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.

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

Murray Drive

REV.NO	DESCRIPTIONS	DATE
	REVISIONS	

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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.

Whittamore Road

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.

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

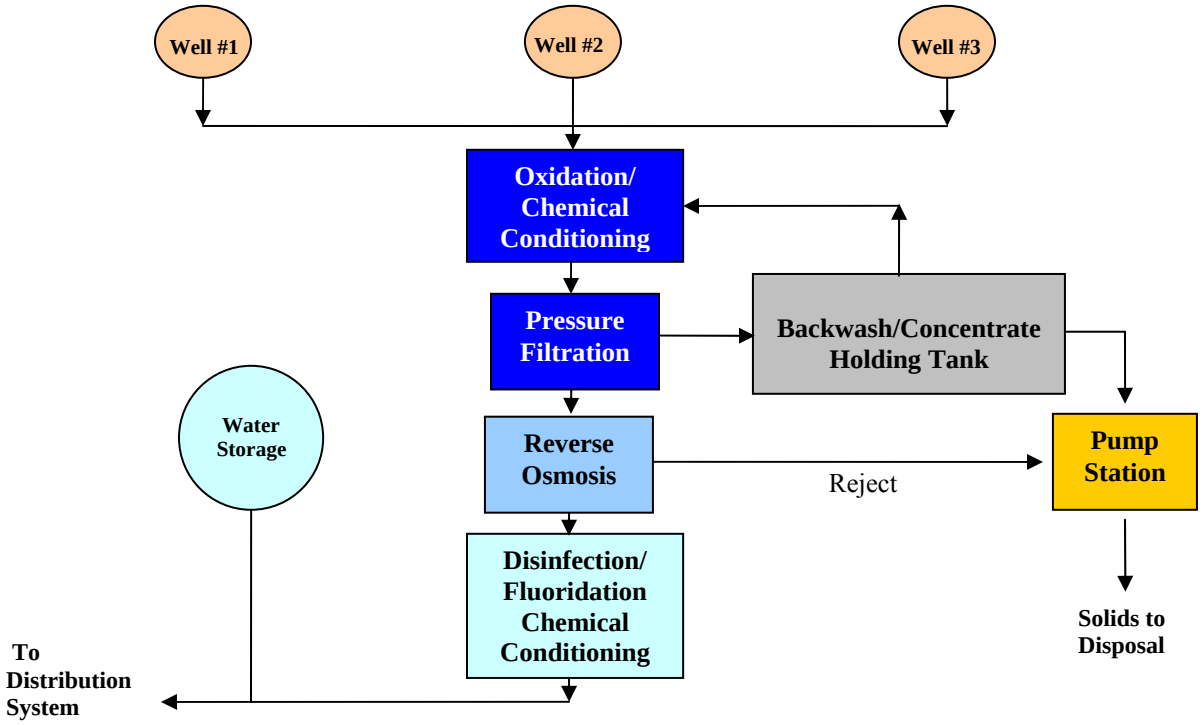
The advantages and disadvantages of providing an extension of the City distribution system to serve all homes in the study area include:

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.

REV NO	DESCRIPTION	DATE
	REVISIONS	

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Chesapeake VIRGINIA

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 • Protects Public Welfare • Continued Use of Private Well	• Extra Building On Property • Access Agreement Needed For City or Third Party Maintenance • 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