26	2" Surface & 4" Binder Asphalt	Ton	6180	$90.00	$556,200.00
27	Geotextile Fabric Under Aggregate	SY	17911	$2.50	$44,777.50
28	Traffic Control for Roadway Construction	LS	1	$ 20,000.00	$20,000.00
	Subtotal Rebuild Roadway				$1,476,276.00
	Sub Total Whittamore				$2,628,204.00
	Murray Drive				
29	10" DI Pipe	LF	2127	$ 68.00	$ 144,636.00
30	8" DI Pipe	LF	4936	$ 58.00	$ 286,288.00
31	6" DI Pipe	LF	162	$ 50.00	$ 8,100.00
32	Hydrants & Appurtenances	EA	16	$ 3,000.00	$ 48,000.00
33	10" Gate Valve & Box	EA	1	$ 2,500.00	$ 2,500.00
34	8" Gate Valve & Box	EA	2	$ 1,300.00	$ 2,600.00
35	6" Gate Valve & Box	EA	16	$ 931.00	$ 14,896.00
36	Connect to existing Water Main	LA	1	$ 3,500.00	$ 3,500.00
37	Service Connections	EA	41	$ 1,600.00	$ 65,600.00
38	Select Borrow, CBR 15 - Pipe Install Only (Backfill)	CY	37	$ 40.00	$ 1,480.00
39	Sawcut Pavement	LF	170	$ 10.00	$ 1,700.00
40	Curb and Gutter Replacement	LF	50	$ 45.00	$ 2,250.00
41	Erosion and Sed. Control	LS	1	$ 4,000.00	$ 4,000.00
42	Traffic Control	LS	1	$ 2,000.00	$ 2,000.00
	Pavement Repair				
43	1.5" SM-2A	TON	4	$ 1,000.00	$ 4,000.00

Battlefield Golf Club Water Project

Murray Drive & Whittamore Road Water Main - Alternative 1

ITEM NO.	***ITEM DESCRIPTION***	***UNIT***	***QTY***	***UNIT COST***	***LINE ITEM COST***
44	4" BM-2	TON	9	$ 1,000.00	$ 9,000.00
45	Aggregate Base Mat.	TON	12	$ 50.00	$ 600.00
46	Grading	SY	7850	$ 1.50	$ 11,775.00
47	2" Topsoil	AC	1.62	$ 26,000.00	$ 42,120.00
48	Seeding	AC	1.62	$ 2,500.00	$ 4,050.00
	Sub Total Murray Drive				$659,095.00
	Total Murray, Whittamore and Mobilization				$3,437,299.00
	10% Contigency				$343,729.90
	Easement Acquisition *				
48	Residential (FH and Water Meters)	SF	1600	$ 8.00	$ 12,800.00
	Total				$3,793,828.90

Battlefield Golf Club Water Project
Community Supply Water Distribution System - Alternative 2

ITEM NO.	***ITEM DESCRIPTION***	***UNIT***	***QTY***	***UNIT COST***	***LINE ITEM COST***
1	Mobilization	LS	1	$100,000.00	$150,000.00
	Whittamore Road				
2	8" DI Pipe	LF	7935	$58.00	$460,230.00
3	6" DI Pipe	LF	370	$50.00	$18,500.00
4	Hydrants & Appurtenances	EA	17	$3,000.00	$51,000.00
5	10" Gate Valve & Box	EA	2	$2,500.00	$5,000.00
6	8" Gate Valve & Box	EA	5	$1,300.00	$6,500.00
7	6" Gate Valve & Box	EA	17	$931.00	$15,827.00
8	Service Connections	EA	30	$1,600.00	$48,000.00
9	Water Main Undercut Excavation & Replacement with Bedding Stone	LF/6" depth	4000	$7.43	$29,720.00
10	Select Backfill, CBR 15 - Pipe Install	CY	7164	$20.00	$143,280.00
11	Temporary Pavement Patch Water Main	SY	5373	$27.00	$145,071.00
12	Sawcut Pavement	LF	16120	$1.00	$16,120.00
13	Erosion and Sed. Control	LS	1	$10,000.00	$10,000.00
14	Storm Drain Pipe-24" RCP	LF	376	$130.00	$48,880.00
15	Flared End Section 24" RCP	EA	47	$2,350.00	$110,450.00
16	Crusher Run Fill at Culverts	CY	47	$50.00	$2,350.00
17	Traffic Control	LS	1	$15,000.00	$15,000.00
	Water Line Sub Total				$1,125,928.00
	Rebuild Entire Roadway-Whittamore				
18	Demolition and removal of pavement and subgrade. Haul off-site	CY	12935	$20.00	$258,700.00
19	24" Select Material, CBR=15, Sand Blanket	CY	11940	$19.00	$226,860.00
20	Grade/compact Subgrade	SY	17911	$1.50	$26,866.50
21	Subgrade Undercut & replacement W/ select material	CY	1000	$40.00	$40,000.00
22	8" Aggregate Base Material	Ton	7630	$35.00	$267,050.00
23	Grade Aggregate Base Material	SY	17911	$2.00	$35,822.00
24	2" Surface & 4" Binder Asphalt	Ton	6180	$90.00	$556,200.00
25	Geotextile Fabric Under Aggregate	SY	17911	$2.50	$44,777.50
26	Traffic Control for Roadway Construction	LS	1	$20,000.00	$20,000.00
	Subtotal Rebuild Roadway				$1,476,276.00
	Sub Total Whittamore				$2,602,204.00
	Murray Drive				
27	8" DI Pipe	LF	7063	$58.00	$409,654.00
28	6" DI Pipe	LF	162	$50.00	$8,100.00
29	Hydrants & Appurtenances	EA	16	$3,000.00	$48,000.00
30	10" Gate Valve & Box	EA	1	$2,500.00	$2,500.00
31	8" Gate Valve & Box	EA	2	$1,300.00	$2,600.00
32	6" Gate Valve & Box	EA	16	$931.00	$14,896.00
33	Service Connections	EA	41	$1,600.00	$65,600.00
34	Select Borrow, CBR 15 - Pipe Install Only (Backfill)	CY	37	$40.00	$1,480.00
35	Sawcut Pavement	LF	170	$10.00	$1,700.00
36	Curb and Gutter Replacement	LF	50	$45.00	$2,250.00
37	Erosion and Sed. Control	LS	1	$4,000.00	$4,000.00
38	Traffic Control	LS	1	$2,000.00	$2,000.00
	Pavement Repair				
39	1.5" SM-2A	TON	4	$1,000.00	$4,000.00
40	4" BM-2	TON	9	$1,000.00	$9,000.00
41	Aggregate Base Mat.	TON	12	$50.00	$600.00
42	Grading	SY	7850	$1.50	$11,775.00

Battlefield Golf Club Water Project
Community Supply Water Distribution System - Alternative 2

ITEM NO.	ITEM DESCRIPTION	UNIT	QTY	UNIT COST	LINE ITEM COST
43	2" Topsoil	AC	1.62	$26,000.00	$42,120.00
44	Seeding	AC	1.62	$2,500.00	$4,050.00
	Sub Total Murray Drive				$634,325.00
	Centerville				
45	8" Water Main - Ductile Iron Pipe	LF	3102	$58.00	$179,916.00
46	Water Main Undercut Excavation & Replacement with Bedding Stone	CY	355	$32.00	$11,360.00
47	Select Backfill , CBR 15 - Pipe	CY	1355	$20.00	$27,100.00
48	Pipe Bedding	CY	200	$54.00	$10,800.00
49	Course Aggregate	TON	670	$50.00	$33,500.00
50	8" Gate Valve Valve	EA	3	$4,500.00	$13,500.00
51	Fire Hydrant Assembly	EA	3	$3,000.00	$9,000.00
52	Crusher Run - Fire Hydrant Only	TON	105	$25.00	$2,625.00
53	Service Connections	EA	5	$2,500.00	$12,500.00
	Utility Trench Pavement Patching	LF	497		
54	2" SM-2A	Ton	15	$90.00	$1,350.00
55	7" BM-2	Ton	160	$90.00	$14,400.00
56	10" Aggregate Base	Ton	222	$35.00	$7,770.00
57	Traffic Control	LS	1	$3,000.00	$3,000.00
58	Erosion and Sediment Control Pipe line	LS	1	$5,000.00	$5,000.00
59	Curb and Gutter Replacement	LF	20	$45.00	$900.00
60	Seeding, Fertilizing and Lime	LS	1	$2,500.00	$2,500.00
61	Sawcut and Remove Pavement	LF	730	$3.85	$2,810.50
62	Storm Drain Pipe - 15" RCP	LF	69	$44.00	$3,036.00
63	Storm Drain Pipe - 18" RCP	LF	52	$62.00	$3,224.00
64	Storm Drain Pipe - 24" RCP	LF	145	$77.00	$11,165.00
65	Flared End Section - 15" RCP	EA	3	$750.00	$2,250.00
66	Flared End Section - 18" RCP	EA	6	$780.00	$4,680.00
67	Flared End Section - 24" RCP	EA	4	$800.00	$3,200.00
68	Drop Inlet	EA	1	$5,000.00	$5,000.00
69	Manhole	EA	1	$4,000.00	$4,000.00
70	Pavement Milling & Overlay for Utility Patch				
71	2" Mill	SY	1500	$15.00	$22,500.00
72	Asphalt Overlay	Ton	240	$125.00	$30,000.00
73	Traffic Control	LS	1	$3,000.00	$3,000.00
74	Pavement Repair Along Centerville Tpk.				
75	2"-Mill 12'wide X 3300' long	SY	4400	$15.00	$66,000.00
76	Asphalt Overlay	Ton	484	$90.00	$43,560.00
77	Isolated Pavement Repair	SY	100	$80.00	$8,000.00
78	VDOT EC-1 For Ditch Stabalization	SY	433	$2.25	$974.25
79	Excavation For Ditch	CY	1500	$5.45	$8,175.00
80	Topsoil	CY	786	$25.00	$19,650.00
81	Select Borrow, CBR 15 - Ditch fill Only	CY	1300	$20.00	$26,000.00
82	Fine Grade Shoulder	SY	3231	$1.50	$4,846.50
83	Concrete Driveway Replacement	EA	1	$2,800.00	$2,800.00
84	Gravel Driveway Replacement	EA	1	$1,000.00	$1,000.00
	Subtotal Centerville Turnpike				$611,092.25
	Total of Construction				$3,847,621.25
	10% Contigency				$384,762.13

Battlefield Golf Club Water Project
Community Supply Water Distribution System - Alternative 2

ITEM NO.	ITEM DESCRIPTION	UNIT	QTY	UNIT COST	LINE ITEM COST
	Easement Acquisition				
	Centerville Turnpike				
85	Residential	SF	23930	$8.00	$191,440.00
	Murry Drive				
86	Residential	SF	1600	$8.00	$12,800.00
	Total Estimate				$4,436,623.38

Battlefield Golf Club Water Project

Community Water Supply and Treatment System - Alternative 2

Item	Quantity	Unit Cost	Unit	Total Cost
Item 1 - Mobilization/Demobilization				
Setup Charge Trailer	1	$920	EA	$920
Trailer/Furniture	6	$2,875	Month	$17,250
Port-a-john	180	$6	Days	$1,035
Water	180	$6	Days	$1,035
Mobilization	1	$80,500	LS	$80,500
Site Cleanup	1	$5,750	LS	$5,750
Item 2 - Erosion and Sediment				
Stabilized construction entrance	1	$5,750	EA	$5,750
Silt fence	200	$2	LF	$460
LOD Fence	2,000	$2	LF	$4,600
R-3 / R4 riprap pad	2	$2,300	EA	$4,600
Dirtbag	1	$1,000	EA	$1,000
Dirtbag discharge area (Pad)	400	$6	SF	$2,300
Item 3 - Earthwork				
Grading	1	$29,000	LS	$29,000
Borrow	1	$2,500	LS	$2,500
Item 4 - Groundwater Withdrawal Permit				
Engineering Support preparing plan, hydrogeologic information, etc	1	$75,000	LS	$75,000
Permit Fee	1	$6,000	LS	$6,000
Item 5 - Well Field				
Property Acquisition for Siting of Wells	3	$75,000	EA	$225,000
Well Construction	3	$40,000	EA	$120,000
Well Pipe, Well Pumps, Motors, Pitless Adapter, Wiring Etc	3	$40,000	EA	$120,000
Item 6 - Raw Water Transmission Mains				
4" SDR 21	3,000	$58	LF	$174,000
Item 7 - Paving and Surfacing				
Paving	1	$3,000	LS	$3,000
Gravel road	1	$2,500	LS	$2,500
Item 8 -Exterior Piping				
Exterior DIP Piping Fittings and Valves	1	$85,000	LS	$85,000
Misc Fittings / Thrust Blocks	1	$10,000	LS	$10,000
Item 9 - Landscaping and Site Improvements				
Landscaping and Site Improvements (incl fencing)	1	$20,000	LS	$20,000
Item 10 - Concrete				
Tank foundation, Footers, Slab, Door Landing Slabs	9	$518	CY	$30,000
Item 11 - Water Treatment Plant Structure and Finishings				
Trusses, CMU, Doors, Etc	800	$150	SF	$120,000
Fixtures and furniture	1	$20,000	LS	$20,000
Emergency Generator	1	$80,000	LS	$80,000
Item 12 - Fe and Mn Pressure Filters Unit Process Equipment				
Manganese Greensand Filters	1	$187,900	LS	$187,900
Item 13 - RO Unit Process Equipment				

Vantage M84-024RO	1	$137,600	LS	$137,600
Vantage M83-006RO	1	$90,100	LS	$90,100
Item 14 - Equipment and Mechanical Work				
Interior Process Piping and Fittings	1	$60,000	LS	$60,000
Disinfection and hydrostatic pressure testing	1	$11,500	LS	$11,500
Fittings and Supports	1	$11,500	LS	$11,500
Controls	1	$25,000	LS	$25,000
Chlorination System	1	$5,000	EA	$5,000
Chlorine/Fluoride Residual Analyzer	1	$5,000	EA	$5,000
Fluroidation System	1	$5,000	EA	$5,000
Dehumidifiers (3)	1	$6,000	LS	$6,000
Exhaust Fan w/ Louvers	1	$4,500	LS	$4,500
Gas Service Pipe	1	$11,500	LS	$11,500
Water heater	1	$1,150	LS	$1,150
Item 15 - Raw Water "Reservior", Backwash/Brine Holding Tank, Pump Station				
20,000 gal Tank for Raw Water for Chemical Pre-treatment	1	$50,000	LS	$50,000
50,000 gal Tank includes excavation, foundation, handrails, etc	1	$200,000	LS	$200,000
Item 16 - Community Water Distribution System				
From URS Virginia Beach	1	$ 4,436,623	LS	$4,436,623
Item 17 - Ground Level Water Storage Tank				
High Service Fire Pump	1	$10,000	EA	$10,000
VFD service pumps (one for redundancy)	2	$10,000	EA	$20,000
Property Acquisition for Siting of Tank	1	$75,000	EA	$75,000
120,000 gal Tank includes foundation, painting, etc	1	$144,000	LS	$144,000
Item 18 - Electrical				
Service Meter/Entrance	1	$4,000	LS	$4,000
Panelboard (1) - 120/240V, 24 Ckt	1	$5,000	LS	$5,000
Service & Equipment Grounding	1	$3,000	LS	$3,000
Emergency Lights (2)	1	$1,500	LS	$1,500
Lighting (11)	1	$5,500	LS	$5,500
Receptacles (10)	1	$3,000	LS	$3,000
Misc Wiring, Unit Htrs, Exh Fans	1	$4,000	LS	$4,000
Alarm Panel (2) & Wiring	1	$6,000	LS	$6,000
Alarm/Intlk Wiring to Treatment Bldg	1	$10,000	LS	$10,000
Flow Switch, Pressure Switch, Flooded Floor Sensor, etc	1	$4,000	LS	$4,000
Telephone Dialer	1	$1,200	LS	$1,200
Elect Unit Heater, 5KW 480V, 3 PH (2)	1	$3,500	LS	$3,500
Well Starter Replacement (5)	5	$5,000	EA	$25,000
Programmable Logic Controller	1	$15,000	EA	$15,000
Well Feeder Line	1	$100,000	LS	$100,000
Electric Work for Reverse Osmosis System	1	$150,000	LS	$150,000
Item 19 - HVAC /Plumbing				
Ventilation	1	$7,260	LS	$7,260
Plumbing	1	$27,720	LS	$27,720
Controls	1	$10,000	LS	$10,000
Water heater	2	$2,500	LS	$5,000
Item 20 - Indirects				
Survey	64	$144	HR	$9,200
Project Manager	120	$863	Days	$103,500
Superintendant	180	$748	Days	$134,550
Administrative	100	$518	Days	$51,750
Insurance	1	$106,375	LS	$106,375
Bonds	1	$106,375	LS	$106,375
Subtotal				$7,647,003
Contingency (10%)				$764,700
Total				$8,411,704

Battlefield Golf Club Water Project
Community Water Supply System O & M Cost Comparison - Alternative 2

Combined Wells	180	gpm
Pumping Duration per Day	3.70	hr
Q=	0.040	MGD
Q=	40,000.0	gpd

Alternative #2 Community Water Supply System

Treatment Process	Chemical Costs			
Oxidation	**NaOCl (12.5%)**			*Cost ($/yr)*
	12 5% chlorine (lbs/gal)	1 26	Dose (mg/L)	
	$/gal =	0 85	3 50	$ 287 50
Disinfection	**NaOCl (12.5%)**			
	12 5% chlorine (lbs/gal)	1 26	Dose (mg/L)	*Cost ($/yr)*
	$/gal =	0 85	1 00	$ 82 14
Fluoridation	**NaF**		Dose (mg/L)	*Cost ($/yr)*
	$/lb =	1 12	1 00	$ 307 53
Alkalinity and pH Adjustment	**Na_2CO_3**		Dose (mg/L)	*Cost ($/yr)*
	$/gal =	0 90	4 00	$ 328 57
				$ 1,005 74 Chemical Costs Sub-Tota

Pumps	Energy Costs			
Production Wells	Horsepower (HP) per well	25		
	Kilowatt (kW)	18 6425		
	Hours Pumping / day	3 7		
	# of Wells Operationing	2	Cost per kW-Hr($/kw Hr)	*Cost ($/yr)*
	kW-hrs/year	50403 7	0 12	$ 6,048 45
Booster Pumps	Horsepower (HP)	25		
	Kilowatt (kW)	18 6425		
	Hours Pumping / day	3 7	Cost per kW-Hr($/kw Hr)	*Cost ($/yr)*
	kW-hrs/year	25,201 9	0 12	$ 3,024 22
Supernatant Recycle Pump	Horsepower (HP)	7 5		
	Kilowatt (kW)	18 6425		
	Hours Pumping / day	0 4	Cost per kW-Hr($/kw Hr)	*Cost ($/yr)*
	kW-hrs/year	2,520 2	0 12	$ 302 42
Pump Station Pumps	Horsepower (HP)	25		
	Kilowatt (kW)	18 6425		
	Hours Pumping / day	3 7	Cost per kW-Hr($/kw Hr)	*Cost ($/yr)*
	kW-hrs/year	25,201 9	0 12	$ 3,024 22
				$ 12,399 32 Energy Costs Sub-Total

Reverse Osmosis	Process Equipment Costs		
			Cost ($/yr)
Vantage M83 RO System	Vender Supplied Information		$ 3,452 1
Vantage M84 RO System	Vender Supplied Information		$ 11,569 99
			$ 15,022 07

WTP Operations	Water Treatment Plant Personnel			
	Number of Operators	Hours/Week/Operator	Payrate ($/hr)	*Cost ($/yr)*
WTP Operator	2	40 00	30	$ 124,800 00
Sampling/Water Quality Analysis	# of Analyses	Cost per Test	Additional Miscellaneous	
	24	$ 1,000 00	$10,000 00	$ 34,000 00
				$ 158,800 00

$ 187,227.13 Total Cost

Battlefield Golf Club Water Project

Residential RO Systems - Point of Entry - Alternative 3

Item	Quantity	Unit Cost	Unit	Total Cost
Item 1 - Individual RO System with booster pumps, tanks, etc.	100	$ 4,813.17	EA	$481,317
Item 2 - RO System Housing				
Building Shed	100	$5,000	EA	$500,000
Item 3 - Piping, Mechanical, and Electrical Work				
Piping from well and to home	100	$5,000	EA	$500,000
Control System for RO	100	$2,500	EA	$250,000
Mechanical/Electrical work in RO Building	100	$3,500	EA	$350,000
Item 4: Indirects				
Survey	64	$144	HR	$9,200
Project Manager	120	$863	Days	$103,500
Superintendant	180	$748	Days	$134,550
Administrative	100	$518	Days	$51,750
Insurance	1	$69,000	LS	$69,000
Bonds	1	$69,000	LS	$69,000
Subtotal				$2,518,317
Contingency (10%)				$251,832
Total				$2,770,149

Battlefield Golf Club Water Project
Residential Point of Entry O & M Cost Comparison - Alternative 3

Number of Homes (ERCs)	100	
Daily Water	400	gpd
RO Efficiency	40	%
Waste Water	1000.000	gpd

Alternative #3 Point of Use Treatment Systems on Individual Wells

Energy Costs

				Cost ($/yr)
Heating and Electric for Shed	kW-hrs/year	1,500 0	Cost per kW-Hr($/kw Hr) 0 12	$ 180 00
Booster Pumps	Watts (W)	1120		
	Horsepower (HP)	1 50		
	Kilowatt (kW)	1 12		
	Hours Pumping / day	6 7	Cost per kW-Hr($/kw Hr)	*Cost ($/yr)*
	kW-hrs/year	2,725 3	0 12	$ 327 04
				$ 50,704 00 Energy Costs for 100 ERC

Process Equipment Costs

Reverse Osmosis		Per Invidual Unit	*Cost ($/yr)*
Individual RO System	Replacement Filter Cartridges	1380	$ 138,000 00
Individual RO System	Replacement Membrances	143 75	$ 14,375 00
Individual RO System	Membrane Cleaning Supplies	230	$ 23,000 00
			$ 175,375 00

City of Chesapeake Personnel

Operations				*Cost ($/yr)*
	Number of Operators	Hours/Week/Operator	Payrate ($/hr)	
WTP Operator	2	40 00	30	$ 124,800 00
Sampling/Water Quality Analysis	# of Analyses	Cost per Test	Additional Miscellaneous	
	100	$ 1,000 00	$10,000 00	$ 110,000 00
				$ 234,800 00

460,879.00	Total Cost

Battlefield Golf Club Water Project
New Private Wells into the Yorktown Eastover Aquifer - Alternative 4

Item	Quantity	Unit Cost	Unit	Total Cost
Item 1				
Abandon Existing Well	100	$ 1,500.00	EA	$150,000
Item 2 - New Wells				
Permitting	100	$100	EA	$10,000
Drilling and Well Installation Cost (incl. pump and wiring)	100	$3,000	EA	$300,000
Disinfection	100	$200	EA	$20,000
Water Quality Testing	100	$1,000	EA	$100,000
Item 3 - Home Water System				
Pressure Tank and Water Conditioner	100	$1,000	EA	$100,000
Plumbing	100	$500	EA	$50,000
Subtotal				$730,000
Contingency (10%)				$73,000
Total				$803,000

Battlefield Golf Club Water Project
New Private Wells (O & M) - Alternative 4

Item	Quantity	Unit Cost	Unit	Total Cost
Item 1				
Filter Replacement, electricity, repairs, new pump replacement	100	$ 100.00	EA	$10,000
ten years, etx.				
Total				$10,000

APPENDIX P
Alternative Evaluation Matrix

URS

Alternatives Evaluation Matrix

Alternatives Evaluation		Alternatives							
		Option 1		Option 2		Option 3		Option 4	
Categories and Criteria	Relative Weight	AR	WR	AR	WR	AR	WR	AR	WR
Regulatory Compliance - Water Quality	20%								
- Meets VA Drinking Water Standards	10	5	50	5	50	4	40	3	30
- Long Term Compliance	10	5	50	5	50	4	40	1	10
Property Owner Impact	16%								
-Affects Property Value	8	5	40	4	32	2	16	3	24
-Homeowner responsibilities / increased burdens / Safety	8	3	24	3	24	1	8	5	40
Operational Requirements	16%								
- Sustainability (waste gen/resources/conserve energy)	8	5	40	0	0	0	0	5	40
- Reliability	8	5	40	4	32	4	32	2	16
Technical Feasibility	14%								
- Time for Implementation	8	4	32	0	0	3	24	5	40
- Constructability	6	3	18	2	12	2	12	5	30
Present Worth	20%								
- Capital costs	10	2	20	0	0	3	30	5	50
- O & M costs	10	5	50	1	10	0	0	5	50
Permitting / Administrative Burdens	14%								
- Permitting	8	3	24	0	0	1	8	3	24
- Level of effort	6	4	24	0	0	1	6	2	12
Total weighted alternative rating	100		412		210		216		366
	Rank		1		4		3		2

Relative weight - relative importance of criteria as compared to other criteria; scale 0 - 10; no importance rated 0, most important rated 10

AR - Alternative rating. Rates the alternatives according to their anticipated performance with respect to the various criteria;
scale 0 to 5; least favorable rated 0, most favorable rated 5.

AR Scale

0	Exceptionally Unfavorable
1	Very Unfavorable
2	Somewhat Unfavorable
3	Somewhat Favorable
4	Very Favorable
5	Exceptionally Favorable

WR - Weighted rating. Relative weight for each criteria multiplied by alternative rating.

Total weighted alternative rating -Sum of weighted ratings for each alternative

Option	Description
1	Provide City Water via a Water Main Extension.
2	Install a Community Groundwater Supply, Treatment, Storage and Distribution System.
3	Install POE Treatment Systems on Existing Private Wells
4	Install New Private Wells