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UniStar
NUCLEAR ENERGY

June 13, 2011

UN#11-140

Mr. John Grace
Water Management Administration
Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, Maryland 21230

Subject: UniStar Nuclear Energy
Calvert Cliffs Nuclear Power Plant, Unit 3
Calvert County, Maryland
Certificate of Public Convenience and Necessity
Condition 16 – Backup Water Study

Reference: Certificate of Public Convenience and Necessity, In the Matter of the Application of UniStar Nuclear Energy, LLC and UniStar Nuclear Operating Services, LLC for a Certificate of Public Convenience and Necessity to Construct a Nuclear Power Plant at Calvert Cliffs in Calvert County, Maryland.
Case No. 9127, dated June 26, 2009.

Enclosed please find Revision 1 of the study, "Options for Emergency Backup Supply for the Desalination Plant and Related Considerations," in accordance with the requirements of the Calvert Cliffs Unit 3 Certificate of Public Convenience and Necessity (Reference) Condition 16. This revised report incorporates comment resolution agreed to by the Maryland Department of the Environment in our October 2010 meeting.

If you have any questions concerning the attached document, please call me at (410) 470-5524.

Sincerely,

Dimitri Lutchenkov

Enclosure – Options for Emergency Backup Supply for the Desalination Plant and Related Considerations, Revision 1, Calvert Cliffs Nuclear Power Plant Unit 3, Calvert County, Maryland, February 11, 2011

cc: Susan Gray – Power Plant Research Program (w/enclosure)
Laura Quinn – NRC Project Manager, Environmental Projects Branch 2 (w/enclosure)
Jay Sakai – Maryland Department of the Environment (w/enclosure)

Enclosure

Options for Emergency Backup Supply for the Desalination Plant and Related Considerations, Revision 1
Calvert Cliffs Nuclear Power Plant Unit 3
Calvert County, Maryland
February 11, 2011

STUDY

BECHTEL POWER CORPORATION
Project Name - Job Number: US EPR Job Number - 25237

STUDY TITLE: Options for Emergency Backup Supply for the Desalination Plant and Related Considerations
Document Number: 25237-000-30R-M01G-00001, Rev. 001 DATE: February 11, 2011

Reason for Issue: For Use
Prepared by: R. Sarma/ ______ Checked/Verified by: E. Johnson/ ______
Approved by: S. Rao/ ______
Project Controls- S. Pierce/ N/A Rev 001 _____ (Attachment 5 validation)
Approved by: E. Sherow/ ______

Applicability Statement:

This document is a formal study to support resolution of one of the conditions recommended by the Maryland Department of the Environment (MDE) to Calvert Cliffs Nuclear Power Plant (CCNPP) Unit 3's Certificate of Public Convenience & Necessity (CPCN) permit. Condition 16 "Emergency Backup Supply" states that:

"Within one year after the issuance of this CPCN, UniStar shall submit to MDE the results of an analysis of alternatives to address the potential need for an emergency backup supply for the desalination plant. The analysis shall consider additional intake locations, treatment equipment and sources of water other than ground water for the non-potable emergency backup water supply needs. The analysis shall describe the type of emergencies under consideration for which a backup supply is needed and evaluate a suite of remedies for each condition. The analysis shall also consider the relative suitability of different aquifers, in light of arsenic levels above drinking water standards in nearby Aquia aquifer users' wells, and to minimize potential short-term impacts on other users. Any appropriations request shall be contained within the analysis and shall include an explanation of the need for the water, the desired volume and duration of the withdrawal and the specific location(s) of the proposed withdrawal(s). MDE shall evaluate the requested appropriation(s) and alternative analysis. MDE may direct UniStar to conduct any field studies or water quality analyses that MDE determines to be needed to determine aquifer or water course characteristics, potential impacts to the resource and potential impacts to other users of the resource."

This study has been requested by the client, UniStar (UNE) and will be distributed external to Bechtel for client review, use and eventual distribution to the MDE.

Reason for Revision 001

- Incorporate client comments.
- This revision does not change the accuracy of information in Attachment 5. Hence no project controls signature is required.

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

This study, as a response to the requirements raised in CPCN Condition 16, includes the water demands for the CCNPP3 desalination plant, along with a list of potential failures that could cause the desalination plant to be out of service. The CPCN Condition 16 questions, along with the corresponding sections that address each question, are noted in Attachment 4 of this study.

As discussed in Section 3.1, the two desalinated water storage tanks, with a working capacity of 300,000 gallons each, allow approximately 11 hours of continuous operation without makeup at approximately 900 gpm to support Unit 3 desalinated water demands. After 11 hours, a readily available backup source needs to be operational.

A timeframe of 2 weeks is the maximum unavailability projected. This timeframe will allow time for events such as those caused by Bay chemistry perturbations to be resolved.

Additionally, the longest projected equipment unavailability was estimated in Table 1 based upon a failure of the high pressure reverse osmosis pump assembly, which conservatively assumes a design with no installed redundant/spare trains of major equipment or a warehouse/shelf spare parts program for major equipment. CCNPP3 will; however, have spare parts provisions for long lead time components and the CCNPP3 design will include installed spare/redundant components to maintain 100% capacity to support maintenance and allow continuous plant operations as long as source water is available for makeup to the desalination plant.

Emergency backup options to the permanent desalination plant are presented in this study. The options considered to be the most viable for detailed consideration were: the groundwater wells and the portable desalination trailers, and these are discussed in more depth, with order of magnitude estimates (that may deviate +/- 30%) provided in Attachment 5 of this study. These options were presented in Attachment 5 as Options 1A/B/C for the Aquia, Upper Patapsco and Lower Patapsco Aquifers, Options 2A/B for the portable trailers, respectively for the purchase and lease options, Option 3 for the 14-day pond (which would be supplemented with leased filtration equipment as noted in Section 3.5.3) and Option 4 for the 14-day backup storage tanks.

Note that, later in the study, Table 2 shows that the mobilization timeframe associated with bringing the desalination trailers online does not allow this option to replace the desalination plant in sufficient time to prevent a plant shutdown in the 11 hours (Section 3.1 of this study) that it would take to drain the desalinated water storage tanks. In addition to the mobilization timeframe, the trailers can only start producing water in the timeframe shown in Table 2. The trailer options require additional time (possibly an additional 2-3 days) to bring the full capacity of desalinated water online. Another consideration that should be noted is that, since the Chesapeake Bay would also be the source of water to the desalination trailers, any bay perturbations that could affect the influent water to the permanent desalination plant could also affect the influent water to the trailers. The result can mean a reduction in the power plant's power level or even an unnecessary power plant shutdown.

Given the mobilization timeframe associated with bringing the trailers online, along with the other considerations noted in Section 3.5, and the need for immediately available replacement fresh water, the groundwater wells were found to be the only expediently available option that can be brought online within the 11 hour timeframe needed to prevent an unnecessary forced plant shutdown. The wells can be readily available onsite with minimal coordination and time required to put them into operation. Also, as discussed in detail in Sections 3.5.6 and 3.6.1, the number of wells can be optimized for 100% availability and have minimal maintenance requirements and impact on drawdown.

Table 2 also shows that the pond can be as readily available as the wells, assuming the required filtration equipment is maintained operational. A rental filtration system would eliminate the maintenance and disposal requirements; however, the rental would require additional time (possibly 2-3 days) for the filtration trailer to arrive onsite.

The backup tanks are also shown in Table 2 to be as readily available as the wells; therefore, mobilization should not an issue for this option.

2.0 INTRODUCTION/BASES

- The desalination process plant planned for Calvert Cliffs Nuclear Power Plant, Unit 3 (CCNPP3) is a part of the Raw Water Supply System. The water supply to the desalination process comes from the Circulating Water Makeup System where the circulating water makeup pumps take their suction from the circulating water intake structure. The planned location for the intake structure on the Chesapeake Bay has been discussed in the Environmental Report of the Combined License Application (COLA) to the U.S. Nuclear Regulatory Commission in sections such as Sections 2.3 and 3.1 and will not be discussed in this study. The Raw Water Supply System boundaries are from the two Circulating Water Makeup System's brackish water supply headers from the Chesapeake Bay to the respective locations where the Raw Water Supply System supplies desalinated water to each of the desalinated users. The Chesapeake Bay water chemistry that was used for the preliminary design of the desalination plant is provided in Attachment 6.
- Certificate of Public Convenience and Necessity (CPCN) Background:
  Any new power plant in Maryland requires a Certificate of Public Convenience and Necessity (CPCN), issued by the Maryland Public Service Commission (PSC). As part of this licensing process, applicants must address a full range of environmental, engineering, and socioeconomic issues.

  The CPCN for CCNPP3 constitutes permission to construct and operate the facility, and includes required air quality and water appropriations construction permits.

  The CPCN application for the proposed Calvert Cliffs Unit 3 is discussed in PSC Order No. 82741 (Case No. 9127). The licensing conditions as recommended in the proposed order of Hearing Examiner were filed with the PSC on April 28, 2009. On June 26, 2009 the proposed order and subsequently the licensing conditions were affirmed, the final order was issued and the docket was closed (Ref. 1).

2.1 Scope

To support UNE in addressing the questions raised in CPCN condition 16, this study assesses:

1) The desalinated water needs being met by the desalination plant
2) Potential internal and external emergency conditions that could cause the desalination plant to be unavailable.
3) The projected timeframe in which the desalination plant could be unavailable due to internal or external emergency conditions.

4) Viable choices of alternative water sources that can be reliably used as a backup for the desalination plant, the timeframe to obtain the alternative water supply and the duration these alternative water supplies can be made available with their required treatment.
5) Order of magnitude estimates are included for only the options considered to be the most viable.

2.2 Need for Backup Capabilities and Impact of a Power Plant Shutdown

During normal power operations, the desalinated water users are the Essential Service Water System, the Demineralized Water Treatment System, the Fire Water Distribution System, the Potable and Sanitary Water System and other users for the additional capacity of desalinated water that is anticipated. In an emergency that would remove the desalination plant from service, the desalinated water users will need to be serviced from a backup fresh water source in order for the power plant to continue normal operations. (Note: The desalination system does not provide a backup source of water to any safety-related system, such as the Essential Service Water System, during any operational mode.)

When the power plant is shutdown, desalinated water is still needed for all users. The Essential Service Water cooling towers serve their cooling function during normal power operation, as well as when the power plant is in a shutdown mode. The Demineralized Water Treatment System also remains in operation when the power plant is shutdown to continue to process the desalinated water further to provide makeup demineralized water to the Demineralized Water Distribution System for various plant systems. The Potable and Sanitary Water System is operating to support the increase in personnel typically onsite during plant shutdowns and the Fire Water Distribution System remains ready in case of a fire emergency, where the fire water storage tanks would require makeup water from the desalination plant.

Without a backup to the desalination plant, a shutdown of the desalination plant would require the operators to shutdown the USEPR (United States Evolutionary Power Reactor). The following are reasons to maintain a backup action plan to supply the needed water until the desalination plant can be placed back into service:

- The desalination plant outage would result in inadequate potable water for drinking water and sanitary purposes to the staff that must remain onsite at all times.
- Forced plant shutdown could result in some grid instability if the shutdown were to occur at peak demand times.
- The desalination backup would help to alleviate unnecessary plant transients and switching to the backup source will increase the ability to withstand upset conditions in the bay by providing a readily available source of fresh water to replace the desalinated water.
- The power plant is designed for a finite number of plant shutdowns. Each forced shutdown would limit the future life of the unit. A readily available source of water would reduce the potential for an unnecessary shutdown potential, due to limitations on fresh water availability, over the life of the power plant.

2.3 Bases

2.3.1 Assumptions

- The scope of this study does not include possible issues that could cause the power plant to experience an unscheduled shut down. Further, the study's scope does not consider normal operational and shutdown activities during which the desalination plant would normally be available.

- No design basis accidents are considered in this study.
- The desalinated water users who are anticipated to use the additional desalinated water capacity are not considered in this study as these users are assumed to have their own backup supply of fresh water.
- All references to fresh water in this study assume that the water will be municipal drinking water quality; however, it should be noted that the alternative available sources of fresh water may require additional treatment to make the effluent "equivalent quality to desalinated water". Alternative sources that may require additional treatment, such as groundwater wells, are discussed in Section 3.5 of this study.
- The possibility of multiple, simultaneous issues that could cause a failure of the desalination plant are not considered. Only one issue is assumed to occur at any one period of time.
- Disposal of the water produced during the well tests, such as the 24-hour test, conducted for the well drilling is a possible issue to be addressed. One possible alternative use, depending upon the timeframe that the wells are to be drilled, could allow Construction to reuse the water for dust control and other nonpotable purposes. If the water cannot be reused in some manner, disposal of the water will need to be addressed.
- The mobilization timeframe associated with the purchased desalination trailers' option assumes that there are no union contractual obligations regarding labor.
- For the leased or purchased desalination trailer option, the following is assumed:
  - o The water treatment supplier will provide their own provisions to meet their feed pressure requirements.
  - o The client will provide the temporary cabling from the centralized power center to each of the desalination trailers. (Connection points in the power center would be allotted conservatively for up to 20 trailers.)
  - o The UNE decision to proceed with the desalination trailers as a backup option is assumed to be made in a timeframe to allow the Raw Water Supply System design to include these provisions. These provisions would include tapping into the underground piping sections to provide an aboveground connection point for the source water, provisions in the desalination specification to allow for tapping into the piping to the potable water system upstream of the point where potable water treatment is provided and provisions for tapping into the reject line to the wastewater retention basin.
- No redundant, spare trains are included in the scope of this study for any of the emergency backup options.

2.3.2 Methodology

- The flowrates and the quality of water for the desalinated water users (Essential Service Water/Ultimate Heat Sink cooling towers, Demineralized Water Treatment System, Fire Protection System and the Potable and Sanitary Water System) are first evaluated to quantify the flowrate requirements of CCNPP, Unit 3 from any backup water source.

- Issues internal and external to the desalination plant are considered in order to estimate the longest timeframe that the desalination plant may be out of service, with the exclusion of issues that could also cause the main power plant to be taken out of service.
- All plausible sources of fresh water are considered that can continuously provide the required flowrate to sustain continued operation of the power plant for the longest timeframe projected for the desalination plant's unavailability.
- Order of magnitude estimates will be made for the most viable and practical fresh water options.

3.0 DESCRIPTION

3.1 Desalinated Water Storage Capacity and Basis

The Desalinated Water Storage Tanks' storage capacity uses the flowrates for normal plant operations that can be found on the Water Balance Diagram (Ref. 3):
The desalinated water demands for CCNPP3 are currently noted in Ref. 3 as 629 gpm (makeup for evaporation and blowdown losses of 2 Essential Service Water/Ultimate Heat Sink (UHS) cooling towers during normal operation) + 80 gpm (makeup to produce demineralized water) + 5 gpm (fire system leakage reserve) + 93 gpm (continuous potable water usage total based upon AREVA document, Ref. 4) + 5 gpm (miscellaneous users in the Turbine Island such as equipment washdown) and totals 812 gpm for Unit 3 demands (use 900 gpm for conservatism). Since the desalinated water flowrates may have some variance, a margin is added to represent the total desalinated water users. As noted above the primary user of desalinated water is the ESW/UHS cooling tower for replenishing the cooling towers for losses due to evaporation and blowdown. The desalination backup supports normal fire system leakage reserves. It does not assume actual fire replenishment needs concurrent with failure of the desalination plant. In the event of fire, operations would focus water resources on fire suppression. The ESW cooling tower would operate on stored capacity within its basin and technical specification limits.

The design for CCNPP3 includes two storage tanks with a working capacity of 300,000 gallons each. This allows the approximate 900 gpm of Unit 3 desalinated water demands to support a continuous operational time during normal plant operations of approximate 11 hours without makeup.

During normal power plant operations, there are peak desalinated water demands that are accounted for as follows:

- UHS Cooling Towers' Projections:
  The UHS cooling towers' peak demands do not occur during normal power plant operations.
- Fire Water Tank Refill Requirements By Code:
  NFPA 804 (Ref. 6, Section A.9.2.2) requires that a fire water storage tank must be refilled in 8 hours for a 300,000 gallon fire water tank (Ref. 6, Section 9.2). [Note that, to fill the 300,000 gallon tank within 8 hours, the flowrate should be approximately 625 gpm. The flowrate and timeframe for fire water tank refill can be met by the inventory of one of the desalinated water storage tanks.].
- Demineralized Water Projections:

There are no peak demineralized water demands occurring during normal power operations. The demineralized water storage tanks can meet the normal demineralized water demands for two or more days without makeup from the desalination plant.

- Potable and Sanitary Water Projections:
  Potable/sanitary water is used for demands such as human consumption, lavatory/service sinks, toilet flushes, showers, washing machines, dishwashers, emergency eyewash stations and emergency shower stations. Additionally, potable water is used for air humidifiers for equipment support in several of the nuclear island buildings; however, equipment design will be such that operating the power plant without the humidifiers will not impede any proposed plant operational function.

  If makeup is not available from the desalination plant, potable/sanitary water can be trucked in to the site to refill the potable water storage tanks, as necessary. This is one option that would particularly allow emergency eyewash station and emergency shower station requirements to be met. Emergency eyewash station requirements can be alternatively met with portable eyewash options, if necessary.

  The potable and sanitary water demand peaks are projected conservatively based upon the simultaneous occurrence of both intermittent and continuous flowrates. Peak potable/sanitary water occurrences are considered, for the purpose of this study, to represent personnel shift changes at the power plant, where the timeframe overlap for each shift change may be a total of 1 hour.

  The peak demands for the Potable And Sanitary Water System are not expected to be met by the inventory of the desalinated water storage tanks since the potable water storage tank can meet peak demand for over 1-1/2 hours based upon a proposed potable water storage tank capacity of approximately 60,000 gallons, without accounting for any refill of the potable water storage tank.

3.2 Benchmark Typical Desalination Plant Performance

The repair history information made available by one water treatment supplier is the seawater reverse osmosis (ROs) system at Diablo Canyon Nuclear Power Plant, which has been operated for 15 years without the need for backup equipment, according to the supplier.

In a direct discussion with the Diablo Canyon Chemistry department, they have had desalination technology for about 25 years and it has worked well for them. They have the capacity to produce approximately 600 gpm but typically produce approximately 250 gpm. They have a 'quality of water and flowrate' type of turnkey operational contract with their supplier. They currently have seawater ROs. Their usage includes fire water production, demineralized water production (with additional treatment) and potable water (with disinfectant and hardness treatment). The only shutdown was 20 years ago due to a loss of offsite power event (since the water treatment equipment was not on emergency diesels) (See Reference 10).

One water treatment supplier notes that none of the desalination plants that they have built and operated over the years worldwide [i.e. 4.7 million gallons per day (MGD) desalination plant in Antigua for over 15 years; 84 MGD in Ashkelon, Israel for over 4 years and others in Jeddah, Saudi Arabia at 6.7 MGD; Sur, Oman at 22 MGD and Gold Coast, Australia at 33 MGD] have had mechanical failures that have shutdown the desalination plant because they have maintained redundant or installed spares for major equipment and worked out any pretreatment issues that may have arisen.

Lastly, the Tampa Bay desalination project, the largest desalination project for the U.S., demonstrates the viability of desalination with properly chosen technology.

Both seawater pretreatment and reverse osmosis technology are very mature technologies and reliable with proper selection of pretreatment and equipment and with installed spares and warehouse spares for long lead items.

3.3 Desalination Plant Primary and Secondary Risks of Failure

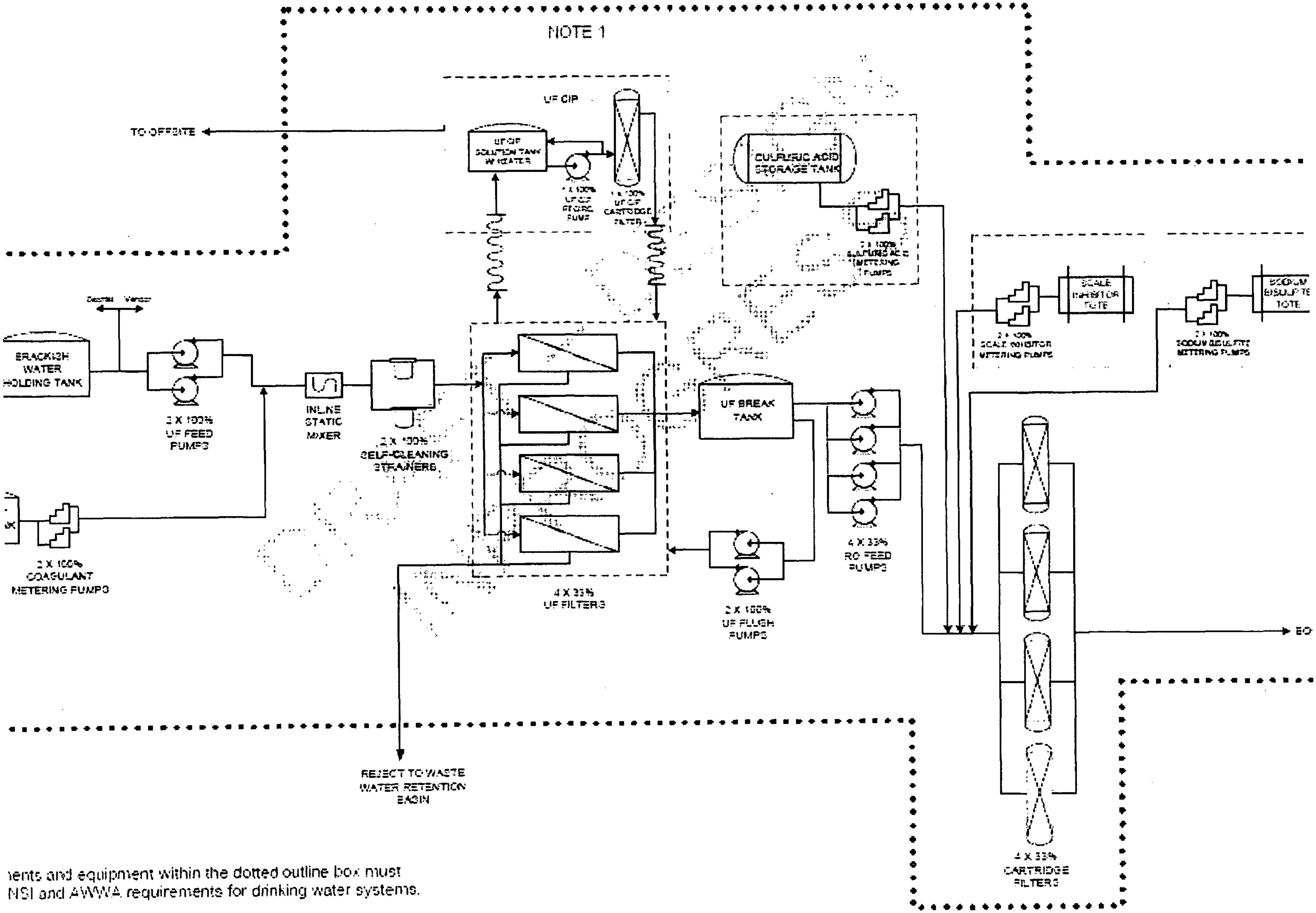
The proposed design for the Calvert Cliffs Unit 3 desalination plant includes installed spare trains for all active components, including the high pressure RO pumps, the Ultrafiltration (UFs) and ROs. This allows a spare train to always be available. Besides installed spares, additional spare parts provisions will also be in place, such as warehouse shelved parts, where practical (see Figures 1A & 1B and Table 1).

According to the water treatment suppliers' input and industry experience, although extremely unlikely, the largest risk of failure would be one of the high pressure RO pumps or their motor (approximately 10-13%). If there is no installed spare train of pumps in the design and there is no warehouse spare, the pump assembly could conservatively take approximately 10 weeks to be delivered. The CCNPP3 site plans to have an installed spare pump and other spare parts provisions for this pump which is expected to reduce the replacement time to an approximate 8-10 hour timeframe (with an additional 24 hours for mobilization and planning, for a total time of approximately 34 hours).

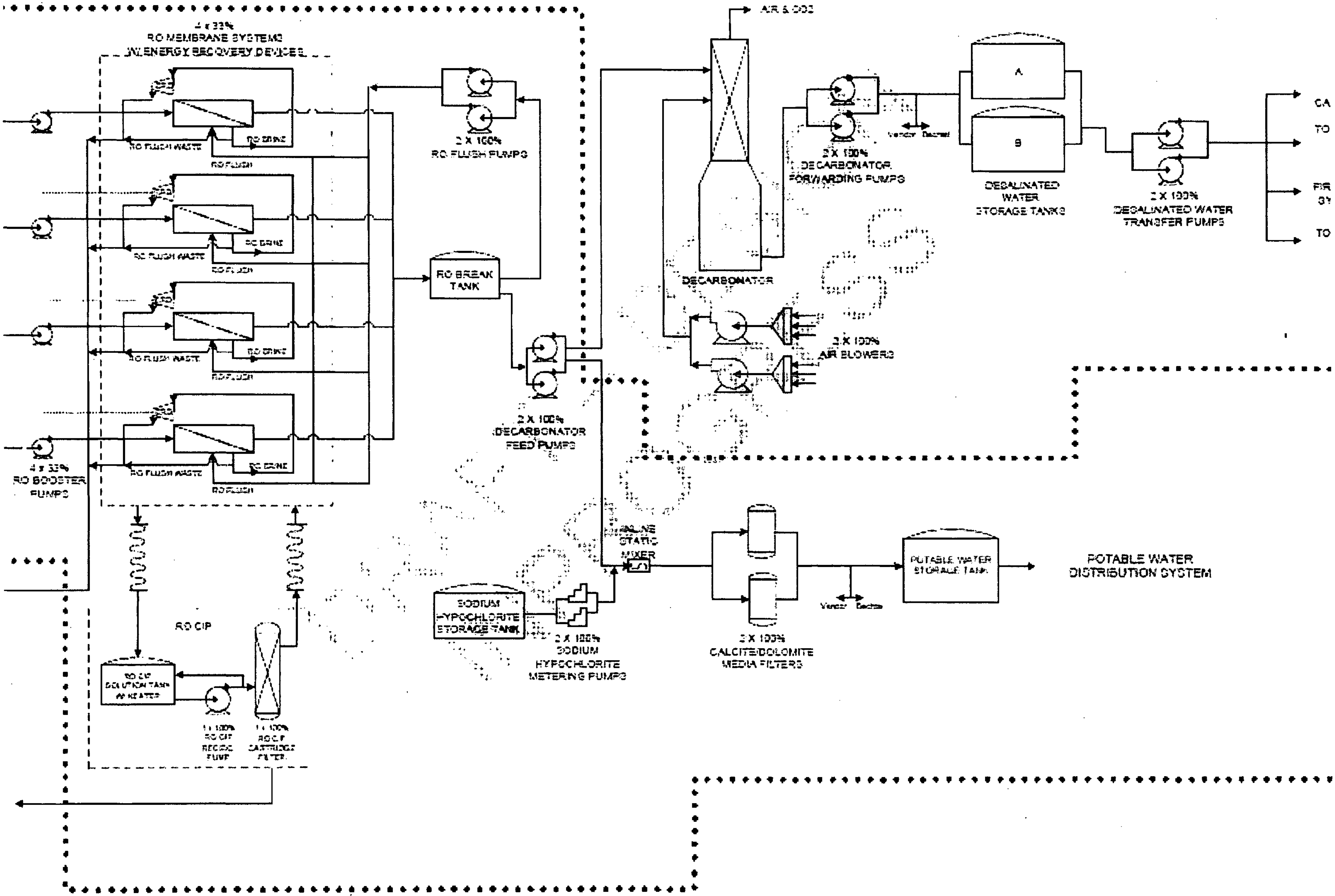
The second most likely risk of failure discussed was the UF and RO membranes. For equipment consumption, it is noted that 3-5% of the total membranes (RO & UF) may fail on average each year according to one water treatment supplier. Further, while the failed membrane may be under warranty, it must still be removed and sent to the manufacturer for inspection. A spare membrane would need to be installed until a determination is made as to warranty replacement.
(Note: Suspect RO membranes are typically removed due to accurate monitoring of the RO membrane performance and the ability to remove only the poorly performing RO membranes. Industry experience has been that the design of the new membranes is very 'robust' and very rarely fails in an installed system unless the pretreatment of the RO feed water is inadequate.)

As with the high pressure RO pumps, CCNPP3 will have an installed spare for both the UF and RO membranes and spare parts provisions to reduce the replacement time to an approximate 8-10 hour timeframe (with an additional 24 hours for mobilization and planning for a total time of approximately 34 hours).

The recommended CCNPP3 design will include installed spares and warehouse spares. For instance, the CCNPP3 design for UF and RO trains includes 4 33% trains of UF and RO membranes and their respective feed pumps, including the high pressure RO pumps. If these types of provisions for spares were not a part of the design, there would an approximate 2 week delivery timeframe associated with obtaining a replacement RO membrane and an approximate 6 week delivery timeframe associated with a replacement UF membrane, as shown in Table 1.



ients and equipment within the dotted outline box must
NSI and AWWA requirements for drinking water systems.



d equipment within the dotted outline box must comply with NSF/ANSI and AWWA requirements for drinking water systems.
height of both desal storage tanks to be approximately 40 feet.

3.4 Potential Issues That Could Shutdown The Desalination Plant

To properly assess issues (external and internal to the desalination plant) that have the potential to cause the desalination plant to be taken out of operation (including consideration of single or multiple points of failure), certain issues are excluded from this study. Issues that would shut down both the power plant and the desalination plant are not included (i.e., events that may create prohibitive Chesapeake Bay conditions, such as macrobenthic impacts; events that may prohibit the proper operation of the intake structure or loss of electrical power to the circulating water intake structure equipment, such as the circulating water makeup pump motors or perhaps flooding of the circulating water intake structure, etc.). Additionally, Loss of Offsite Power (LOOP) without Island Mode Operation (Ref. 5) or Station Blackout (SBO) conditions are also excluded since the desalination plant is not needed for safe shutdown of the power plant and no alternate sources are planned for the desalination plant during these conditions. Also, operator errors are not considered (i.e. valve mispositioning, accidental mix-up of chemicals used in the process, etc.). It is assumed that operator errors associated with operator actions can be addressed in a reasonable period of time.

- Possible Electrical Issues:
  a. Loss of the operating normal power supply*
     * [Note: A "loss of the operating normal power supply" to the desalination plant is a low probability, since the design for CCNPP3 includes a redundant normal power supply to the desalination plant for additional reliability. The desalination plant equipment is powered through the separate site specific transformer (i.e. different from the normal auxiliary transformer) from the switch yard. Any backup water supply equipment will be powered from the normal auxiliary transformer with an open crosstie breaker with the site specific transformer. This provides the redundant power supply to both desalination plant and alternate water supply equipment.
  b. Pump motor failure (particularly the high pressure reverse osmosis pump)
  c. Electrical or I&C component failure (i.e. fuses, Programmable Logic Controller, transformer failure, Motor Control Center issue, bus issue, breaker issue, solenoid valve malfunction, instrumentation malfunctions, etc.)

- Possible Mechanical Issues:
  a. Pump malfunction (particularly the high pressure reverse osmosis pump or energy recovery device)
  b. Ultrafiltration or reverse osmosis membrane failure/malfunction
  c. Filter clogging
  d. Pipe break (occurring for any reason anywhere between the branch from Circulating Water Makeup System piping and Raw Water Supply System piping to the desalination processing equipment; from the processing equipment to the tank or from the tank to any of the desalinated water users)
  e. Valve failure at a critical point in the Raw Water Supply System
  f. Tank leakage/damage (any tank from the brackish water holding tank, desalinated water storage tanks or the desalination process tanks)
  g. Loss of instrument air to the air-actuated valves or other air-operated control devices
  h. Flooding of the desalination building
  i. Impact of material choices for components or piping
  j. Issues due to improper pretreatment (if insufficient sampling)

k. Failure of a chemical injection or process

- Other Possible Issues:
  a. Major perturbation in Chesapeake Bay Water Quality parameters:
  Although major Chesapeake Bay water quality perturbation is a low probability event, nonetheless it may impact the performance of the RO system. The desalination plant will be designed to address the seasonal changes in Chesapeake Bay parameters. The system design will be based on local sampling at the existing intake structure area, global Chesapeake Bay parameters obtained from the Chesapeake Bay Program Water Quality database and expertise of the desalination equipment /system supplier.

Any of the representative issues noted above (internal or external to the desalination plant) have the potential to affect the operation of the desalination plant. Crediting the planned spare parts provisions, the most bounding replacement timeframe of 10 weeks (see Table 1, as follows) can be reduced significantly, as discussed previously in Section 3.3 and in this section. As a result, the replacement timeframe that is conservative to consider in this study is 2 weeks. This represents a bounding value for repair of potential equipment failures, electrical system failures, component failures or unforeseen Chesapeake Bay perturbations. Refer to Table 1 of this document for notes of potential equipment or component failures, actions and conservatively noted replacement timeframes. (Note: Potential Chesapeake Bay perturbations are not predicated on any known events). During the 2 weeks of projected unavailability of the desalination plant, the backup source of water needs to be aligned to allow continuous plant operation.

Table 1*
TYPICAL SPARE PARTS' POTENTIAL FAILURES AND ESTIMATED REPLACEMENT TIMEFRAMES

EQUIPMENT	Estimated Equipment Delivery Timeframes <24-Hours	< 1 Week	1 Week	2-3 Weeks	1 Month	>1 Month
-High pressure RO pump assembly						~ 10 weeks (motor can be rewound, if necessary)
High Pressure Pump (HPP) shaft seal				X		
HPP coupling				X		
Comments to HPP & Motor assuming operator error	**Potential Failures** – Pump & motor not aligned, not properly lubricated, preventative maintenance procedures not followed. All could cause a failure. **Potential Action** – Proper training and adhering to the maintenance routine. Install a dedicated redundant pump & motor and additional emergency spares if necessary. NOTE: This would be the same for all pumps.					
Energy Recovery Device (ERD) rotating assembly						~ 10 weeks
Comments to ERD assuming operator error	**Potential Failures** – Not aligned & preventative maintenance procedures not followed. All could cause a failure. **Potential Remedy** – Proper training and adhering to the maintenance routine. Recommendations from one supplier were to design the pump & motor assembly to operate without the ERD, if necessary and to include a spare rotor in stock; however, an entire warehouse spare ERD may be included in the spare parts program.					
Fuses			X			
Panel lights			X			
Pressure gauges			X			
Comments to electrical & instrumentation failures assuming operator error	**Potential Failures** – Preventative maintenance procedures not followed. No single instrument failure would shut the plant down. **Potential Action** – Proper training and adhering to the maintenance routine. All critical instruments would have built in redundancy.					
Chemical pumps					X	
Comments to chemical pumps' failures assuming operator error	**Potential Failures** – Preventative maintenance procedures not followed. No single chemical injection pump failure would shut the plant down. **Potential Remedy** – Proper training and adhering to the maintenance routine. All chemical pumps will have a duty spare installed, plus spare pumps and components will be kept on site.					
Reverse Osmosis Membrane		2-5 days (best case if standard shelf item with supplier)		~ 2 weeks (worse case)		
Ultrafiltration Membrane		2-5 days (best case if standard shelf item with supplier)				~ 6 weeks (worse case)
Comments to membrane failures assuming operator error	**Potential Failures** – Preventative maintenance procedures & cleaning regimes not followed. This would mean a slow degradation of the membranes and replacements can be phased in. It is highly unlikely but there have been plants that have had a membrane failure due to chlorine getting into the membranes, as an example. **Potential Action** – Proper training and adhering to the maintenance routine. A certain percentage of membranes are always kept on site. As part of the contractual agreement, a complete set of membranes will always be available within a contracted number of days. A small retainer would be charged, according to the suppliers.					
Water Treatment Tanks/Pressure Vessels		2-5 days (best case if standard shelf item with supplier)				
Comments to tanks failures assuming operator error	**Potential Failures** – Preventative maintenance procedures not followed or physical damage. **Potential Remedy** – Proper training and adhering to the maintenance routine and the tanks would need to be well protected. The design would minimize the tanks needed.					
Other consumables (i.e. Filters, other pump seals, etc.)		2-5 days (best case if standard shelf item with supplier)				
Comments to consumables' failures assuming operator error	**Potential Failures** – Preventative maintenance procedures not followed or physical damage. Not ordering consumables in time can run the risk of desalination plant shutdown without a properly maintained spare parts program. **Potential Action** – Proper training and adhering to the maintenance routine and computer generated purchasing. Stock multiples of what is consumed and develop local suppliers.					

* *Parts' Delivery and Replacement Note:*
Table 1 is a list of some of the typical spare parts that may be used in a typical desalination plant and the estimated time it would take to receive replacement parts. As the water treatment supplier has not been chosen and equipment manufacturers may vary within supplier organizations, this list may vary and is not comprehensive. With onsite spare parts, projections are that replacement should be possible within an 8-hour shift for most components with coordinated personnel quantities, transport equipment and other required supporting material available.

3.5 Alternative Sources Of Fresh Water Evaluated

As noted in the Introduction section of this document, the Environmental Report for the proposed power plant contains an extensive discussion of the proposed intake location for CCNPP3 and the remainder of the property shoreline. Alternate intake locations on the Bay are not feasible due to potential environmental impacts and associated significant costs. As a result, alternative water sources were pursued, and discussed in the following subsections of this study.

The following alternative sources of fresh water were evaluated as emergency backup sources of fresh water in the unlikely event that the desalination plant should be taken out of service.

3.5.1 Trucked Water Options

- Fresh Water Trucking

Discussions with a local fresh water trucking company provided an option of delivering municipal water by truck at less than 24 hours of notice. This particular company can have 5 to 6 trucks readily available at any one time operating 24 hours a day and can fill the desalination tanks from 2 separate locations on the tank simultaneously, per the company owner.

The trucks contain their own power, pumping capacity to fill the 40 ft desalinated water storage tanks and their own piping, with only the need for a threaded connection. Given that the tanks will likely have only flanged connections, flange to threaded piping adapters will need to be kept available. No additional treatment would be required for this option to supply the desalinated water demands, including the potable water system.

Each truck has regulatory restrictions to haul a maximum of 7,000 gallons in one load. As a result, four trucks would have to be available to simultaneously fill the two desalinated water tanks every 30 minutes in order to keep pace with the desalinated water demands. This 30-minute window would have to be a sufficient amount of time for these trucks to return to the nearest fresh water source, get refilled and also be able to return to the site and continue the cycle of filling the desalinated water storage tanks to meet the approximately 900 gpm of required flow. This option would be logistically very challenging to maintain and would cause an increase in the road traffic into and out of the plant site. The viability of this option is not being pursued further at this time.

- Portable Desalination Trailers

Portable desalination trailers can be leased or purchased that would provide a continuous temporary supply of desalinated water if the desalination plant is out of service for a prolonged period of time. The leased option can be configured with fairly short notice, but based upon the availability of the needed components from the supplier. The trailers would be delivered by the water treatment supplier at the earliest possible timeframe and would be maintained and operated by the supplier, as needed, then taken away when no longer needed.

The purchase option supplier requires additional time (see Table 2) to put the trailers together as it is a specialty plant that would be specific to Calvert Cliffs only. This option would need to be maintained over the years even if not used regularly.

Increased capacity can be obtained by adding more trailers, as necessary.

Significant disadvantages of either trailer option must be pointed out such as:

1. The full capacity of 900 gpm is not immediately available within the 11 hour timeframe that it would take to empty the desalinated water storage tanks.

2. Chesapeake Bay perturbations such as oil & grease spills/dumps, TSS spikes, COD and BOD loading and seasonal changes in salinity of the Bay water could impact the availability of this option since the water source, like the permanent desalination plant, is the Chesapeake Bay.

3.5.2 Barged Options

The barge would have to be located and be available. Barge companies that stated available service to the Calvert Cliffs area, such as McDonough Marine and Poseidon, indicated that leased barges are largely "first come, first serve". Leasing may be by the day at one company or have multi-month minimum lease periods.

Poseidon indicated that their barges are sized at approximately 40'Lx10'Wx7'H (and can travel to the area depending on wave/tide action, etc. at approximately 5 to 6 knots) and have a cargo capacity of 17 tons to maintain the 2.5' draft they require. Their barges are considered 'platform barges' and can carry containers or drums. A client would have to arrange for their own tugboat to push the barge and the client would have to locate and make arrangements separately with a fresh water supplier.

McDonough Marine indicated that the barge locations to support the Calvert Cliffs area would be from Norfolk or Baltimore. Their barges in these areas range in size and capacity from 110'Lx30'Wx7'H with a cargo capacity of 200 tons to 180'Lx54'Wx12'H with a cargo capacity of 2,200 tons. Their barges have an internal coating, but not a coating that allows water to be hauled for potable purposes. Any potable grade water would have to be hauled in *FDA approved* containers and the water supplier would have to be located & priced by client separately. They also indicated that tugboats are available from the company on an hourly rental basis and the client would have to locate and make arrangements separately with a fresh water supplier.

- Barged Fresh Water

References to fresh water in this section are referring to the grade of water that would be obtained from a municipal water source and as such, the water would be suitable for potable/sanitary purposes, as well as other desalinated water purposes. Fresh water from other sources may require additional treatment for potability.

The logistics of barging fresh water from an offsite location raises certain considerations:

1. If a barge can be made available from the nearest location, Baltimore, a tugboat would also have to be available and retained on an hourly basis to pull the barge to the Calvert Cliffs area. Separate provisions would have to be arranged for the fresh water. This water would not be able to be placed directly into a barge with built-in compartments as the barges are not designed for fresh water hauling. Their compartments' coating would not be approved to haul

potable quality water. Fresh water containers would instead have to be located and stacked onto the barge.

2. The amount of fresh water that can be delivered will have to be estimated. A gauge of the capacity will be based upon Ref. 2 and the barge companies' input, as noted above, which indicates that a barge may accommodate 60 times the capacity of what may be trucked. Using the truck restriction over the road at 7,000 gallons, a 200 ton-capacity barge carrying about 400,000 gallons of fresh water may be possible. Given the daily requirement of over 1,200,000 gallons per day (10,008,000 pounds), three of the 2,200-ton capacity barges would be needed each day with provisions to transport the water from the dock area to the desalinated water storage tanks. The viability of this option is not being pursued further at this time given obstacles, such as the lack of a definitive fresh water source that is readily permitted for use, the unknowns surrounding treatment requirements for the fresh water and the long term availability of the fresh water source.

- Barged Containerized Desalination Units

A barged desalination plant can be an option where significant acreage may not be available to allow temporary desalination provisions to be located.

Given the barge dimensions noted for the fresh water barge option, 2 to 3 of the largest barges and accompanying tugboats would have to be available when needed for accommodating the footprint of a barged containerized desalination unit with the capacity to continuously supply the flowrate requirements to the desalinated water users via the desalinated water storage tanks and to the potable and sanitary water system upstream of the additional treatment points for potability as required.

Disposing of the reject stream would have to be considered, including any possible permitting issues that this option may introduce. Additionally, an electrical substation and a piping system would be needed. Also, as discussed in Section 3.5.1 for the portable desalination trailers, there are Chesapeake Bay perturbations that could impact the availability of this option since the water source is still the Chesapeake Bay brackish water piped via the Circulating Water Makeup System piping enroute to the circulating water cooling tower.

As noted earlier in Section 3.5.1, Chesapeake Bay perturbations also could impact the availability of this option since the water source, like the permanent desalination plant, is the Chesapeake Bay.

The barged desalination units would have to be maintained ready onsite or at a remote location in order to have the units as a readily available backup to the permanent desalination plant. The viability of this option is not being pursued further at this time.

3.5.3 Piped Option

Another option considered would be routing a pipeline from nearby St. Leonard township (approximately 10 miles) to the Calvert Cliffs site to fill the desalinated water storage tanks, if needed, as a backup source of fresh water.

This water would be municipal drinking quality water with no anticipated treatment requirements; however, the unforeseen costs that may arise from routing piping through residential areas, any potential permitting issues or potential public resistance could make this option unviable to pursue at this time. This study includes no further development of this option.

3.5.4 14-Day Desalinated Water Storage Pond Option

Additionally, an option was considered of installing a pond sized for at least 17,500,000 gallons of desalinated water capacity. The initial fill of the pond would come from the desalination plant. This option would provide a reserve volume of desalinated water sufficient to account for a potential 14-day downtime of the desalination plant.

With the passage of time, however, the desalinated water stored in a pond would have significantly deteriorated due to contaminants picked up from the atmosphere, waterfowl waste, biological growths, cooling tower drifts, rainfall runoff, etc. Although the concept of a covered pond would mitigate some of these issues, the concept of covering such a large body of water is not a practical solution from cost, logistical, operational or design standpoints.

An uncovered pond was found to be a more economical choice from a capital cost standpoint. Although the capital cost for an uncovered pond initially appears comparable to other alternate water options, the unrealized operations and maintenance (O&M) costs of an uncovered pond of such a large size is projected to be very high given O&M activities such as the following:

- Periodic dredging requirements due to solids' buildup at the bottom of the pond;
- Treatment processes such as filtration, disinfection and potentially other treatment processes (depending on what contaminants would be present) would be required before transferring water from the pond to the Desalinated Water Tanks. Treatment components such as filtration will require periodic maintenance and even replacement whether these components are used or sit idle.
- Continuous makeup to the pond could likely require upsizing the capacity of the desalination plant to keep pace with losses, such as evaporation and seepage.
- The pump and any other supporting components and instrumentation would also require periodic maintenance in order to ensure that this option will be available as the backup to the desalination plant should an emergency ever arise.

The location for the pond would be in the construction batch plant area, which is near the desalination/water treatment building. In order for the pond to be available at the startup of the power plant, the construction batch plant area would need to be made available to construct the pond.

3.5.5 14-Day Desalinated Water Backup Storage Tanks' Option

An additional storage option involving the installation of backup storage tanks was considered. This option would also provide a reserve volume of desalinated water sufficient to account for the potential 14-day shutdown of the desalination plant. A total of 17.5 million gallons of desalinated water is proposed to be stored in four 4.3 million gallon capacity tanks. As noted earlier for the pond option, the initial fill for the tanks could come from the desalination plant.

Makeup should be minimal; however, there are also Operations and Maintenance (O&M) activities to be considered such as maintaining the pump and any other supporting components and instrumentation periodically. Also, there are contaminants, such as bacteria, particulates and metal oxides, that may be introduced in this option from having the desalinated water sitting idle for long periods of time, even years, that will challenge the quality of this water. One of the advantages of the backup tanks' option is that the pumps can be operated periodically in recirculation mode, which can help to avoid problems typically associated with stagnation and serve as a means of ensuring that the pumps are operational.

As previously discussed for the pond option, this water should be capable of supplying water to produce potable water. There may also be difficulties in assuring that this water (which has sat idle for long periods of time) can be made acceptable for drinking and sanitary purposes from a state or local government permitting standpoint.

The location for the backup tanks would be in the construction batch plant area. As with the pond, in order for the tanks to be available at the startup of the power plant, the construction batch plant area would need to be made available to construct the tanks.

3.5.6 Groundwater Well Options (Ref. 7)

From shallow to deep, the local aquifer systems in southern Maryland (see Attachment 1A for a schematic cross-section of the hydrostratigraphic units) are as follows:

- Surficial aquifer
- Piney Point - Nanjemoy aquifer
- Aquia aquifer
- Magothy aquifer
- Potomac Group of aquifers include:
  - Upper Patapsco aquifer
  - Lower Patapsco aquifer
  - Patuxent aquifer

Surficial Aquifer

Within the southern Maryland region, the Surficial aquifer is not a reliable source of large quantities of groundwater. This is due to its relative thinness, limited saturated thickness (particularly during prolonged drought), and topographic dissection by deeply incised stream channels which causes the aquifer to be subdivided into relatively small areas that are hydrologically isolated from each other. The Surficial aquifer is tapped by irrigation wells and some older farm and domestic wells, but it is not widely used as a potable water supply because of its vulnerability to contamination and reduced dependability during droughts. Wells completed in this aquifer generally yield less than 50 gpm. At the Calvert Cliffs site, portions of the Surficial aquifer have been eroded by streams and the aquifer is not present below an elevation of about 65 ft above mean sea level (msl).

Chesapeake Group

From youngest to oldest, Chesapeake Group consists of the Saint Mary's, Choptank, and Calvert Formations. The Chesapeake Group is a significant aquifer east of the Calvert Cliffs plant site in the Delmarva Peninsula. However, beneath the western shore of Maryland, in the vicinity of the Calvert Cliffs site, the Chesapeake Group is described as a confining unit. With the exception of a relatively thin sandy unit at its base (lower Calvert Formation), the silts and clays of the Chesapeake Group are hydrostratigraphically undifferentiated, and they comprise the Chesapeake Confining Unit, which separates the overlying Surficial aquifer from the underlying Piney Point - Nanjemoy aquifer.

Although thin and discontinuous sand units capable of producing small quantities of groundwater are present locally, these saturated materials within the Chesapeake Confining Unit beneath the western shore of Maryland may yield water, but not of quantities sufficient for most uses. The localized sand units are recharged by precipitation and percolation through the overlying Surficial aquifer, moving a few miles or less downgradient along the flow path, and discharging to the Chesapeake Bay, streams, or localized areas of pumping.

A boring log from a production well at the Calvert Cliffs site indicates that the base of the Chesapeake Confining Unit is at an elevation of approximately –205 ft msl and its total thickness is approximately 250 ft.

Piney Point – Nanjemoy Aquifer

The Piney Point - Nanjemoy aquifer is stratigraphically complex, consisting of several geologic units.

The Piney Point Formation thickens to the southeast and ranges from 0 ft in central Calvert County to approximately 45 ft thick in southern Calvert County at Solomons. A boring log from a production well at the Calvert Cliffs site indicates that the base of the Piney Point Formation is at an approximate elevation of –225 ft msl and its total thickness is approximately 10 ft.

The Nanjemoy Formation coarsens upward overall from predominantly sandy silts and clays to dominantly clayey sands. This allows it to be subdivided into two hydrostratigraphic units. The sandy upper Nanjemoy Formation is hydraulically connected to the overlying Piney Point Formation and is assigned to the Piney Point - Nanjemoy aquifer. The more clayey sediments of the lower Nanjemoy Formation are placed in the Nanjemoy Confining Unit. A boring log from a production well at the Calvert Cliffs site indicates that the base of the coarser grained upper Nanjemoy Formation (bottom of the Piney Point - Nanjemoy aquifer) is at an approximate elevation of –315 ft msl and the total thickness of the Piney Point - Nanjemoy aquifer is approximately 115 ft.

Although a few major users in southern Calvert and St. Mary's counties pump from the Piney Point - Nanjemoy aquifer, it is primarily used for domestic water supply. Domestic well yields are generally less than 20 gpm, with maximum reported well yields of up to 200 gpm in the Piney Point Formation and up to 60 gpm in the Nanjemoy formation.

Aquia Aquifer

The Aquia Formation is poorly to well sorted, shelly, and contains glauconitic quartz sand with carbonate cemented sandstones and shell beds. The Aquia Formation (aquifer) dips to the southeast with its upper surface ranging in elevation from approximately -100 ft msl in northern Calvert County to -500 ft msl just off Solomons in southern Calvert County. A boring log from a production well at the Calvert Cliffs site indicates that the base of the Aquia aquifer is at an approximate elevation of –560 ft msl and its total thickness is approximately 145 ft.

Aquia aquifer transmissivity maps derived from pumping tests display a general correlation to Aquia aquifer thickness maps, with highest transmissivity values in areas of greatest aquifer thickness. Reported transmissivities in northern Calvert County at Randle Cliff Beach are 1330 ft^2/day where the Aquia reaches its maximum thickness of approximately 200 ft. Farther south, at Solomons, reported transmissivities are 755 ft^2/day where the aquifer thins to approximately 145 ft. A transmissivity of 935 ft^2/day is reported at the Calvert Cliffs site. Storage coefficient values of the Aquia aquifer determined from pumping tests in southern Maryland range from 4×10^{-4} to 1×10^{-4}.

The Aquia formation is a productive aquifer with reported well yields of up to 500 gpm. Attachment 1B is a summary of selected well completion reports and indicates that the average yield of 78 wells with screen diameters five inches or greater is about 200 gpm. Recharge to the Aquia aquifer is from direct infiltration of precipitation in central Anne Arundel and Prince George's counties where these units are exposed at the surface. Natural discharge of the Aquia aquifer is to the southeast, primarily from subaqueous exposures of the aquifer that are presumed to occur along the Continental Shelf. Other discharge occurs at local pumping locations.

The Aquia aquifer is used extensively for domestic and major-user water supplies in southern Maryland. By the 1980s, a deep cone of depression (up to 100 ft) in the potentiometric surface had developed in the Solomons area of Calvert and St. Mary's county where it is heavily pumped for public, commercial, and military supplies. This cone of depression has diverted the groundwater flow direction in Calvert County to the south and southeast toward this pumping center. Because of these considerations, water supply managers in these counties are seeking to shift some groundwater usage from the Aquia aquifer to deeper aquifers.

Brightseat Confining Unit

The confining unit underlying the Aquia aquifer is composed of several geologic units. These include the lower Paleocene Brightseat Formation and several upper Cretaceous units, including the Monmouth, Matawan, and Magothy Formations. The fine-grained sediments of these formations combine to form the hydraulically indistinguishable Brightseat Confining Unit. The Brightseat Confining Unit has a composite thickness ranging from approximately 20 to 105 ft. A boring log from a production well at the Calvert Cliffs site indicates that the base of the Brightseat Confining Unit is at an elevation of approximately -590 ft msl and the unit attains a thickness of approximately 30 ft.

Most researchers model the Brightseat Confining Unit as a no-flow boundary; however, a few vertical hydraulic conductivity and specific storage values have been reported. Samples from Prince George's County yielded vertical hydraulic conductivity and specific storage values of 9.5×10^{-4} ft/day and 7.4×10^{-5} ft^{-1}, respectively.

Magothy Aquifer

The Magothy aquifer consists of interbedded red, brown, and gray sands and clays. The Magothy aquifer is present in the northern and central portions of Calvert County where it is used extensively for public and domestic supplies. It thins to the south and pinches out in southern Calvert County where it is not a significant aquifer.

Transmissivities of 450 ft^2/day to 4,570 ft^2/day have been reported for the Magothy aquifer in southern Anne Arundel County. Reported transmissivity values for southern Maryland counties range from 1,000 ft^2/day to 12,000 ft^2/day. The primary use of this aquifer occurs in Anne Arundel, Prince George's, and Charles counties.

A boring log from a production well at the Calvert Cliffs site indicates that the base of the Magothy aquifer is at an elevation of approximately -610 ft msl and the aquifer appears to attain a thickness of less than 25 ft. As a result, since the southern boundary of the Magothy aquifer is near the Calvert Cliffs site, there is reason to believe that there is not significant thickness at the Calvert Cliffs site to provide the necessary yield.

Potomac Group

The lower Cretaceous Potomac Group consists of the following (in descending order): the Patapsco, Arundel, and Patuxent Formations. These units form a thick (greater than 1500 ft) series of unconsolidated sediments, which locally contain three confining units and three aquifers. Because of the significant depth of these formations, and the abundance of exploitable supplies of groundwater in shallower aquifers, these units are not currently used as a significant source of groundwater in the vicinity of the Calvert Cliffs site. Consequently, available hydrogeologic information for the Potomac Group of aquifers and confining units is limited.

The Upper Patapsco aquifer underlies the Magothy aquifer and is separated from it by clayey units in the top of the Patapsco Formation and bottom of the Magothy Formation. These clayey units are collectively referred to as the Upper Patapsco confining unit. The Upper Patapsco aquifer includes sand units in the upper part of the Patapsco Formation. This aquifer is not continuous and is comprised of complexly stratified sandy units separated locally by silts and clays. Individual sand units in the Upper Patapsco aquifer are difficult to correlate laterally, but they appear to be sufficiently interconnected at the regional scale to form a single aquifer. The aquifer is recharged by precipitation at outcrops in western and northern Charles, Prince George's and Anne Arundel counties. It subcrops beneath the tidal part of the Potomac River, where river water intrusion has been documented in the Indian Head area.

The Upper Patapsco aquifer is extensively used for public supply in central Charles County, where a cone of depression to an elevation of about -120 ft msl has formed in the potentiometric surface. The aquifer is also pumped heavily by major users in Prince George's and Anne Arundel counties. Upper Patapsco transmissivities reported for Charles and Anne Arundel counties range from 1,000 ft^2/day to 10,000 ft^2/day. A few major users pump the Upper Patapsco aquifer in northern St. Mary's and Calvert counties.

The Lower Patapsco aquifer underlies the Upper Patapsco aquifer. The two aquifers are separated by clayey units forming the Middle Patapsco confining unit in the middle part of the Patapsco Formation. The Lower Patapsco aquifer is comprised of sandy units in the lower part of the Patapsco Formation. The aquifer extends northeast to northern Anne Arundel County, but its correlation to the west and southwest is uncertain. It extends across the Chesapeake Bay to the eastern shore of Maryland. The Lower Patapsco aquifer is pumped heavily by users in central and northwestern Charles County, but there are few users in St. Mary's or Calvert counties. A well completed in the Lower Patapsco aquifer was drilled at the Cove Point LNG terminal approximately 3.85 miles south of Calvert Cliffs in 2008. That well is 1702 ft deep and yields a reported 953 gpm. Pumping tests performed in the Lower Patapsco aquifer in western Charles County yielded a transmissivity of 1,130 ft^2/day. Specific capacities for the tested wells ranged from 1.8 gpm/ft to 7.1 gpm/ft. Lower Patapsco aquifer transmissivities reported for Charles and Anne Arundel counties range from 1,000 ft^2/day to 5,000 ft^2/day.

The Patuxent aquifer lies below the Lower Patapsco aquifer, and is separated from it by the Arundel confining unit. The Arundel Formation consists of a thick series of dense clays and silts and probably allows very little leakage. However, the Arundel Formation is not uniformly recognized in southern Maryland.

The Patuxent aquifer is the deepest Coastal Plain aquifer in Maryland, and rests on the Piedmont bedrock surface. Patuxent aquifer transmissivities reported for Charles and Anne Arundel counties range from 200 ft^2/day to 8,000 ft^2/day. Pumping tests performed in the Patuxent aquifer in western Charles County yielded a transmissivity of 937 ft^2/day. Because of its great depth and the known presence of brackish water in the Patuxent aquifer in coastal areas, its potential for development is thought to be limited.

<u>Potential for Subsidence Induced by Groundwater Withdrawals</u>

Land subsidence may be caused by large drawdown in potentiometric head resulting from groundwater withdrawals if sediments are compressed due to loss of hydrostatic pressure.

Generally, compaction of sediments induced by groundwater pumpage is relatively small until water-level declines exceed the previous maximum stress on the sediments, which is referred to as the preconsolidation stress.

It has been estimated that, for the Atlantic Coastal Plain, the preconsolidation stress equivalent is about 65 ft below sea level and that water levels reduced to the 80-percent management level in the Aquia aquifer near Lexington Park in St. Mary's County, Maryland could result in land subsidence of 0.73 to 1.09 ft. The 80-percent management level is defined by the Maryland Department of the Environment as 80 percent of the total available drawdown, measured from the pre-pumping water level to the top of the aquifer (refer to Attachment 1C of this study).

Attachment 1F of this study shows that the elevation of the 80-percent management level in the Aquia aquifer near Lexington Park is -358 ft msl. Based upon these data, the maximum ratio of subsidence to drawdown to be expected in the Aquia aquifer is about 0.0037:
1.09 ft subsidence / [-65 ft – (-358 ft)] drawdown = 0.0037
Therefore, if pumping during the 6-year construction period for Unit 3 were to induce 52 ft of water-level drawdown in the Aquia aquifer at Calvert Cliffs, as determined by a numerical model prepared by Bechtel Power Corporation, a maximum of about 0.192 ft (2.31 inches) or about 0.032 ft per year (0.38 inch per year) of subsidence could potentially occur. Because of the length of time required for drainage of the thick confining units above the Aquia aquifer, the actual subsidence rate is likely to be less than this value and subsidence would continue after water levels in the aquifer have stabilized. This estimated subsidence rate is the maximum that would occur over the area of greatest drawdown. A lower average rate would apply over the area of influence of the pumping wells and subsidence would be distributed over a large area as the stresses are redistributed vertically.

It should be noted that the simulated rate of pumping in the Bechtel model during the construction period (738,000 gpd) is conservative as it is substantially greater than the annual average of 550,000 gpd that could be withdrawn (a daily average on an annual basis of 450,000 gpd authorized by the Water Appropriation Permit for Units 1 and 2 [Ref. 11] plus 100,000 gpd authorized for construction of Unit 3 by Condition 17 of the CPCN). The Water Appropriation Permit for Units 1 and 2 authorizes withdrawal of a daily average of up to 865,000 gallons during the month of maximum use, but that rate is not authorized over the multi-year construction period that the Bechtel numerical model simulates. The total authorized withdrawal rate of 550,000 gpd is about 75 percent of the rate simulated in the Bechtel model. For this reason, the simulation results of the Bechtel model should be considered a bounding analysis of the maximum drawdown that can reasonably be expected from groundwater withdrawals to support construction of Unit 3.

Based on this analysis, there would be no significant impact to plant safety due to subsidence from increasing groundwater withdrawals from the Aquia aquifer by the 100,000 gpd authorized by the CPCN for the approximate six years of Unit 3 construction. Occasional withdrawals after construction is complete, during routine or emergency shutdowns of the desalination plant (i.e. withdrawal was conservatively analyzed for a period of 10 weeks, if required), to provide the back-up fresh water supply at a rate of approximately 900 gpm also would not induce significant subsidence (although the shutdown needs would be much less than 10 weeks, as noted in Sections 3.3 and 3.4 of this study). Although the water level in the vicinity of Calvert Cliffs will be lowered temporarily, the Bechtel model predicts (even at the higher rate modeled) that following the six-year pumping period, water levels return in approximately three years to where the regionally predicted water level would have been if the pre-construction pumping rate had been maintained.

Analysis of the Available Data

Calvert Cliffs Unit 3 will require an emergency back-up water supply capable of yielding approximately 900 gallons per minute (gpm) for a period of up to 10 weeks when the desalination plant is not in service. As stated previously, withdrawal was conservatively analyzed for a period of 10 weeks. Assuming that the key spare parts for emergency repair of the desalination plant are on hand in an on-site warehouse, the period during which a back-up groundwater supply is required could be reduced to approximately 10 days to 2 weeks maximum. The Surficial aquifer and local aquifers within the Chesapeake Group are not capable of reliably producing the required supply.

Groundwater withdrawals from the coastal plain aquifers of southern Maryland over the past decades have resulted in significant drawdowns of regional extent. For this reason, the Maryland Department of the Environment (MDE), Water Management Administration (WMA) assumes an active role in managing the groundwater resources of southern Maryland. Although the Piney Point – Nanjemoy aquifer may be capable of reliably producing the required supply, this aquifer is now generally allocated for domestic use. Users of larger volumes of water are generally encouraged to withdraw from deeper aquifers.

The Aquia, Upper Patapsco and Lower Patapsco aquifers are each capable of producing the supply required by Unit 3. The five wells that provide fresh water to Calvert Cliffs Units 1 and 2 are completed in the Aquia aquifer. These wells each yield an average of about 300 gpm and average 620 feet deep. Condition 17 of the Certificate of Public Convenience and Necessity (CPCN) issued by the Maryland Public Service Commission authorizes UniStar to appropriate and use a daily average of 100,000 gallons (gpd) on an annual basis from up to two wells to be drilled into the Aquia aquifer to support construction of Unit 3.

Groundwater withdrawn from the Unit 1 and 2 production wells is reported to contain arsenic at concentrations greater than the U.S. Environmental Protection Agency Maximum Contaminant Level (MCL) of 10 micrograms per liter. These wells also produce groundwater containing iron at concentrations greater than the Secondary MCL of 0.3 milligrams per liter. Therefore, it should be assumed that if the back-up groundwater supply for the desalination plant were to be developed from the Aquia aquifer it would likely require treatment to remove arsenic and iron (refer to Section 3.6.1 of this study for further discussion of the treatment). Further, the available information regarding the yield of wells completed in the Aquia indicates that at least three wells approximately 600 ft deep would likely be required to provide a supply of 900 gpm.

Public information regarding well yield and groundwater quality in the Upper and Lower Patapsco aquifers in southern Calvert County is scant. Because of the depth of these aquifers and the perceived abundance of water in more shallow aquifers, few wells have been drilled into the Upper or Lower Patapsco aquifers in the vicinity of Calvert Cliffs. However, recent published research indicates that the water-yielding characteristics of these aquifers are relatively good.

A Well Completion Report for a production well drilled in 2008 into the Lower Patapsco aquifer at the Cove Point LNG terminal approximately 3.85 miles south of Calvert Cliffs indicates the well is 1702 ft deep and was tested with a yield of 953 gpm. Discussions with the water-well drilling contractor who drilled the well revealed that a similarly productive zone was encountered within the Upper Patapsco Formation several hundred feet above the zone in which the well was completed. That zone was approximately 800 to 1,000 ft deep. The report of analysis of a groundwater sample collected from the Cove Point well indicates water of generally good quality, and in compliance with Federal drinking water standards, that would not require treatment to remove arsenic or iron.

Recommended Aquifer for Development of a Back-Up Groundwater Supply

These results suggest that it may be possible to develop the required yield from the Upper or Lower Patapsco aquifers. Further, it seems likely that the quality of groundwater from these aquifers would be acceptable. Attachment 1C lists water-quality analytical results for wells in these aquifers.

It would be prudent to coordinate development of a backup supply for operation of Unit 3 with development of a groundwater supply to support construction of Unit 3. However, the allocation from the Aquia aquifer to support construction provided in Condition 17a of the CPCN is for an average of only 100,000 gpd (69.4 gpm) on a yearly basis. If the backup supply for operation of Unit 3 is to rely upon wells drilled into the Aquia based upon this allocation, an additional 830 gpm will be required, totaling 900 gpm.

Based upon these findings, there are two alternative courses of action:

1. Drill the required number of test/production wells into the Upper Patapsco aquifer. If no suitable productive zone is encountered above a depth of approximately 1,000 ft below grade, advance the test/production well(s) deeper and complete them in the Lower Patapsco aquifer. These wells would likely produce groundwater of sufficient yield and quality to provide both the required back-up supply when the desalination plant is out of service and the supply to support construction of Unit 3. Condition 17a of the CPCN authorizes withdrawal of a daily average of 100,000 gpd from the Aquia aquifer to support construction. Drawing from the Upper or Lower Patapsco aquifers, rather than from the Aquia aquifer, may be a better alternative since there are few high-yield production wells currently existing in these deeper aquifers in southern Calvert County. Therefore, withdrawals from the Upper or Lower Patapsco aquifers by CCNPP3 would have less of a regional effect on the potentiometric surfaces of these aquifers.

2. Drill the required number of test/production wells into the Aquia aquifer as authorized by CPCN Condition 17c. Construct the wells so as to provide the maximum yield that the formation will allow, but restrict the combined withdrawals from the wells to the average of 100,000 gpd on a yearly basis allocated by CPCN Condition 17a. After completing construction of Unit 3, when a back-up water supply for the plant will be required, an additional well may be needed if the combined yield of the currently drilled wells is less than the approximate 900 gpm required for the backup option to meet. The anticipated use on an occasional basis for a maximum of 2 weeks when the desalination plant is out of service would create a negligible long-term draft on the aquifer. Use of the Aquia aquifer also may require treatment of the groundwater to remove arsenic and iron. See the discussion in Section 3.6.1 of this study for a more detailed groundwater treatment discussion.

The recommended location for the proposed wells, regardless of which aquifer is developed, is in the vicinity of the desalination plant. In this way, the wells would be conveniently located near the desalination plant for further processing, would induce negligible water-level drawdown interference with the existing production wells for Units 1 and 2 [see Attachment 1E, the closest of which is approximately 3,300 ft from the desalination plant] and would be relatively close to the location of the concrete batch plant, where much of the water to support construction will be needed. Wells completed in the Aquia aquifer should be separated by a horizontal distance of at least 500 feet, to minimize water-level interference between pumping wells and maintain pumping water levels above the 80-percent management level. If wells are completed in different aquifers they could be located closer to each other because water-level interference between the wells would not be significant.

Because of the depth of the three aquifers recommended for consideration as a source of backup water for Unit 3 operation, it would not be practical to conduct a test boring program to evaluate their yield potential and groundwater quality before drilling a production well at the Unit 3 site. Instead, a test/production well should be advanced at the site of each proposed production well. Samples of the formation collected while drilling the test well, the driller's log and the results of a down-hole geophysical survey should be used to determine the target depth for completion of the production well. The test well can then be reamed to the proper diameter for construction of a production well that will provide the maximum yield. After construction is complete, each new production well will be test pumped to determine its sustainable yield and groundwater quality.

At this time, development of a numerical model of the target aquifers is not recommended to simulate the effects of pumping the proposed wells. A relatively simple analytical model can be used to predict water-level drawdown resulting from operation of the new wells. As indicated by the analysis in the following paragraphs, whether the required groundwater supply is developed from the Aquia, Upper Patapsco or Lower Patapsco aquifers, the potentiometric surface in each aquifer would remain above the MDE 80-percent management level at each well.

The primary criterion used by the MDE for evaluating water-appropriation permit applications in the confined aquifers of the Maryland Coastal Plain is the "80-percent management level" (see Attachment 1D of this study). The 80-percent management level is defined as 80-percent of the available drawdown in an aquifer, measured from the pre-pumping water level to the top of the aquifer. MDE regulates ground-water users to prevent the regional potentiometric surface from declining below this level. This regulation is intended to prevent water levels from declining below the top of an aquifer, and thus causing partial dewatering of the aquifer near large production wells. This surface for the Aquia aquifer is illustrated in Attachment 1F of this study, which indicates an elevation of about –350 ft msl in the vicinity of Calvert Cliffs.

The elevation of the potentiometric surface in the Aquia aquifer near Calvert Cliffs in 2002 was about -110 ft msl. As noted above, properly constructed wells in the Aquia aquifer can yield about 300 gpm. Based upon the Theis Equation and the aquifer parameters noted above, the drawdown in each well after 10 weeks of pumping three wells spaced 500 ft apart, assuming 70% efficient production wells, would be about 235 ft. Increasing drawdown in the Aquia aquifer by 235 ft from the 2002 level of about – 110 ft msl would result in a groundwater elevation in the production wells at Calvert Cliffs Unit 3 of about – 345 ft msl, which is above the 80-percent management level for this aquifer.

For the Upper Patapsco aquifer, the 80-percent management level in the vicinity of CCNPP is about -550 ft msl (Attachment 1H of this study). The transmissivity of the Upper Patapsco aquifer near Calvert Cliffs is about 2,500 ft^2/day. Assuming a storage coefficient of 1×10^{-4} and a pumping rate of 500 gpm, the Theis Equation yields a drawdown in each well of about 145 ft after 10 weeks of pumping two wells spaced 25 ft apart in this aquifer, assuming 70% efficient production wells. The two pumping wells would be spaced at least 100 ft. apart, but they have been spaced proximally to provide a conservative estimate of drawdown. Increasing drawdown in the Upper Patapsco aquifer by about 145 ft from the 2002 level of about -40 ft would result in an estimated groundwater elevation in a production well at Calvert Cliffs Unit 3 of about -185 ft msl, more than 350 ft above the 80-percent management level for this aquifer.

The 80-percent management level for the Lower Patapsco aquifer in the vicinity of CCNPP is about -1050 ft msl (Attachment 1G). The transmissivity of the Lower Patapsco aquifer near Calvert Cliffs is about 2,000 ft^2/day. Assuming a storage coefficient of 1×10^{-4} and a pumping rate of 500 gpm, the Theis Equation yields a drawdown in each well of about 180 ft after 10 weeks of pumping two wells spaced 25 ft apart in this aquifer, assuming 70% efficient production wells. The two pumping wells would be spaced at least 100 ft. apart, but they have been spaced proximally to provide a conservative estimate of drawdown. Increasing drawdown in the Lower Patapsco aquifer from the 2002 level of about -20 ft would result in an estimated groundwater elevation in a production well at Calvert Cliffs Unit 3 of about -200 ft msl, more than 800 ft above the 80-percent management level for this aquifer.

As noted in the discussion above, there is limited public data available regarding the groundwater quality in the Upper and Lower Patapsco aquifers in the vicinity of Calvert Cliffs. Analyses of samples from selected wells are provided in Attachment 1C. Additional unpublished data may be available in the files of the MDE WMA and from the files of local well drilling contractors. Compilation of this data may provide additional information regarding the groundwater quality near the site of Unit 3.

The results of analysis in 2007 of one groundwater sample from one production well in the Aquia aquifer for Units 1 and 2 is provided in Attachment 1J (attached) from the Calvert Cliffs Environmental Report. The chemical quality of groundwater of other Aquia CCNPP wells may vary from the available data.

3.6 Availability/Reliability of Desalination System

Both water treatment suppliers that contributed input to the study have indicated that, in their experience (see Section 3.2 of this study), it is unlikely that the whole desalination plant will be shut down due to water treatment equipment issues. They have increased their operating desalination plants' availability/reliability by designing in installed spare trains of major equipment and/or maintaining a warehouse spare parts program for major equipment and consumable parts. For instance:

1. Installed spares in the process, commissioned and ready for use. Typically installed as 100% (1+1) or 50% (2+1) spare;
2. Shelf spares (New boxed spare part in inventory);
3. Consumable spares (Materials that are used on a regular basis such as chemicals or filters). Normally stocked as projected usage for 30-90 days.
   [Note: Consumable spare parts also include wearing parts, such as pump seals; o- rings and chemical pump wet-end parts.]

One supplier emphasized that using installed spare parts in areas that are critical to the continued operation of the facility is the most prudent design. The installed spare parts design would virtually eliminate unscheduled shutdowns of the desalination process. Any other option only reduces the down-time of the plant, but does not prevent it. Installed spares also reduce the shelf spare parts required. As stated in Section 3.3 of this study, the proposed design for the desalination plant at CCNPP3 includes installed spares for all major active components allowing a spare train to always be available.

Additionally, as noted in Section 3.4 of this study, the CCNPP3 design will include redundant normal power supplies which will increase the availability and reliability of the desalination plant.

A comprehensive spare parts program will be implemented to minimize unavailability. For instance, one supplier recommendation was to plan for the possibility of a periodic membrane replacement. The CCNPP3 design includes installed spares for the membranes and spare part replacement from the warehouse (or other storage location) then for a replacement spare membrane to be ordered to maintain as a spare part.

3.6.1 Viable water options for further discussion

In the unlikely possibility that an event occurs, which could not be prevented by the design steps noted previously in Section 3.6, there have been considerable discussions in this study regarding alternate emergency backup fresh or desalinated water options.

Logistical considerations of the options considered the most viable are discussed in more detail below with order of magnitude estimates included in Attachment 5. Additional provisions may be required if any additional treatment is needed for the wells beyond what is currently in place in the permanent plant.

Portable Desalination Trailers:

Potential suppliers have estimated that approximately 14, up to possibly 20, support trailers may be needed to accommodate flowrates of 900 to 1000 gpm. These trailers would provide the required booster pumps, break tanks, membranes, pretreatment, etc. necessary to provide desalinated water from brackish water via the normal source water supply, the Circulating Water Makeup System. The acreage estimated to accommodate twenty 53 ft x 10 ft trailers is 8 acres. This acreage may be available in the area that would be formerly occupied by Construction's batch plant area (see Attachments 2 and 3 of this study).

Order of magnitude cost data for the portable desalination trailer option is presented separately as a purchase (Option 2A) and a lease (Option 2B) option in Attachment 5.

- Temporary piping is recommended for either trailer option since the vendors piping would be headered and laid out depending on the formation of their portable trailers.

  Temporary piping estimates include:

  - 1 line from each of the circ water makeup piping headers that branches to desalination building would tee to an aboveground stub to allow piping to connect to a vendor pump.
  - 1 line headered from vendor trailers to waste water retention basin (if required, the pretreatment wastes from the trailers would be routed to the retention basin for on site treatment and discharge).
  - 2 lines to route to each desal tank.
  - 1 line, to branch off from the line to each desal tank, that will be routed for the potable and sanitary water system upstream of the primary disinfectant injection point to allow potability processing.

- Electrical power for vendor trailers is recommended via a 480V electrical panel (with stepdown transformer to allow 120V, if necessary) to be outside of desal building. Temporary cabling (120V) to each trailer (with 480V cabling to each of the trailers that have high pressure pumps, which is approximately 5 of the trailers).

14-Day Desalinated Water Storage Pond:

Since the desalinated water storage pond would be located in the construction batch plant area, the pond may not be available at the startup of the power plant.

The capital cost of the desalinated water storage pond (presented as Option 3 in Attachment 5) appears to be cost effective; however, the cost of upsizing the desalination plant to keep pace with continuous evaporation has not been included in Attachment 5. Also, as noted in Section 3.5.4, these costs are beyond the costs of the construction wells that will still need to be drilled. Note that the construction well costs are not reflected in the order of magnitude estimates stated in Attachment 5 for the pond option.

Additionally, maintenance requirements, such as those outlined in Section 3.5.4 (including the O&M costs of filtration equipment proposed as a rental versus continuous maintenance of unused filtration equipment) were not included in Attachment 5 but will make this option expensive over time.

14-Day Desalinated Water Backup Storage Tanks:

Similar to the pond, the backup storage tanks would be located in the construction batch plant area and may not be available at the startup of the power plant. Once in place; however, the tanks would require minimal maintenance in comparison to all but the well option.

This option (Option 4 in Attachment 5) is the most expensive of the viable options from a capital cost standpoint. Also, note that the additional costs of the construction wells are not reflected in the order of magnitude estimates stated in Attachment 5 for the tanks' option.

Wells:

[Note: Certain types of wells that are shallower well designs, such as beach wells and collector wells, were not considered viable and are not discussed in detail in this study. Collector wells would be developed in the shallow aquifer, which as discussed earlier, does not have sufficient yield to support the anticipated groundwater demand. Beach wells would produce brackish water that would require desalination.]

As discussed extensively in Section 3.5.6, the most viable aquifers to provide the required groundwater supply are the Aquia, Upper and Lower Patapsco aquifers. The following drilling information is summarized for comparison purposes [with order of magnitude cost data in Attachment 5 as Options 1A (Aquia), 1B (Upper Patapsco) and 1C (Lower Patapsco)] and either option would meet the approximately 900 gpm of flowrate required for CCNPP3 fresh water demands.

Drilling Method 1[1]
Drill a 10" pilot hole first and then ream it to 14" (in the Aquia) or 18" (in the Upper and Lower Patapsco)

- Aquia aquifer: 550' 8" casing; 100' 8" screen; total depth 650'; 40 HP pump; 3 wells @ 300 gpm each
- Upper Patapsco aquifer: 850' 12" casing; 350' 6" screen; total depth 1,100' (the 6" screen extends into the 12" casing by 100'); 75 HP pump; 2 wells @ 500 gpm each
- Lower Patapsco aquifer: 1,550' 12" casing; 250' 6" screen; total depth 1,700' (the 6" screen extends into the 12" casing by 100'); 75 HP pump; 2 wells @ 500 gpm each

Drilling Method 2[1]

Drill a 15" hole from the start (in the Aquia) and a 17" hole (in the Upper and Lower Patapsco) and no reaming is required.

- Aquia aquifer: 550' 8" casing; 100' 8" screen; total depth 650'; 40 HP pump; 3 wells @ 300 gpm each
- Upper Patapsco aquifer: 650' 10" casing; 350' 8" casing; 100' 8" screen; total depth 1,100'; 60 HP pump; 2 wells @ 500 gpm each
- Lower Patapsco aquifer: 800' 10" casing; 730' 8" casing; 100' 8" screen; total depth 1,630'; 60 HP pump; 2 wells @ 500 gpm each

[1](Note: The cost structures for these 2 drilling methods vary; however, see Attachment 5 for representative order of magnitude estimates.)

If the Aquia aquifer is chosen for drilling, the yield limitations per well would likely necessitate at least 3 wells to meet the desalination backup demands for Unit 3. More than 3 wells may be required to provide redundancy in back-up supply in the unlikely event that a well becomes unserviceable. As noted in Attachment 5, this aquifer represents the most economical choice; however, this aquifer is also used by Units 1 and 2 and elsewhere throughout southern Calvert County.

The Aquia aquifer would be beneficial for providing makeup water to the desalinated water users as required to support the power plant's continued operation.

Another point to consider from Section 3.5.6 in choosing the aquifer is drawdown interference. Pumping water levels in each aquifer must remain above the 80% Management Level after pumping for 10 weeks. Although a withdrawal of 10 weeks was conservatively analyzed, 2 weeks is the timeframe that would be the longest required with an extensive spare parts program.

Still, as noted in Ref. 7, the spacing of the wells in the Aquia aquifer must be at least 500 feet apart to maintain their pumping water levels above the 80-Percent Management Level (the farther apart they are located the less will be any drawdown interference between wells). [The study already allows for the farthest well to be drilled approximately 1100 feet away from the desalination building (see Attachments 2 and 3 which shows the outline of the Construction batch plant area) and the next 2 wells to be drilled approximately 600 ft and 100 ft, respectively, from the desalination building, as necessary.]

Note that wells in the Aquia aquifer present the worst case scenario in terms of the required separation. Wells in either the Upper or Lower Patapsco aquifers could be closer because their pumping water levels are well above the regulatory level. This could be an important consideration in choosing which aquifer to develop, considering the 500 ft separation required for the wells in the Aquia compared to the nominal 25-foot separation that would be required between wells in the Upper or Lower Patapsco aquifers.

The projected drawdown of wells in each aquifer level was also discussed in Section 3.5.6 and these projections can be summarized as follows:

- Aquia aquifer: Drawdown after pumping three wells spaced 500 ft apart at 300 gpm each for 10 weeks (a timeframe for which withdrawal was conservatively analyzed), assuming 70% efficient wells = 235 ft, which corresponds to an elevation of about -345 ft msl. The 80% Management Level for the Aquia aquifer in the vicinity of CCNPP is about -350 ft msl.
- Upper Patapsco aquifer: Drawdown after pumping two wells spaced 25 ft apart at 500 gpm each for 10 weeks (a timeframe for which withdrawal was conservatively analyzed), assuming 70% efficient wells = 145 ft, which corresponds to an elevation of about -185 ft msl. The 80% Management Level for the Upper Patapsco aquifer in the vicinity of CCNPP is about -550 ft msl.
- Lower Patapsco aquifer: Drawdown after pumping two wells spaced 25 ft apart at 500 gpm for 10 weeks (a timeframe for which withdrawal was conservatively analyzed), assuming 70% efficient wells = 180 ft, which corresponds to an elevation of about -200 ft msl. The 80% Management Level for the Lower Patapsco aquifer in the vicinity of CCNPP is about -1050 ft msl.

If the Upper and/or Lower Patapsco Aquifers are chosen for drilling, any treatment for potability would likely only be to comply with secondary drinking water standards, which are not enforceable.

Order of magnitude cost data for Options 1A/B/C in Attachment 5 include:
- Well field development costs (drilling and installing per well)
- Pumps and system hookup (including I&C and electrical power requirements)
- Permanent piping from the wells to the desalinated water storage tanks and upstream of the primary disinfection injection point of the Potable and Sanitary System
- Electrical conduit from each well (irrespective of aquifer chosen) to header into a single conduit from the wells' location to the desalination building.
- Electrical power to be from permanent MCC with manual control of water level to the desalinated water storage tanks and the Potable and Sanitary System

Permanent piping is recommended for this option and is estimated based upon:
- 1 line from each well (regardless of Aquifer chosen) routed to the 2 desalinated water storage tanks
- 1 line to tee off from the line to each desalinated water storage tank that will be routed to the potable and sanitary water system upstream of the primary disinfectant injection point

[Note: Attachment 5 will represent drilling wells separately to the Aquia, Upper Patapsco or the Lower Patapsco aquifers. Logically, and as noted in Section 3.5.6, the wells' drilling will pass through the Aquia then the Upper Patapsco and, if necessary, the Lower Patapsco, to meet the yield requirements.]

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Regardless of which backup water supply chosen, Bechtel's Water Treatment Group indicates that, for potability, the same treatment would be needed (i.e. disinfectant and hardness), with the exception of the additional treatment requirements of the Aquia aquifer (i.e. for arsenic levels). For all of the aquifer options, their tie-in point can be upstream of the permanent desalination plant's disinfectant and hardness treatments.

For the Aquia aquifer, existing site wells were found to have arsenic limits above the national primary drinking water standards. Iron may be present at levels that are not recommended for any the systems using desalinated water.

As there are no existing wells onsite at Calvert Cliffs at the Upper or Lower Patapsco aquifer levels, projections of the groundwater quality from the available information of Upper and Lower Patapsco aquifer wells in the vicinity of the site have indicated that the Upper Patapsco aquifer may require treatment for iron and manganese, both of which were found to be at levels that are not recommended for the systems using desalinated water. Indications are that the Lower Patapsco aquifers may require no additional treatment beyond the disinfectant and hardness treatments.

Budgetary information has been provided in Attachment 5.

3.6.2 Alternate Water Sources' Estimated Delivery Timeframe

Table 2 below is a list of some of the alternate fresh water sources and the estimated delivery timeframe for equipment to start producing fresh water. The timeframes given in this list may vary depending on availability from the suppliers for options other than the wells.

Table 2
ALTERNATE FRESH WATER OPTIONS' DELIVERY COMPARISONS

Equipment	**Estimated Equipment Delivery Timeframes**					
	<24-Hours	< 1 Week	1-2 Weeks	2-3 Weeks	1 Month	>1 Month
-Portable desalination trailers*			Best case: Expedited: 3-5 days; use 1-2 weeks for conservatism (leased option, as available) to begin producing water but not at the capacities needed (option impractical)		Worse case: 2 – 4 weeks (leased option)	2 – 4 months if not pre-built and maintained ready (purchased option)
-Barged containerized desalination unit*			Barge and tugboat separate rental: and first come/first serve (estimated timeframe) and additional time for a prebuilt desalination unit mobilization makes this option impractical			Desalination Unit: 2 – 4 months if not pre-built and maintained ready
-Barged Fresh Water*			Barge and tugboat separate rental: and first come/first serve (estimated timeframe); separately locating a source of fresh water to be continuously available makes this option impractical			
-Trucked Fresh Water	A continuous stream of trucks to and from the site makes this option impractical for large flowrate requirements					
-14-Day Desalinated Water Storage Pond	**Option can be readily available if filtration equipment maintained**	**Rental Filtration Trailer Arrival Pending**				
-14-Day Desalinated Water Backup Storage Tanks	**Option can be readily available**					
-Drilled Wells	**Option can be readily available**					

*Additional time may be required for production of fresh water quantities needed.

4.0 RESULTS, CONCLUSIONS AND RECOMMENDATIONS

The specific questions raised in CPCN Condition 16 are addressed in this study and a listing showing where each question is addressed is included in Attachment 4.

Of the potential failure issues which could take the desalination plant out of service, the longest projected time would be due to a high pressure reverse osmosis pump assembly failure or energy recovery device, with a delivery time of up to 10 weeks, and the next most likely issue as a failure of a reverse osmosis or ultrafiltration membrane, with a delivery time that may range from a few days to up to 6 weeks. This study points out; however, that the availability of the desalination plant can and will be increased for CCNPP3 by:

- Designing in redundant/spare trains of major equipment
- Maintaining a robust warehouse/shelf spare parts program for major equipment
- Maintaining a spare parts program for consumables

This philosophy of having extensive spare parts provisions in place is designed to increase the availability of the desalination plant. Also, these provisions can drastically reduce the projected downtime from approximately 10 weeks to a conservatively projected downtime of 2 weeks or less. The two week timeframe allows time for events caused by Bay chemistry perturbations to be resolved. For further conservatism, Section 3.5.6 includes an assessment of the drawdown impact on the aquifers based upon 10 weeks (a timeframe for which withdrawal was conservatively analyzed) of continuous use at 900 gpm. The drawdown impact for the aquifers was projected to be minimal.

This study also assessed the various aquifers in the Calvert Cliffs area for their potential to provide a possible backup water supply option to the desalination plant. The option of drilling wells to meet fresh water demands as a backup source has the initial upfront capital cost to consider. The capital cost of this option could potentially have less of an impact by coordinating the wells' use with Construction, per UNE direction, since Construction will also need to drill wells to obtain fresh water for various construction activities. These activities include, but are not limited to, sanitary and potable use by the construction workforce, dust suppression, hydrostatic testing of pipes and tanks, concrete mixing and curing, and wash waters. Specifically, it is noted that Construction's batch wells appear to be located in the vicinity of the desalination building (approximately 300- 500 ft away). These wells could become the backup to the desalination plant by drilling Construction's batch wells upfront to be able to meet the yield requirements of the desalination plant and by using a variable frequency drive pump in each well that is sized to meet the CCNPP3 desalinated water demand capacity. This type of pump driver could be restricted as necessary to observe the water withdrawal limits imposed upon Construction by the CPCN Condition 17. The well would be available throughout the Construction timeframe and remain available for backup use should the need arise. Permanent piping can be installed, at the time of the desalination plant's construction, from each well to the desalination plant and to the potable water system, upstream of its chemical injections with electrical interface to allow filling of the water storage tanks as required.

Given the CPCN's limited appropriation on ground water withdrawal from the Aquia aquifer to a daily average of 100,000 gallons on a yearly basis and a daily average of 180,000 gallons for the month of maximum use to support the construction of the Calvert Cliffs Nuclear Power Plant Unit 3 as Condition 17, the deeper aquifers as an option grows more appealing. [Note that, if the backup water supply for the desalination plant is a well drilled in either the Upper or Lower Patapsco aquifers, the following FSAR/ER sections that may be affected include (but are not limited to): FSAR Section 2.4, ER Sections 2.3, 3.3 and 3.4.].

The study also assessed the next most viable option as an emergency backup, which would be portable, containerized desalination trailers trucked to the plant site. A lease and purchase option was made available. The leased option allows a 'portable desalination plant' to be made available as needed but no operating and maintenance (O&M) considerations; however, the additional lease information stated in Attachment 5 must also be considered. The purchase option allows the trailers to become the property of UNE but with required O&M considerations to maintain the trailers readily available to UNE over the years. (O&M estimations are beyond the scope of this study.) Some critical considerations for the desalination trailer option include: Chesapeake Bay perturbations could also affect the source water that would be needed for this option, operating and maintenance requirements to keep these trailers maintained for an emergency that may never occur, mobilization efforts that would be required to get all of the trailers to the site and to begin to bring these units online and the additional time to reach the full fresh water flowrate requirements, even if the trailers were maintained readily available for transport to the plant site or housed permanently onsite.

The 14-day pond and backup storage tank options were assessed as well. The viability of the pond would be impacted by the O&M costs and the backup tanks would be impacted by the capital costs. Attachment 5 does not reflect the cost of the construction wells, which will still be required to be drilled.

The options of the portable trailers, 14-day storage pond, 14-day backup storage tanks and the wells were considered further with order of magnitude estimates made available in Attachment 5 to this study (with the various well aquifers presented as Options 1A, 1B and 1C; the desalination trailers presented as Options 2A and 2B; 14-day storage pond as Option 3 and 14-day backup storage tanks as Option 4). Valves and other such detailed components are not included in the estimate information provided as the scope of this study does not include detailed system design. Note that these estimates, as strictly order of magnitude estimates, may deviate +/- 30% from actual, as contractors' costs, labor rates, site conditions, etc. may have an impact.

The study concludes that groundwater wells are the only expedient and cost effective option available to efficiently replace the permanent desalination plant within the 11 hours timeframe that the desalinated water storage tanks can continuously supply fresh water without makeup from the desalination plant. Deeper aquifer wells at the Upper and Lower Patapsco levels could mean that the Aquia level would not incur additional groundwater usage for CCNPP3. Wells at these deeper aquifer levels have an initial upfront expense but, in comparison to the critical time impacts associated with the portable desalination trailer options, the wells offer a simple to operate and a readily available source of water that requires minimal treatment and maintenance.

In essence, the recommended steps discussed in this study include:

- Drilling production wells, instead of conducting test boring programs, would be the most practical. This would make the wells available both to meet construction needs (with particular consideration of the deeper aquifers, the Upper Patapsco or, if necessary, the Lower Patapsco) and as a backup to the CCNPP3 desalinated water demands (with variable speed well pumps recommended by well contractors if there is a difference in the production allowances between construction needs and the CCNPP3 backup needs).
- Ensuring that the Raw Water Supply System design includes underground piping routed from the CCNPP3 proposed wells to the desalination building, aboveground tie-in points required from the wells and subsequent electrical and instrumentation/control supporting equipment configuration requirements in the desalination building. All of these are steps to support the immediate

availability of the wells for the normal desalinated water demands, should the desalination plant have to be shut down.

- After a successful bidder for the permanent desalination plant equipment is chosen, ensuring that the required spare parts are identified and quantified to set up the robust spare parts program for high availability and minimal downtime.
- With the deeper aquifer wells, considering the additional potential for using these wells for potable/sanitary water purposes. This would remove the additional potable/sanitary requirements imposed on the desalination plant and all piping enroute to and through the Raw Water Supply System and on to the Potable and Sanitary Water System.

Budgetary estimates provided were detailed in Attachment 5 of this study.

In summary, should a condition arises that would remove the desalination plant from service, the emergency backup to the desalination plant would need to provide approximately 900 gpm, 24 hours/day at approximately 1.3 million gallons per day for a maximum of 2 weeks, given installed spares and an extensive warehouse spare parts program. Given the 11 hours of storage in the desalinated water storage tanks, the emergency backup needs to be a readily available fresh water source. With the time limitations, the only practical option that remains available is the groundwater well option.

5.0 SOURCES/REFERENCES

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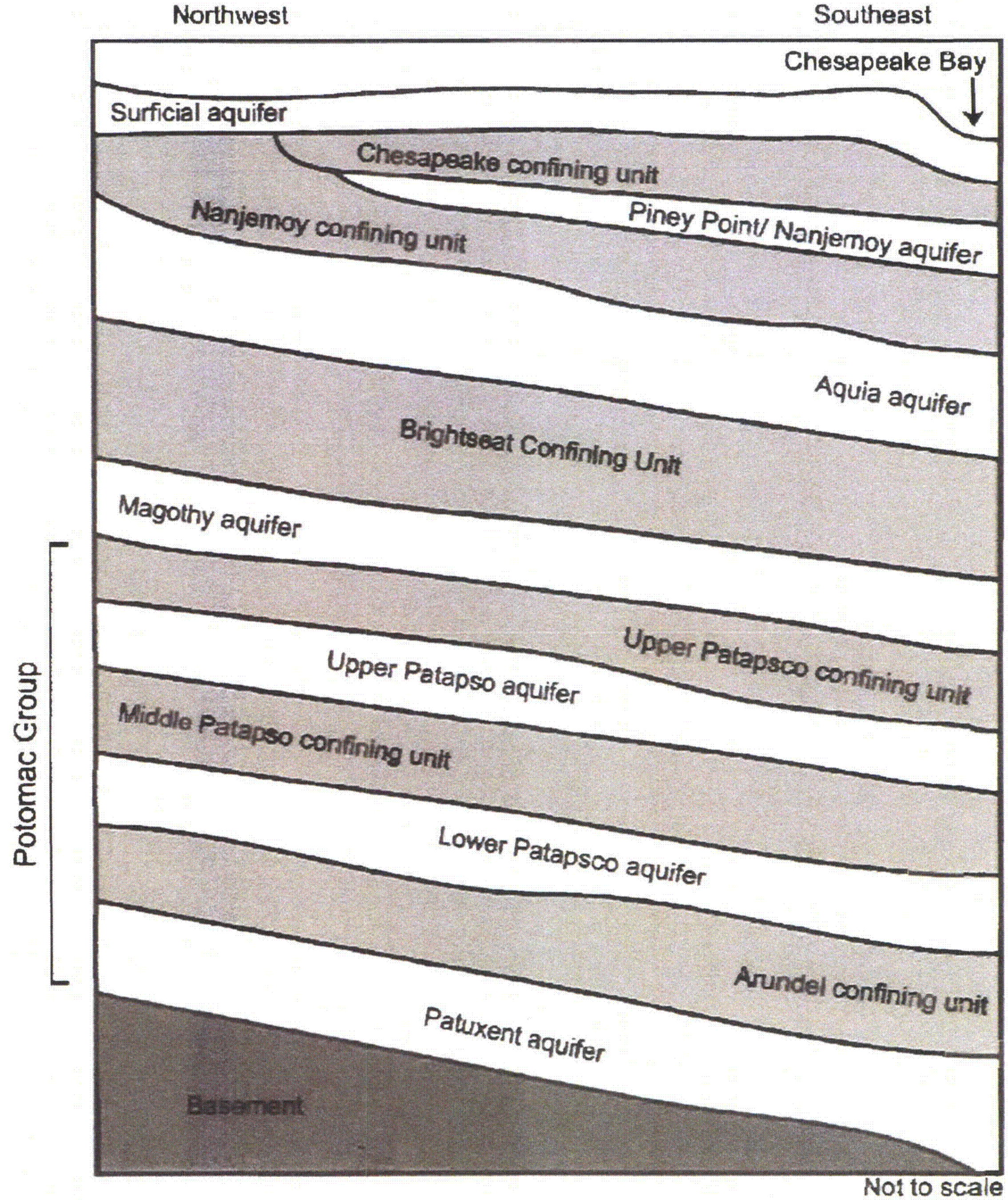
2. Bechtel Document No. 25470-000-G27-GGG-00001, Department of Transportation Article: The Environmental Advantages of Inland Barge Transportation": http://www.portofmemphis.com/pdfs/Barge%20Transportation.pdf, dated: June 8, 2009
3. Bechtel Document No. 25470-000-M5-YA-00001, Rev. 002 (AREVA Document No. CCNP3-002-M5-YAA-00001, Rev. 000), Calvert Cliffs Unit 3 Water Balance Diagram
4. AREVA Document 126-9026052-000, Required Demineralized & Potable Water Usage Calculation
5. Bechtel Document 25465-000-3DR-EGPT-00001, Rev. 000 (U.S. EPR Document No. EPR00-115-3DR-EGPT-00001, Rev. 000), U.S. EPR System Design Requirements Document
6. National Fire Protection Agency Code (NFPA) 804, 2006 Edition Standards for Fire Protection for Advanced Light Water Reactor Electric Generating Plants
7. Bechtel Document 25237-000-G65-GEK-00001, Rev. 000, GHES Well Report
8. Bechtel Document No. 25470-000-M6-WR-00001, Rev. 00B (U.S. EPR Document No. CCNP3-002-M6-SWR-00001-00B), Raw Water Piping and Instrumentation Diagram
9. Bechtel Document No. 25237-000-G27-GGG-00024, Groundwater Wells Relative Spacing; GIS Map Code: US-CALV-000131-R000C (Attachment 1E of this document)
10. Bechtel Document No. 25237-000-IE-GGG-00012, E-mail between E. Johnson (Bechtel) and T. Konerth (UNE) re: Diablo Canyon Water Chemistry
11. Bechtel Document No. 25470-000-G27-GGG-00048, State Water Appropriation Permit No. CA69G010, Revision 05, Effective date July 1, 2000, Expiration Date July 1, 2012

12. Maryland Geological Survey, 2007b, Water Supply Potential of the Coastal Plain Aquifers in Calvert, Charles, and St. Mary's Counties, Maryland, with Emphasis on the Upper Patapsco and Lower Patapsco Aquifers, Report of Investigations No. 76, D. Drummond, 2007
13. Bechtel Document No. 25237-000-30R-M21G-00001, Rev. 000, Calvert Cliffs Desalination Study (Rev 000).

6.0 ATTACHMENTS

- ATTACHMENT 1A	Aquifer Levels Diagram
- ATTACHMENT 1B	Summary Yield Characteristics for the Aquia Aquifer
- ATTACHMENT 1C	Water Quality Analysis for Well Screened in Upper Patapsco, Lower Patapsco and Patuxent Aquifers in Calvert, Charles and St. Mary's Counties
- ATTACHMENT 1D	80% Management Diagram
- ATTACHMENT 1E	Groundwater Wells Relative Spacing
- ATTACHMENT 1F	Aquia Aquifer 80% Management Level Diagram
- ATTACHMENT 1G	Lower Patapsco Aquifer 80% Management Level Map
- ATTACHMENT 1H	Upper Patapsco Aquifer 80% Management Level Map
- ATTACHMENT 1J	Summary of Analytical Results for Groundwater Well Sampling at Calvert Cliffs May 31, 2007
- ATTACHMENT 2	Diagram of the Water Supply Options
- ATTACHMENT 3	Access to Water Supply Options
- ATTACHMENT 4	CPCN Requirements Addressed (1 Sheet)
- ATTACHMENT 5	Order of Magnitude Estimates of Viable Options
- ATTACHMENT 6	Chesapeake Bay Water Chemistry

Attachment 1A: Aquifer Levels Diagram (1 Sheet)



(Source of Information Documented in Ref. 7)

Attachment 1B: Summary Yield Characteristics for the Aquia Aquifer (2 Sheets)

Well No.	Specific Capacity (gpm/ft)	Yield (gpm)	Screen Length (ft)	Well Depth (ft)	Screen Diameter (in)	Duration of Yield Test (hours)	Screen Segments (ft)
CA Bc 31	1.0	105	30	373	8	6	
CA Bc 43	4.2	450	120	420	8	36	
CA Bc 44	5.0	352	115	435	6	24	
CA Bc 45	4.3	352	115	435	6	24	
CA Cc 39	0.7	110	17	514	8	12	
CA Cc 40	1.0	192	14	524	8	12	
CA Cc 41	1.1	150	20	540	8	12	
CA Db 21	1.0	75	14	540	5.5	12	
CA Db 26	1.0	75	37	576	5	4	
CA Db 40	1.5	275	62	447	5	24	
CA Db 44	1.6	82	57	589	5	8	
CA Db 46	1.8	254	40	540	6	12	
CA Dc 29	0.4	40	23	537	6	8	
CA DC 34	1.4	271	45	465	8	24	
CA Dc 37	2.7	270	40	595	6	24	
CA Dc 48	0.7	100	20	530	6	24	
CA Dc 50	4.1	350	60	605	6	24	
CA Dc 53	3.2	350	80	605	6	24	
CA Ed 23	3.2	350	124	607	6	24	
CA Ed 24	2.9	310	113	637	6	24	
CA Ed 25	2.8	310	113	623	6	18	
CA Ed 45	2.5	230	66	606	5	8.5	
CA Ed 46	2.8	230	101	621	5	9	
CA Fd 39	1.2	125	30	626	5.25	8	
CA Fd 68	2.5	503	70	620	12	26	32, 36
CA Fd 69	2.4	503	70	546	12	24	5, 38, 24
CA Fd 70	3.0	460	60	640	8	24	
CA Fd 71	2.2	351	60	667	8	24	
CA Fd 72	2.2	300	62	567	6	24.7	20, 62
CA Fd 73	2.0	302	60	557	6	24.7	
CA Fe 18	0.6	100	30	657	5.25	12	
CA Fe 19	3.1	351	120	700	8	48	
CA Fe 20	2.5	351	110	703	8	8	
CA Fe 30	3.3	400	100	686	8	27	
SM Bb 26	3.0	240	124	559	5	24	
SM Bb 28	1.9	320	122	601	5	24	
SM Cc 15	0.7	50	30	545	5	4	
SM Cc 19	0.8	100	20	560	5	6	
SM Dc 26	1.2	50	10	350	6	12	
SM Dc 58	1.5	90	51	396	6	15	
SM Dd 30	2.7	250	30	366	7.25	8	
SM Dd 33	2.0	100	15	465	5	8	
SM Dd 39	3.0	300	30	510	6	12	
SM Dd 41	0.8	70	17	502	8	8	
SM Dd 44	3.0	110	65	459	5	10	23, 42
SM Dd 45	2.6	56	46	536	6	12	
SM Dd 65	2.1	300	70	520	8	24	

Sheet 1 of 2

(Source of Information Documented in Ref. 7)

Attachment 1B: Summary Yield Characteristics for the Aquia Aquifer

Well No.	Specific Capacity (gpm/ft)	Yield (gpm)	Screen Length (ft)	Well Depth (ft)	Screen Diameter (in)	Duration of Yield Test (hours)	Screen Segments (ft)
SM Dd 66	4.1	460	80	502	8	24	30, 50
SM De 36	3.7	200	52	620	6	12	26, 26
SM De 50	1.5	100	25	555	5	7	
SM Df 1	4.2	225	20	587	8		
SM Df 3	3.3	257	20	565	6		
SM Df 4	2.0	300	20	547	7.5		
SM Df 5	2.0	300	20	552	8		
SM Df 7	1.6	171	20	518	6		
SM Df 10	2.3	225	20	534	6		
SM Df 12	1.7	300	20	489	7.5		
SM Df 22	2.5	225	24	600	6		
SM Df 42	3.6	210	20	570	5.5	12	
SM Df 43	2.6	200	20	553	8		
SM Df 61	2.3	200	20	600	6	24	
SM Df 73	1.1	100	20	620	5	6	
SM Df 76	4.3	200	28	602	6.5	8	
SM Df 78	2.0	300	30	600	6	24	
DM Df 86	2.9	63	41	609	6	26	
SM Df 89	2.5	215	42	621	6	24	
SM Df 93	2.8	314	50	565	6	8	
SM Df 94	5.9	294	50	610	6	24	
SM Df 95	6.4	400	50	580	6	24	
SM Df 96	5.6	300	50	539	6	8	
SM Dg 1	2.5	162	20	480	7.5		
SM Dg 10	2.7	250	20	492	5	11	
SM Dg 14	2.4	400	50	540	6	24	
SM Ef 81	3.8	400	65	590	10	12	
SM Ef 83	1.3	150	37	572	8	10	
SM Fe 23	2.2	180	14	405	7.5	24	
SM Fe 24	1.5	25	9	411	5.5	12	
SM Fe 40	4.0	125	50	475	6	24	

Geo Mean	2.1	197	40	545	6.4	14.8	
Maximum	6.4	503	124	703	12.0	48.0	
Minimum	0.4	25	9	350	5.0	4.0	
N	78						

At CCNPP the Aquia aquifer ranges from -415 to -560 ft msl.
CCNPP production wells

Sheet 2 of 2

(Source of Information Documented in Ref. 7)

Attachment 1C: Water Quality Analysis for Well Screened in Upper Patapsco, Lower Patapsco and Patuxent Aquifers in Calvert, Charles and St. Mary's Counties (7 Sheets)

(Sheet 1 of 7)

[deg C, degrees Celsius; µS/cm, microsiemens per centimeter at 25° Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picoCuries per liter; *, lab pH; <, less than; E, estimated; M, measured; --, not reported]

Well number	Date	pH, field	Temperature (deg C)	Specific conductance (µS/cm)	Residue @180 deg C	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sulfate (mg/L as SO_4)	Alkalinity (mg/L as $CaCO_3$)
Upper Patapsco aquifer											
CA Db 96	2/4/2003	7.0	18.5	240	127	12.1	10.4	13.9	9.13	3.9	110
CA Fd 71	5/10/1993	7.9	20.7	202	126	44	4.4	0.69	0.36	5.1	96
CH Bc 12	3/28/1950	7.8	--	357	224	70	8.6	5.9	2.4	13	--
CH Bc 22	2/7/1956	8.2	--	260	--	--	--	--	--	--	--
CH Be 60	4/23/1986	7.4	17	310	181	64	6.1	2.5	1	7.7	150
CH Bf 151	3/11/1986	7.5	15	335	163	20	12	26	9.1	9.4	149
CH Bf 157	9/8/1986	8.2	19	300	188	24	12	25	8.8	8.5	157
CH Bf 158	9/30/1986	8.5	19	260	160	35	8	11	4.6	9.9	124
CH Cc 5	4/2/1952	7.9	--	411	265	88	7.6	5.9	3.5	7.5	--
CH Cd 7	4/3/1952	7.9	--	466	306	116	4.9	2.1	0.2	4	--
CH Cd 9	3/9/1961	7.9	--	423	275	96	5.7	3	0.1	5.2	--
CH Ce 3	1/22/1947	8.0	--	514	338	121	4.7	1.1	0.8	11	--
CH Cg 24	1/29/2002	7.3	19.8	281	--	48.3	7.24	6.63	3.03	8.6	131
CH Ee 56	3/9/1961	7.6	16.5	301	186	66	2.6	2	0.2	8	--
CH Fe 3	12/15/1961	8.2	16	355	226	86	3.8	1.2	<.05	8.2	--
CH Fe 5	1/21/1981	7.9	19.5	430	325	130	3.3	0.4	0.2	15	230
SM Df 84	1/5/1983	8.4	20.5	261	171	68	2.5	0.59	0.32	6	157
SM Df 100	8/11/2000	8.4	21	238	165	56.3	2.3	0.39	0.203	4.6	177
SM Ff 36	5/15/2001	9.8	18	582	349	126	7.01	1.52	0.463	0.2	293
Lower Patapsco aquifer											
CA Fd 85	11/28/2001	8.7	25.2	414	264	102	1.7	1.08	0.261	13.6	213
CH Ac 11	3/9/1961	6.8	15.7	149	122	30	2.3	1.8	0.4	0.2	--
CH Bb 1	7/13/1956	8.0	--	299	229	69	2.9	0.7	0.1	9.6	--
CH Bb 2	5/28/1952	8.3	--	342	222	78	2.5	0.3	0.2	10	--
CH Bb 4	5/28/1952	8.2	--	291	215	68	2.7	0.4	0.1	16	--
CH Bb 5	7/13/1956	8.0	14.5	270	202	67	2.4	0.3	<.05	11	--
CH Bb 6	5/17/1988	7.9	17	286	196	67	2.3	0.27	0.25	9	123
CH Bb 7	5/17/1988	7.9	18	315	202	70	2.3	0.31	0.27	10	135
CH Bb 8	10/14/1957	7.9	15.5	314	227	69	3.2	0.4	0.5	10	--
CH Bb 9	5/17/1988	7.6	17	262	187	62	1.8	0.36	0.34	11	122
CH Bb 12	5/19/1988	7.2	18.4	750	477	170	7.7	5.8	3.9	4.8	334
CH Bb 14	10/14/1957	7.8	15.5	314	218	66	3.2	0.4	0.5	9.4	--
CH Bb 15	1/5/1956	8.2	--	352	238	60	5.2	6.8	4.4	1.6	--
CH Bb 16	3/1/1956	8.3	--	325	--	--	--	--	--	--	--
CH Bb 17	5/24/1988	7.7	19.1	497	307	110	3.6	4.4	0.86	2.1	182

Attachment 1C: Water Quality Analysis for Well Screened in Upper Patapsco, Lower Patapsco and Patuxent Aquifers in Calvert, Charles and St. Mary's Counties

(Sheet 2 of 7)

Chloride (mg/L)	Fluoride (mg/L)	Iron (µg/L)	Manganese (µg/L)	Arsenic (µg/L)	Nitrite plus nitrate (mg/L as N)	Phosphorus (mg/L)	Total organic carbon (mg/L)	Silica (mg/L)	Radon-222 (pCi/L)	Gross alpha-particle activity (pCi/L)	Gross beta-particle activity (pCi/L)	Well number
Upper Patapsco aquifer												
0.94	0.39	4900	89	0.3	<.06	--	E.4	9.1	150	7	17	CA Db 96
1.9	0.3	110	18	--	--	--	--	11	--	--	--	CA Fd 71
1.2	0.5	--	--	--	--	--	--	16	--	--	--	CH Bc 12
2.8	--	--	--	--	--	--	--	--	--	--	--	CH Bc 22
1.6	0.5	85	29	<1	--	0.11	--	10	--	--	--	CH Be 60
0.9	0.2	350	24	<1	--	0.03	0.1	9.7	--	--	--	CH Bf 151
1.2	0.2	500	20	<1	--	0.03	0.4	9.3	--	--	--	CH Bf 157
0.7	0.4	530	14	<1	--	0.01	0.5	9.9	--	--	--	CH Bf 158
0.5	0.9	--	--	--	--	--	--	19	--	--	--	CH Cc 5
7	1.3	--	--	--	--	--	--	24	--	--	--	CH Cd 7
0.6	0.9	--	--	--	--	--	--	36	--	--	--	CH Cd 9
3.8	1.2	--	--	--	--	--	--	34	--	--	--	CH Ce 3
2	0.4	270	15.1	0.3	0.05	0.103	3.4	10.5	--	--	--	CH Cg 24
2	0.6	--	--	--	--	--	--	17	--	--	--	CH Ee 56
2.5	0.7	--	--	--	--	--	--	13	--	--	--	CH Fe 3
1.3	1.3	220	20	--	--	--	--	36	--	--	--	CH Fe 6
1.8	0.3	30	10	1	<.100	0.38	0.4	12	--	--	--	SM Df 84
1.74	0.4	51	9.3	--	--	--	--	12.6	--	--	--	SM Df 100
2	1.1	<10	<3.2	--	--	--	--	14.3	--	--	--	SM Ff 36
Lower Patapsco aquifer												
2.07	0.4	105	12.5	<.2	<.05	--	E.4	13.5	140	M	2	CA Fd 85
2.2	0.4	--	--	--	--	--	--	45	--	--	--	CH Ac 11
11	0.8	--	--	--	--	--	--	30	--	--	--	CH Bb 1
20	0.6	--	--	--	--	--	--	19	--	--	--	CH Bb 2
10	0.8	--	--	--	--	--	--	25	--	--	--	CH Bb 4
6.1	0.9	--	--	--	--	--	--	34	--	--	--	CH Bb 5
7.5	0.9	45	14	--	--	--	0.3	33	--	--	--	CH Bb 6
11	1	78	7	--	--	--	0.1	33	--	--	--	CH Bb 7
8.5	0.9	--	--	--	--	--	--	36	--	--	--	CH Bb 8
2.9	0.8	34	10	--	--	--	0.2	34	--	--	--	CH Bb 9
49	0.3	1000	89	--	--	-	3.5	35	--	--	--	CH Bb 12
11	0.8	--	--	--	--	--	--	34	--	--	--	CH Bb 14
15	0.3	--	--	--	--	--	--	37	--	--	--	CH Bb 15
13	--	--	--	--	--	--	--	--	--	--	--	CH Bb 16
47	0.8	410	7	--	--	--	1.2	30	--	--	--	CH Bb 17

(Source of Information Documented in Ref. 7)

Attachment 1C: Water Quality Analysis for Well Screened in Upper Patapsco, Lower Patapsco and Patuxent Aquifers in Calvert, Charles and St. Mary's Counties

(Sheet 3 of 7)

Well number	Date	pH, field	Temperature (deg C)	Specific conductance (µS/cm)	Residue @180 deg C	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sulfate (mg/L as SO_4)	Alkalinity (mg/L as $CaCO_3$)
CH Bb 19	5/18/1988	7.6	17.4	473	319	110	3.6	0.75	0.73	3.6	217
CH Bc 2	10/14/1957	7.8	15.5	255	193	59	3.2	0.4	0.1	10	–
CH Bc 3	5/17/1988	8.0	18	281	193	67	2	0.19	0.14	8.3	131
CH Bc 5	5/25/1988	8.0	16.2	420	272	100	3.5	0.65	0.51	9.1	154
CH Bc 6	5/19/1988	8.0	17.2	252	186	57	1	0.05	0.03	14	110
CH Bc 15	4/14/1955	7.8	--	299	215	68	3.6	0.6	1	7.3	–
CH Bc 23	5/19/1988	7.5	18.5	720	462	140	7.2	4.1	3.1	3.9	327
CH Bc 24	5/26/1988	7.2	17.7	659	410	80	9.9	34	14	42	202
CH Bc 49	5/19/1988	7.6	17	294	206	68	2.8	0.58	0.27	10	132
CH Bc 67	5/19/1988	7.7	18.4	675	402	150	4	0.29	0.24	7.3	154
CH Bc 68	5/19/1988	7.8	16.4	244	182	58	1.2	0.12	0.12	18	113
CH Bc 70	5/19/1988	7.7	18.4	242	181	60	1.8	0.09	0.14	13	112
CH Bc 72	5/19/1988	7.8	17.2	264	197	64	2.3	0.33	0.19	10	123
CH Bc 74	10/25/1989	7.9	16.9	239	167	55	–	0.22	0.04	15	101
CH Bd 46	6/26/1986	7.4	18.1	410	297	95	3.7	0.6	0.3	13	209
CH Be 58	8/28/1985	7.6	21	350	210	70	2.6	0.9	0.3	16	132
CH Bf 146	12/21/1983	8.0	23	260	204	64	1.5	0.48	0.11	11	135
CH Bf 147	2/27/1984	7.4	22	270	304	66	1.6	0.24	0.19	9.3	132
CH Bf 150	7/16/1985	8.3	22.5	245	183	56	1	0.21	0.12	23	102
CH Bg 17	3/4/2003	8.0	20.6	240	152	54.2	3.21	1.09	0.612	5.8	119
CH Cb 7	5/11/1988	6.8	14	290	--	63	2.7	2.8	1.7	9.9	134
CH Cb 8	8/26/1953	6.9	--	536	339	47	2.7	23	19	0.8	--
CH Cb 9	5/17/1988	7.8	16.5	370	242	76	2.8	0.83	0.74	11	146
CH Cb 11	5/18/1988	7.5	17.2	590	374	140	4.6	1.6	0.74	8.3	234
CH Cb 16	4/27/1961	7.6	--	340	232	76	3.5	0.3	0.1	12	–
CH Cb 18	5/17/1988	7.6	16.5	481	304	110	2.8	0.42	0.51	7.6	181
CH Cb 19	5/18/1988	8.0	18.5	374	242	86	2.7	0.52	0.48	8.1	156
CH Cb 26	11/12/1958	7.5	10	334	220	73	4.3	1.4	0.8	11	–
CH Cb 28	5/18/1988	7.5	16.5	297	201	66	3.9	1.7	1.3	12	129
CH Cb 29	5/17/1988	8.0	17	302	207	70	2	0.25	0.21	10	138
CH Cb 34	5/17/1988	7.0	14.5	1310	766	270	7.5	8.1	8.7	12	367
CH Cb 38	5/18/1988	7.7	16.8	290	201	62	3	1.1	1	15	134
CH Cb 39	11/2/1989	7.9	15.5	257	183	66	–	0.18	0.21	12	126
CH Cb 40	11/2/1989	7.6	15	384	249	85	–	0.78	0.77	10	186
CH Cd 24	5/12/1960	7.8	–	279	200	--	–	1.2	1.2	13	--

(Source of Information Documented in Ref. 7)

Attachment 1C: Water Quality Analysis for Well Screened in Upper Patapsco, Lower Patapsco and Patuxent Aquifers in Calvert, Charles and St. Mary's Counties

(Sheet 4 of 7)

Chloride (mg/L)	Fluoride (mg/L)	Iron (µg/L)	Manganese (µg/L)	Arsenic (µg/L)	Nitrite plus nitrate (mg/L as N)	Phosphorus (mg/L)	Total organic carbon (mg/L)	Silica (mg/L)	Radon-222 (pCi/L)	Gross alpha-particle activity (pCi/L)	Gross beta-particle activity (pCi/L)	Well number
21	0.6	170	27	--	--	--	1.3	35	--	--	--	CH Bb 19
2.5	0.8	--	--	--	--	--	--	37	--	--	--	CH Bc 2
6.2	0.8	59	6	--	--	--	0.3	33	--	--	--	CH Bc 3
42	0.8	260	18	--	--	--	0.3	25	--	--	--	CH Bc 5
2.9	0.9	69	1	--	--	--	0.5	37	--	--	--	CH Bc 6
6	1.1	--	--	--	--	--	--	36	--	--	--	CH Bc 15
41	0.4	760	88	--	--	--	3.5	34	--	--	--	CH Bc 23
60	0.5	1400	43	--	--	--	2	33	--	--	--	CH Bc 24
8.8	0.7	130	8	--	--	--	0.6	33	--	--	--	CH Bc 49
120	1.5	110	14	--	--	--	<.1	35	--	--	--	CH Bc 67
1.6	0.7	57	2	--	--	--	0.2	36	--	--	--	CH Bc 68
1.3	0.9	80	6	--	--	--	0.1	35	--	--	--	CH Bc 70
3.7	0.8	97	11	--	--	--	0.5	36	--	--	--	CH Bc 72
1.3	--	21	2	--	--	--	0.3	35	--	--	--	CH Bc 74
2.9	1.4	220	24	<1	--	1.1	0.3	33	--	--	--	CH Bd 46
1.9	1	31	18	<1	--	1	1	38	--	--	--	CH Be 58
2.1	0.9	60	10	--	--	--	--	33	--	--	--	CH Bf 146
2.6	0.9	140	20	--	--	--	--	83	--	--	--	CH Bf 147
4	0.4	7	2	<1	--	0.37	--	21	--	--	--	CH Bf 150
0.78	1.26	204	13.9	<.3	<.06	--	E.3	10.2	330	M	4	CH Bg 17
7.1	0.9	370	55	--	--	--	--	33	--	--	--	CH Cb 7
101	<.05	--	--	--	--	--	--	32	--	--	--	CH Cb 8
22	1.1	110	19	--	--	--	0.6	33	--	--	--	CH Cb 9
45	1.2	480	21	--	--	--	<.1	34	--	--	--	CH Cb 11
11	1.3	--	--	--	--	--	--	35	--	--	--	CH Cb 16
40	1.1	170	19	--	--	--	0.8	33	--	--	--	CH Cb 18
18	0.8	100	16	--	--	--	0.7	35	--	--	--	CH Cb 19
13	1.1	--	--	--	--	--	--	35	--	--	--	CH Cb 26
7.2	1.1	640	30	--	--	--	0.2	32	--	--	--	CH Cb 28
7	0.8	110	10	--	--	--	0.1	34	--	--	--	CH Cb 29
210	0.5	2400	370	--	--	--	5.2	39	--	--	--	CH Cb 34
3.1	1	460	22	--	--	--	0.2	33	--	--	--	CH Cb 38
2.3	--	280	11	--	--	--	0.3	34	--	--	--	CH Cb 39
1.7	--	610	24	--	--	--	0.5	32	--	--	--	CH Cb 40
7.5	1.2	--	--	--	--	--	--	40	--	--	--	CH Cd 24

(Source of Information Documented in Ref. 7)

Attachment 1C: Water Quality Analysis for Well Screened in Upper Patapsco, Lower Patapsco and Patuxent Aquifers in Calvert, Charles and St. Mary's Counties

(Sheet 5 of 7)

Well number	Date	pH, field	Temperature (deg C)	Specific conductance (µS/cm)	Residue @180 deg C	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sulfate (mg/L as SO_4)	Alkalinity (mg/L as $CaCO_3$)
CH Ce 18	6/17/1959	7.9	--	273	210	--	--	0.4	0.6	15	--
CH Ce 37	11/9/1973	7.7	--	275	--	70	1.7	0.2	0.1	17	--
CH Ce 55	6/26/1997	7.4	--	394	--	--	--	--	--	--	--
CH Ce 56	3/19/1997	7.7	--	370	302	79.2	2.08	0.52	0.167	13.4	162
CH Da 1	3/20/1951	7.4	11	371	244	54	7.6	15	9.4	9	--
CH Ee 78	6/16/1978	7.8	23	620	402	140	2.4	1	0.4	24	--
CH Ee 91	1/12/1984	7.5*	--	--	298	100	2.1	0.4	0.2	12	204
CH Ff 60	5/1/1984	7.8	22	345	315	88	1.8	0.28	0.15	12	180
SM Bc 39	3/28/2002	8.4	26	297	188	69.9	0.98	0.4	0.139	10	147
SM Dd 72	5/15/2001	8.3	22.5	420	267	97.2	1.26	0.45	0.189	15.2	207
Patuxent aquifer											
CH Bc 75	11/24/1996	7.9	19.5	306	214	68	1.8	0.47	0.08	7.7	129
CH Bc 80	8/29/1996	7.8	--	593	378	150	3.3	0.48	0.23	7.8	252
CH Bd 52	10/8/1998	7.7	20.3	425	278	98	2.4	0.83	0.15	8.4	192
CH Cb 10	10/18/1955	7.5	--	464	308	104	1.1	1.4	1	6.6	--
CH Cb 35	5/18/1988	7.8	19.1	575	366	130	3.4	0.39	0.39	7.7	227
CH Cc 34	7/19/1996	7.8	21.4	373	244	85	2.5	0.29	0.11	9	151
CH Ce 57	2/19/1997	7.3	23	1010	602	220	3.8	1.7	0.52	10	366

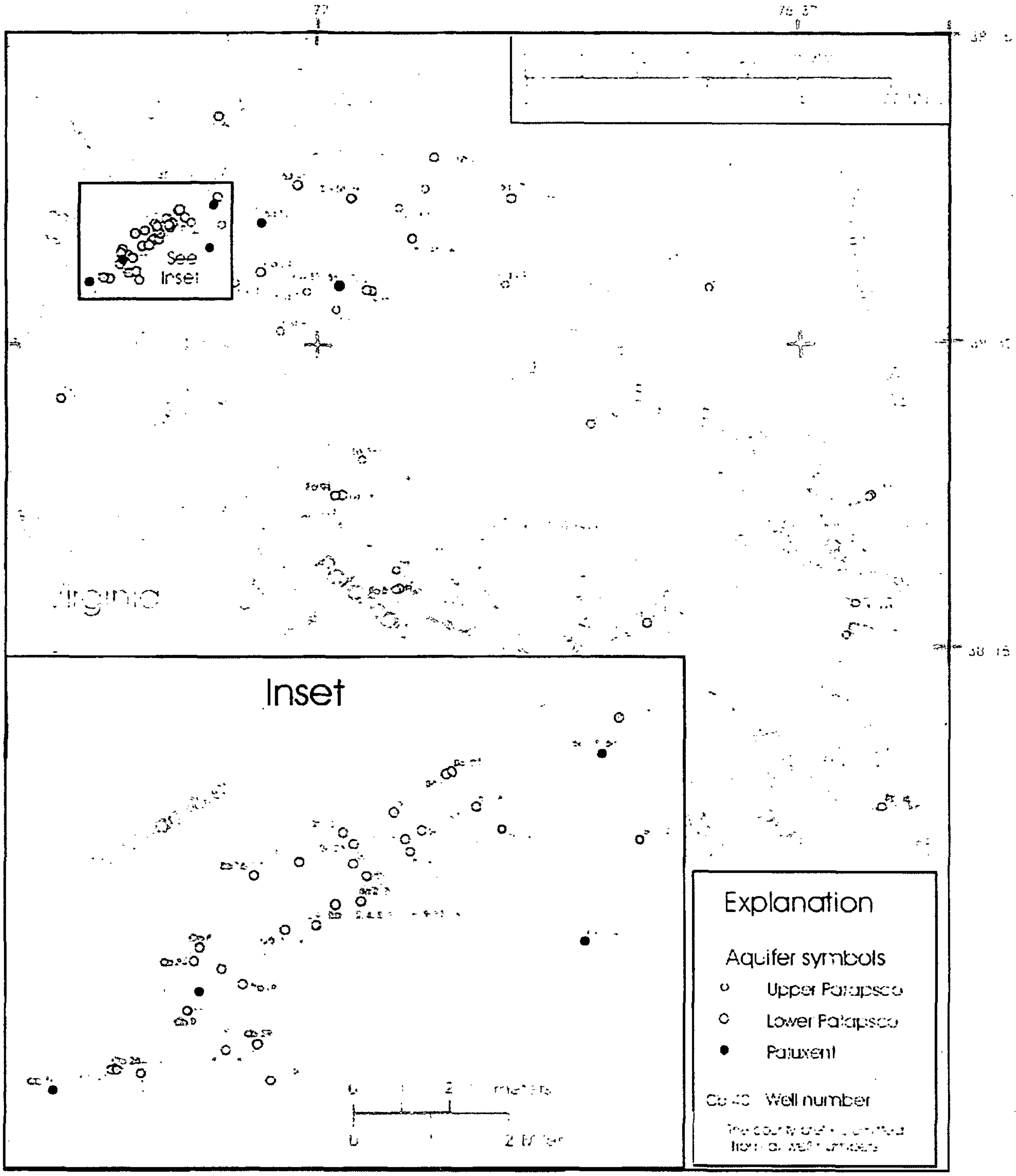
(Source of Information Documented in Ref. 7)

Attachment 1C: Water Quality Analysis for Well Screened in Upper Patapsco, Lower Patapsco and Patuxent Aquifers in Calvert, Charles and St. Mary's Counties
(Sheet 6 of 7)

Chloride (mg/L)	Fluoride (mg/L)	Iron (µg/L)	Manganese (µg/L)	Arsenic (µg/L)	Nitrite plus nitrate (mg/L as N)	Phosphorus (mg/L)	Total organic carbon (mg/L)	Silica (mg/L)	Radon-222 (pCi/L)	Gross alpha-particle activity (pCi/L)	Gross beta-particle activity (pCi/L)	Well number
2	0.9	--	--	--	--	--	--	41	--	--	--	CH Ce 18
2.1	1.2	--	--	--	--	--	--	37	--	--	--	CH Ce 37
--	--	--	--	--	--	--	--	--	360	--	--	CH Ce 55
1.86	1.1	249	13.2	--	<.05	--	--	41	380	6.4	5.6	CH Ce 56
6.8	0.1	--	--	--	--	--	--	32	--	--	--	CH Da 1
31	0.8	490	20	--	--	--	--	42	--	--	--	CH Ee 78
9.6	1.1	380	20	--	--	--	--	4	--	--	--	CH Ee 91
1.7	1.4	100	10	--	--	--	--	37	--	--	--	CH Ff 60
2.29	0.7	--	340	E.1	--	--	--	15.7	--	--	--	SM Bc 39
2.03	0.7	49	8.1	<.2	<.05	--	4.2	14.5	--	1.4	1	SM Dd 72
											Patuxent aquifer	
16	0.9	17	2	--	--	--	--	22	--	--	--	CH Bc 75
43	0.9	48	8	--	--	--	--	16	--	--	--	CH Bc 80
20	0.8	80	9	--	--	--	--	34	--	--	--	CH Bd 52
28	0.7	--	--	--	--	--	--	33	--	--	--	CH Cb 10
44	1.2	110	120	--	--	--	<.1	34	--	--	--	CH Cb 35
21	1.3	100	13	--	0.09	1.3	--	38	--	--	--	CH Cc 34
96	1.2	450	28	--	--	--	--	41	--	--	--	CH Ce 57

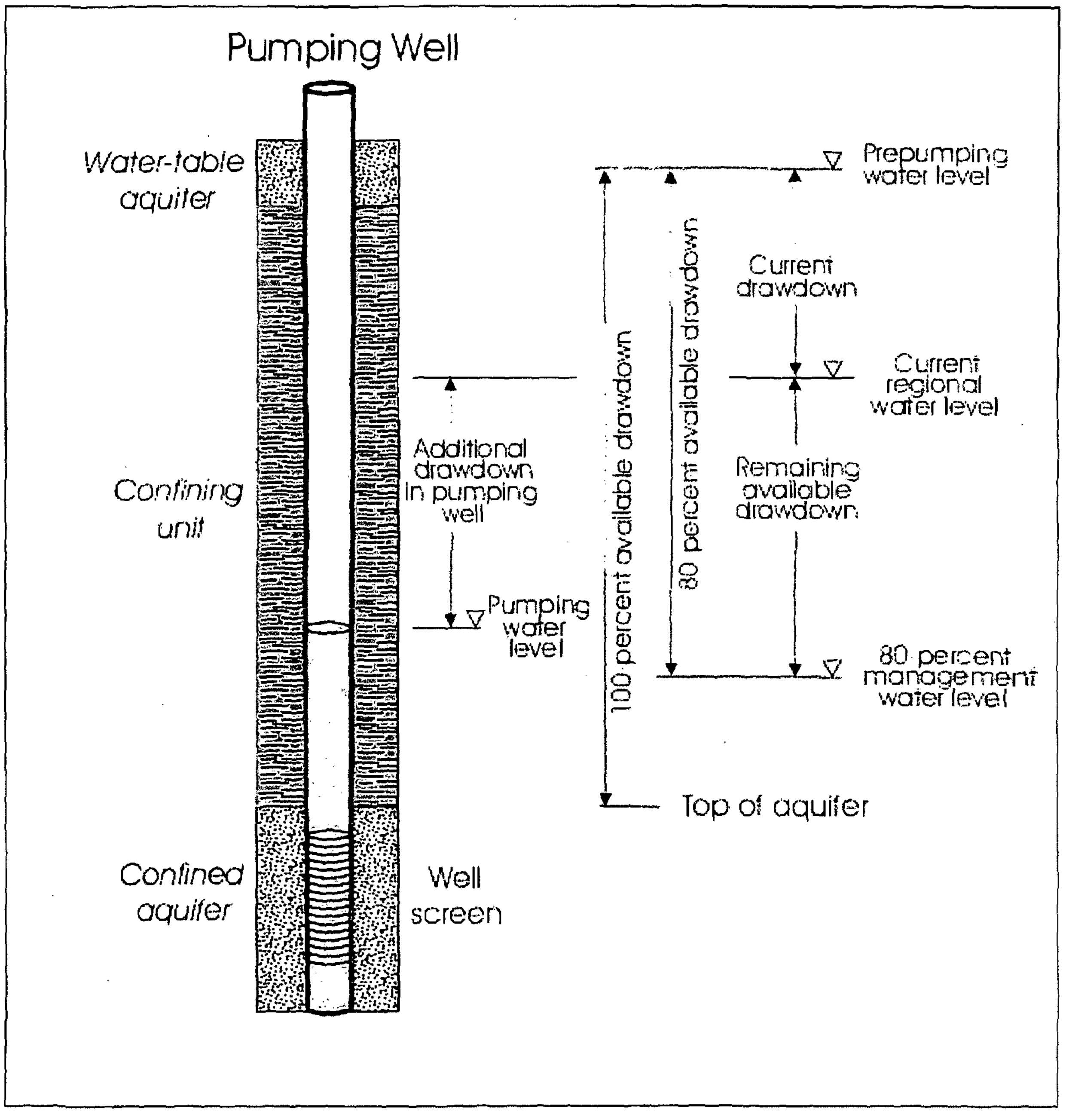
(Source of Information Documented in Ref. 7)

Attachment 1C: Water Quality Analysis for Well Screened in Upper Patapsco, Lower Patapsco and Patuxent Aquifers in Calvert, Charles and St. Mary's Counties
(Sheet 7 of 7)



(Source of Information Documented in Ref. 12)

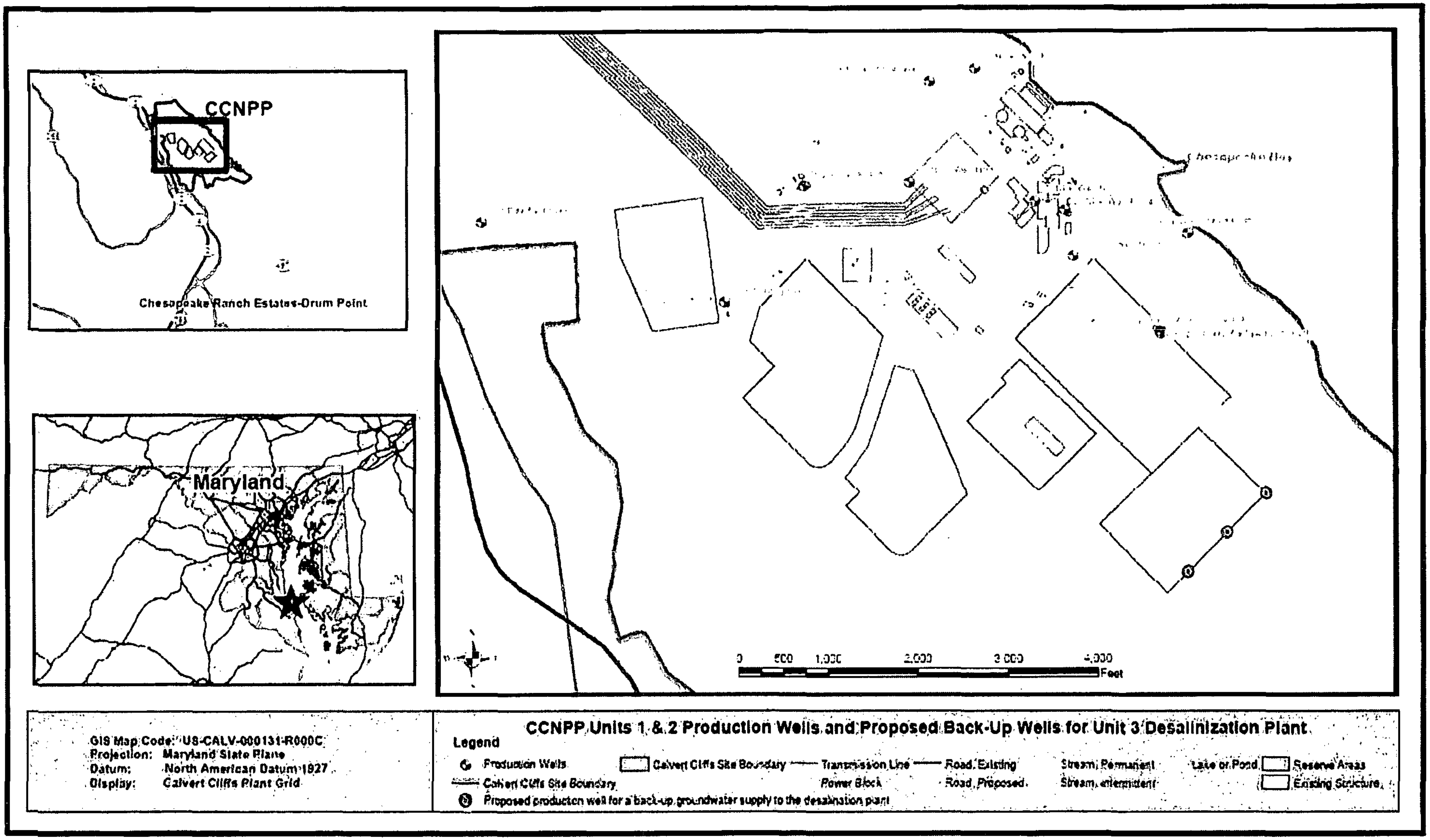
Attachment 1D: 80% Management Diagram (1 Sheet)



Schematic diagram showing the 80-percent management level and remaining available drawdown near a pumping well.

(Source of Information Documented in Ref. 7)

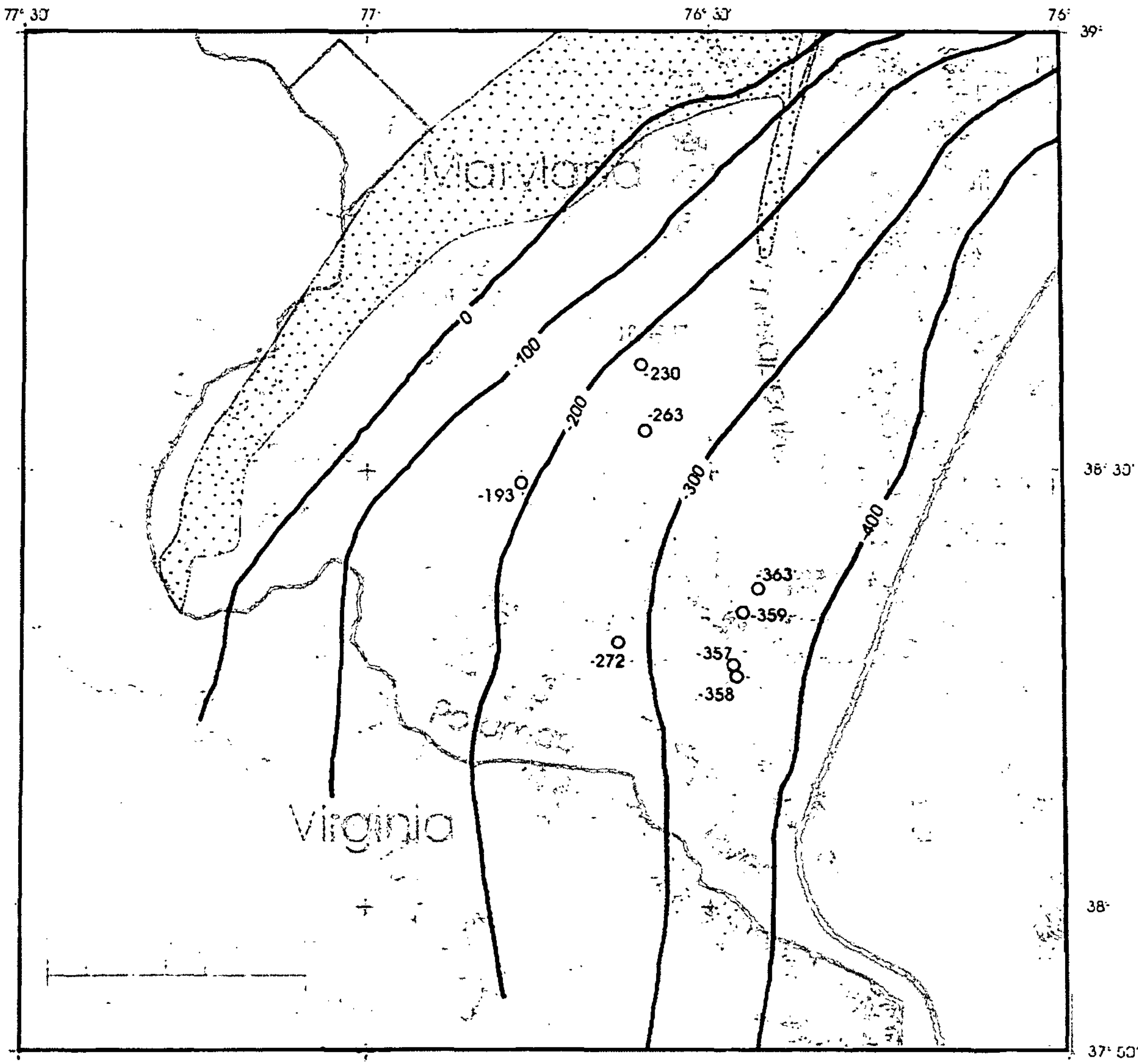
Attachment 1E: Groundwater Wells Relative Spacing (1 Sheet)



(Reference 9)

(Note: The number of wells shown for CCNPP3 is approximate. To support 100% availability, the number of wells can be optimized.)

Attachment 1F: Aquia Aquifer 80% Management Level Map (1 Sheet)



Explanation

—-100— Altitude of the 80-percent management surface, in feet relative to sea level. Contour interval is 100 feet.

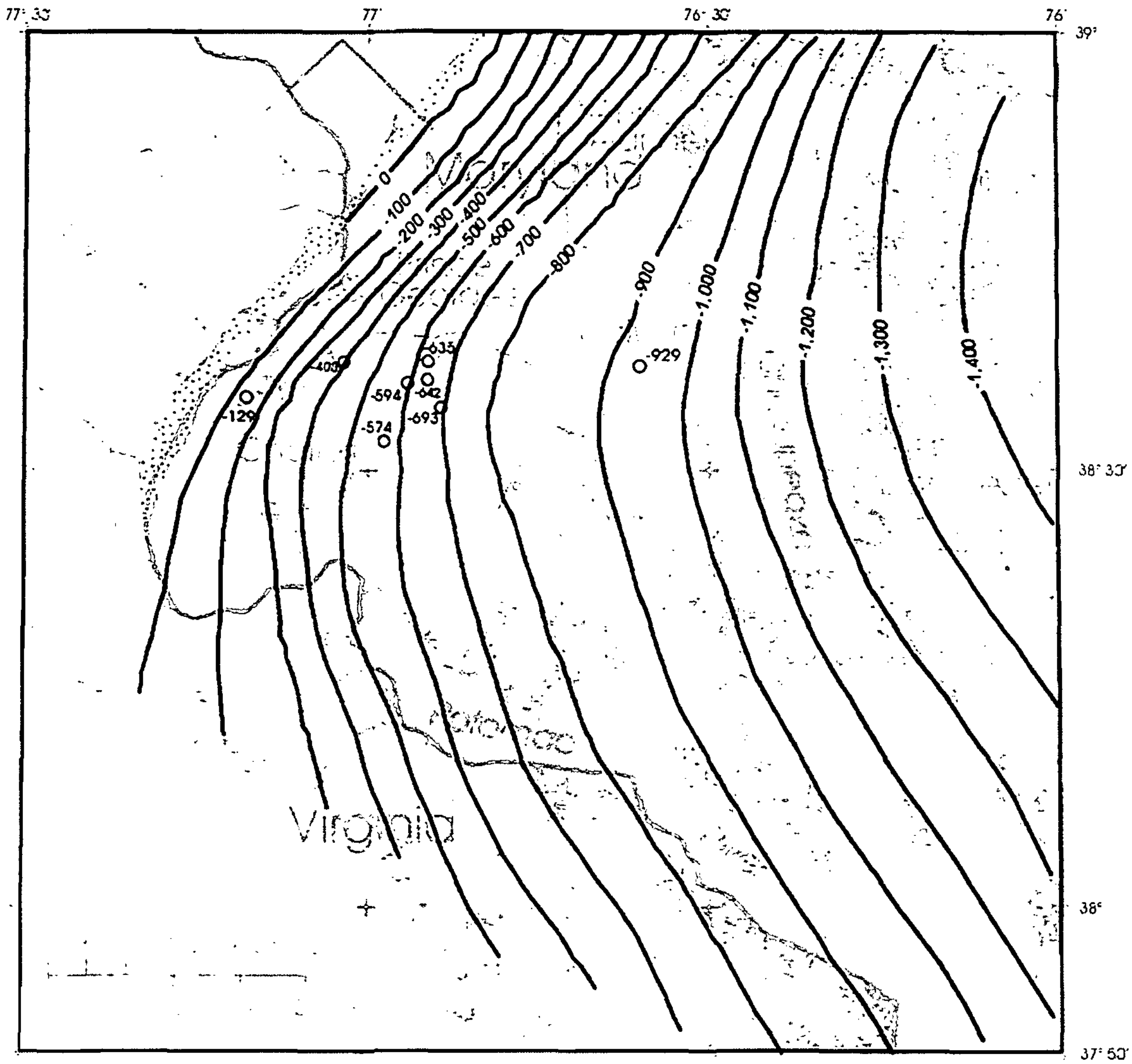
Approximate downdip extent of the Aquia aquifer.

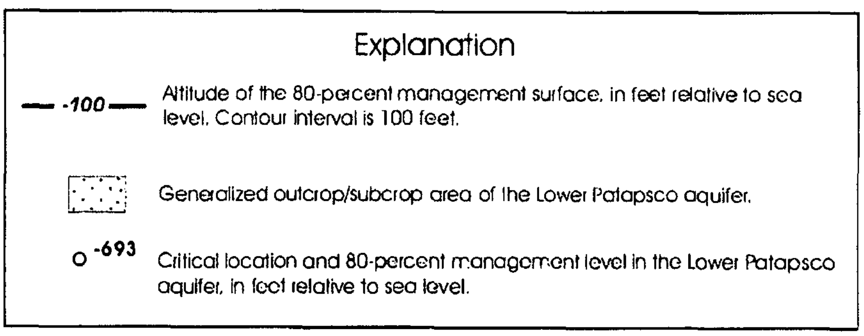
o -358 Critical location and 80-percent management level in the Aquia aquifer, in feet relative to sea level.

Generalized outcrop/subcrop area of the Aquia aquifer.

(Source of Information Documented in Ref. 7)

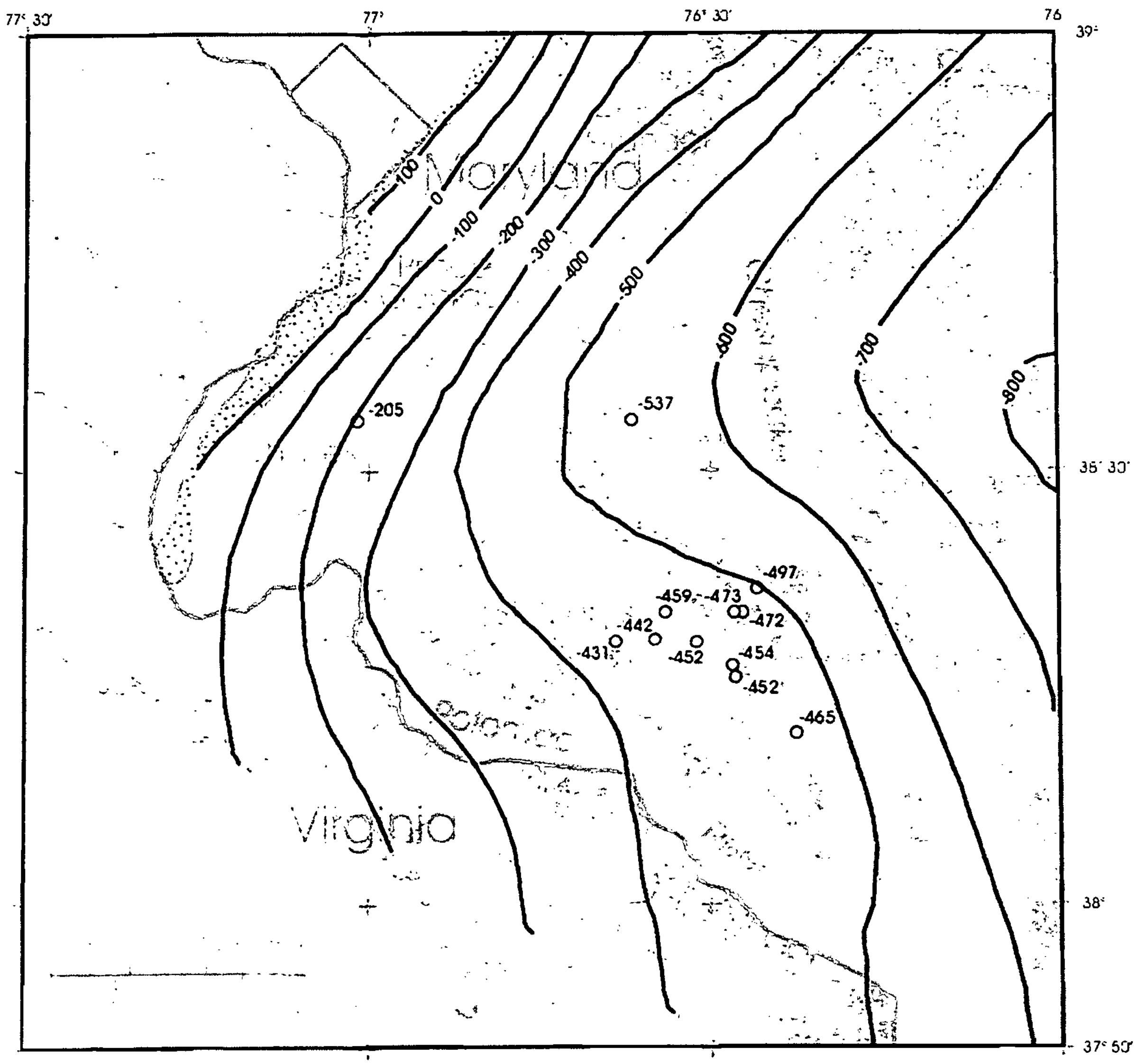
Attachment 1G: Lower Patapsco Aquifer 80% Management Level Map (1 Sheet)





(Source of Information Documented in Ref. 7)

Attachment 1H: Upper Patapsco Aquifer 80% Management Level Map (1 Sheet)



	Explanation
-100	Altitude of the 80-percent management surface, in feet relative to sea level. Contour interval is 100 feet.
	Generalized outcrop/subcrop area of the Upper Patapsco aquifer.
-465	Critical location and 80-percent management level, in the Upper Patapsco aquifer, in feet relative to sea level.

(Source of Information Documented in Ref. 12)

Attachment 1J: Summary of Analytical Results for Groundwater Well Sampling at Calvert Cliffs May 31, 2007 (2 Sheets)

Parameter	Units	OW 752A Surficial Aquifer	OW 319A Surficial Aquifer	OW 319B Upper Chesapeake Unit	OW 319B Duplicate Upper Chesapeake Unit	CCNPP Well No. 5 Aquia Aquifer	Rinse Blank
Metals							
Arsenic	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Barium	mg/l	0.027	0.055	0.044	0.044	0.025	<0.010
Cadmium	mg/l	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Calcium	mg/l	1.5	9.2	85	85	7.0	0.62
Chromium	mg/l	<0.0049	0.025	<0.0031	<0.0030	<0.0025	<0.0025
Iron	mg/l	1.8	23	8.0	8.0	3.2	<0.10
Lead	mg/l	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Magnesium	mg/l	1.4	3.2	3.1	3.1	2.3	<0.10
Mercury	mg/l	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Potassium	mg/l	1.5	3.7	2.4	2.4	10.0	<0.10
Selenium	mg/l	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Silicon	mg/l	6.3	13	16	16	5.3	2.3
Silver	mg/l	<0.012	<0.012	<0.001	<0.001	<0.012	<0.001
Sodium	mg/l	4.9	8.3	9.9	9.8	29	1.5
Non-metals							
Alkalinity, Bicarbonate	mg/l	<5	24.6	190	187	101	<5
Alkalinity, Total as $CaCO_3$	mg/l	<2.2	24.6	190	187	101	<2.2
Carbon Dioxide	mg/l	**	85.4	21.3	21	20	<5
Biologic Oxygen Demand	mg/l	<2	<3	<3	<3	<2	<2
Chemical Oxygen Demand	mg/l	21	24	26	28	26	<10
Chloride (Titrimetric, Mercuric Nitrate)	mg/l	4	10	13	12	2	<1
Color, True	color units	5	10	5	5	<5	<5
Enterococci	MPN/100ml	<1	410.6	2	<1	387.3	<1
Total Coliform	MPN/100ml	<1	17.1	<1	<1	1,299.70	<1
Fecal Coliform	MPN/100ml	<1	<1	<1	<1	<1	<1
Hardness, Total	mg/L	29	190	300	300	120	9
Nitrogen, Ammonia	mg/L	<1	<1	<1	<1	<1	<1
Nitrogen, Organic	mg/L	<1	<1	<1	<1	<1	<1
Nitrogen, Total Kjeldahl	mg/L	<1	<1	<1	<1	<1	<1
Nitrogen, Nitrite	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrogen, Nitrate	mg/L	<0.050	2.9	<0.050	<0.050	<0.050	<0.050
Odor, Threshold	TON	<1	15	8	16	<1	<1
Ph*	SU	3.93	5.76	7.25	7.25	7.01	7.4
Phosphorus, Ortho	mg/L	<0.010	<0.010	<0.010	<0.010	0.010	<0.010
Phosphorus, Total	mg/L	0.031	0.064	0.061	0.034	0.041	<0.010
Total Dissolved Solids (TDS)	mg/L	92	110	230	310	210	<10
Total Suspended Solids (TSS)	mg/L	21	210	50	43	12	<2
Sulfate	mg/L	22	20	20	22	7.5	<1

(Environmental Report, Revision 3, Table 2.3-40, Sheet 1 of 2)

(Source of Information Documented in Ref. 7)

Attachment 1J: Summary of Analytical Results for Groundwater Well Sampling at Calvert Cliffs May 31, 2007

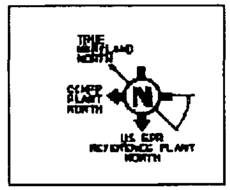
Parameter	Units	OW 752A Surficial Aquifer	OW 319A Surficial Aquifer	OW 319B Upper Chesapeake Unit	OW 319B Duplicate Upper Chesapeake Unit	CCNPP Well No. 5 Aquia Aquifer	Rinse Blank
Temperature	°F (°C)	65.2 (18.4)	69.3 (20.7)	63.2 (17.3)	63.2 (17.3)	68.0 (20.0)	69.1 (20.5)
Turbidity	NTU	7	60	49	37	4.1	<0.10

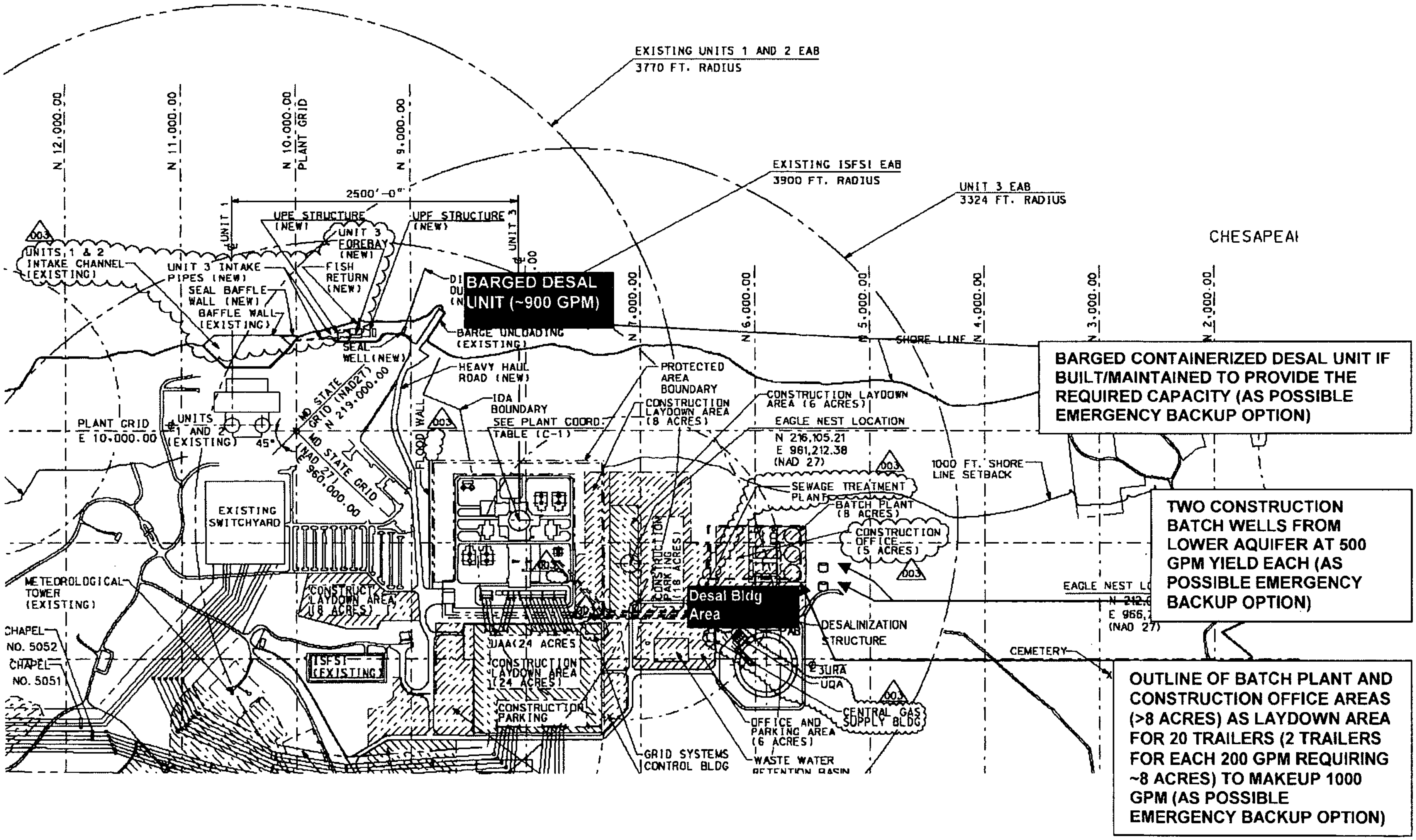
Notes:
SU = Standard Units (pH)
mg/L = Milligrams per liter
TON = Threshold odor number
MPN = Most probable number per 100
NTU = Nephelometric turbidity unit
* = Field Measurement
** = Carbon Dioxide could not be determined due to nondetected alkalinity and low pH

(Environmental Report, Revision 3, Table 2.3-40, Sheet 2 of 2)

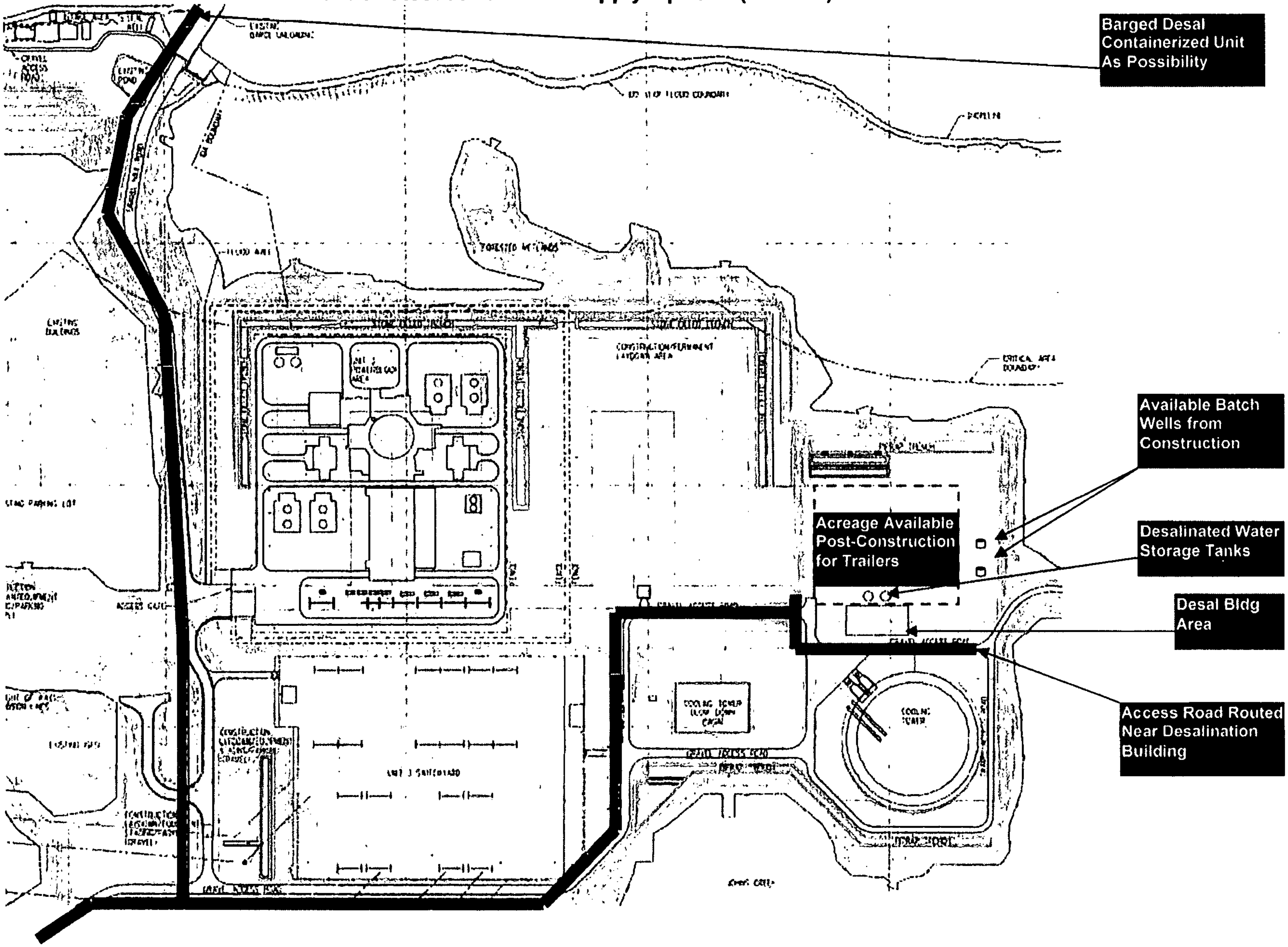
(Source of Information Documented in Ref. 7)

Attachment 2: Diagram of the Water Supply Options (1 Sheet)





Attachment 3: Access to Water Supply Options (1 Sheet)



Attachment 4: CPCN Requirements Addressed (1 Sheet)

"Within one year after the issuance of this CPCN, UniStar shall submit to MDE the results of an analysis of alternatives to address the potential need for an emergency backup supply for the desalination plant. The analysis shall consider additional intake locations, treatment equipment and sources of water other than ground water for the non-potable emergency backup water supply needs.

Discussed in Section 3.5

The analysis shall describe the type of emergencies under consideration for which a backup supply is needed and evaluate a suite of remedies for each condition.

Discussed in Sections 3.3 and 3.4

The analysis shall also consider the relative suitability of different aquifers, in light of arsenic levels above drinking water standards in nearby Aquia aquifer users' wells, and to minimize potential short-term impacts on other users.

Discussed in Sections 3.5.6; 3.6.1 and 4.0

Any appropriations request shall be contained within the analysis and shall include an explanation of the need for the water, the desired volume and duration of the withdrawal and the specific location(s) of the proposed withdrawal(s).

Discussed in Sections 3.5.6; 3.6.1; 2.1 and 4.0

MDE shall evaluate the requested appropriation(s) and alternative analysis. MDE may direct UniStar to conduct any field studies or water quality analyses that MDE determines to be needed to determine aquifer or water course characteristics, potential impacts to the resource and potential impacts to other users of the resource."

(Not discussed in report)

Attachment 5: Order of Magnitude Estimates of Viable Options (2 Sheets)

Calvert Cliffs Unit 3: Study of Options for Emergency Backup for Permanent Desalination Facilities Study

Order of Magnitude Estimate (OOM)

Option #1A: OOM Direct Cost: $3.7M

Scope Description:

Well System for Aquia Aquifer

Emergency Backup to provide fresh water to primary desalination water storage tanks

Drill and install 3 new 8" x 650' wells

Pipe to transfer fresh water to primary desalination water storage tanks

Well water treatment for arsenic, iron, & manganese

Option #1B: OOM Direct Cost: $3.7M

Scope Description:

Well System for Upper Patapsco Aquifer

Emergency Backup to provide fresh water to primary desalination water storage tanks

Drill and install 2 new 12" x 6" x 1,100' wells

Pipe to transfer fresh water to primary desalination water storage tanks

Well water treatment for arsenic, iron, & manganese

Option #1C: OOM Direct Cost: $4.0M

Scope Description:

Well System for Lower Patapsco Aquifer

Emergency Backup to provide fresh water to primary desalination water storage tanks

Drill and install 2 new 12" x 6" x 1,700' wells

Pipe to transfer fresh water to primary desalination water storage tanks

Well water treatment for arsenic, iron, & manganese

Option #2A: OOM Direct Cost: $10.3M

Scope Description:

Portable Desalination Unit - Capital Cost Installed Equipment

Emergency Backup to provide desalinated water to desalination water tanks

Product water lines to primary desalination storage tanks

Reject line to wastewater retention basin

Option #2B: OOM Direct Cost: $2.8M *

Scope Description:

Portable Desalination Unit - Leased Equipment

(Infrastructure Only in cost shown above)

Emergency Backup to provide desalinated water to desalination water tanks

Product water lines to primary desalination storage tanks

Reject line to wastewater retention basin

* NOTE for Option 2B: In addition to the capital cost shown above, the lease arrangement is expected to cost between $250K to $300K per month

Option #3: OOM Direct Cost: $2.8M *

Scope Description:

Pond: 530lf (Length), 150lf (Width), 25lf (Deep); Capacity = 17.5 million gallons

One pump for water transfer from pond to primary desalination water storage tanks

Pipe to transfer water from pond to primary desalination storage tanks

Pipe to transfer water to pond

Mobile Multi-Media Filtration (Leased Equipment)

* NOTE for Option 3: In addition to the capital cost shown above, a lease arrangement would be required to provide multi-media filtration. Also no operation and maintenance cost are included for maintaining the pond (e.g. periodic sediment removal)

Option #4: OOM Direct Cost: $13.5M

Scope Description:

Four desal plant backup storage tanks. Combined capacity = 17.5 million gallons

Four pumps for water transfer from backup storage tanks to primary desalination water storage tanks.

Pipe to transfer water from backup storage tanks to primary storage tanks

Pipe to transfer water to backup storage tanks

Notes

1 The estimated direct costs are current day overnight pricing for material and installation. Cost does not include allowances for indirect field cost (Distributable material, Indirect manual support and field nonmanual oversight), engineering, start-up, owners costs, site security, insurances & taxes, and contingency. These items could add approximately 50% to the cost and would accentuate any delta at the total cost level.

2 The estimates are order of magnitude (OOM) for comparison purposes between alternatives and do not represent a commercial offer. This estimate is defined as OOM due to the absence of a) detailed design, and b) firm pricing specific to the project.

3 No schedule considerations were evaluated.

Attachment 6: Chesapeake Bay Water Chemistry (1 Sheet)

Constituents	Design Values
Aluminum, mg/l	0.5
Arsenic, mg/l	0.1
Barium, mg/l	0.05
Calcium, mg/l	350
Copper, mg/l	0.04
Iron (total), mg/l	0.5
Lead, mg/l	0.002
Manganese (total), mg/l	0.1
Magnesium, mg/l	700
Potassium, mg/l	250
Sodium, mg/l	6,000
Strontium, mg/l	4
Vanadium, mg/l	0.01
Zinc, mg/l	0.02
M Alkalinity, mg/l as $CaCO_3$	150
Ammonia, mg/l	1
BOD_5, mg/l	5
Bromides, mg/l	20
Chlorides, mg/l	11,000
Color, Pt-Co units	10
Conductivity, micromhos/cm	42,000
Fluorides, mg/l	0.6
Nitrates (as NO_3), mg/l	<10
Nitrites (as NO_2), mg/	0.01
Oil and Grease, mg/l	<5
pH, standard units	7.7-7.8
Phosphates (as PO_4), mg/l	<0.4
Silica (dissolved), mg/l	1.5
Silica (total), mg/l	3
Sulfates, mg/l	1,500
Total Organic Carbon (TOC), mg/l	3
Total Dissolved Solids (TDS), mg/l	20,000 (approx.)
Total Suspended Solids (TSS), mg/l	23 (Note 1)
Turbidity, NTU	5.5

The water analysis data presented in this table is the result of water sampling and some necessary adjustments, as annotated in Note 1 below. The water sampling was performed between February 2007 and April 2007 (Reference 13).

Note 1: The higher TSS spikes were not considered in this design water analysis. The duration of these peak values is considered to be for a few hours only and not have a major impact on the pretreatment system.