May 21, 2007
25237-000-T7C-GAMC-00130

Mr. Rod Krich
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Subject: **Calvert Cliffs Desalination Study Revision 000,**
Document Number 25237-000-30R-M21G-00001, Rev. 000
Constellation COLA - Bechtel Job Number 25237
PO Number: 500117

References: 1) Bechtel letter 25237-000-T7C-GAMC-00088 dated April 10, 2007, Calvert Cliffs Desalination Study (Preliminary Report)
2) Email from Rod Krich to Scott Close dated 5/3/2007, Desalination Study Comments

Dear Mr. Milbradt:

The purpose of this letter is to transmit the Desalination Plant Study Revision 0 for the Calvert Cliffs Nuclear Power Plant Unit 3. Revision 0 of this study incorporates comments provided in Reference 2.

The study has been renumbered from 25237-000-G65-GGG-00006 to 25237-000-30R-M21G-00001.

This completes schedule activity F230900016.

If you have any questions regarding the foregoing, please contact me at 301-228-8655 or Shankar Rao at 301-228-8650.

Sincerely,
BECHTEL POWER CORPORATION

Nar Goel
Project Manager

GAT:gcs

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Enclosures: 1) Calvert Cliffs Desalination Study, 25237-000-30R-M21G-00001, Rev. 000 (31 pages)
2) Comment Resolution Table (2 pages)

Action Summary

Response Required: No
Due Date: N/A
Bechtel AIL/Schedule: N/A

cc:

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Calvert Cliffs Desalination Study
Study Number: 25237-000-30R-M21G-00001, Rev. 000

EXECUTIVE SUMMARY

Constellation Energy has requested Bechtel Power Corporation to perform a feasibility study for an alternate source to well water supply for the new EPR Unit 3 at the Calvert Cliffs Nuclear Plant. Fresh water needs to be supplied as a source of water for potable water use, demineralized make-up water feed, miscellaneous services, fire protection and Ultimate Heat Sink (UHS) cooling tower make-up. If sufficient well water capacity from the aquifer to satisfy these water demands is not available from the wells, the alternate water supply would be desalinated Chesapeake Bay water.

For sizing purposes Constellation has stipulated 1,750,000 gallons per day of desalinated water; of this flow 1,250,000 gallons per day are for the new Unit 3 and 500,000 gallons per day for additional capacity usage. The desalination plant will be located indoors to the extent possible and the equipment required to produce demineralized water would be built as an annex to the desalination plant as a common facility. The equipment required to demineralize the desalinated water for make-up to the plant as well as potable water treatment equipment and related facilities required to meet the Maryland Department of the Environment (MDE) and Public Health water quality requirements are not in the scope of this study.

Desalination technologies include multi-stage flash (MSF) evaporation, multi effect distillation (MED) and seawater reverse osmosis (SWRO). MSF and MED have been largely used in the Middle East for the production of potable water when the SWRO technology was in the development stages. SWRO has now become competitive compared to the MSF and MED technologies for applications all around the world, including the US. For this study SWRO has been selected as the technology of choice based on technical considerations such as size of the plant, difficulties in routing extracted steam and condensate from the desalination unit and the power plant, and other practical considerations.

The system proposed in this study consists of membrane filtration (microfiltration or ultrafiltration) as a pretreatment system that will provide feed to the reverse osmosis equipment. The SWRO equipment consists of cartridge filters, seawater reverse osmosis (SWRO) membranes, decarbonator, cleaning and flushing equipment, miscellaneous chemical feed systems, storage tanks, instrumentation, controls, and power supply equipment. The bulk of the equipment will be housed in a Desalination Plant Building. SWRO product water will be distributed to the various services for new Unit 3 as described above, including the demineralized water system for Unit 3. The wastes resulting from the membrane filtration and SWRO equipment will be collected in a Waste Water Retention Basin and discharged to the Chesapeake Bay, as this waste will be similar to the circulating water cooling tower blowdown. A major technical advantage in using desalinated water is that, under normal water salinity

conditions, it allows for higher operating cycles of concentration in the UHS Cooling Tower. This reduces UHS cooling tower blowdown discharge.

1.0 INTRODUCTION

1.1 Purpose

The purpose of this study is to recommend an alternative process for supplying make-up water to Calvert Cliffs Nuclear Plant Unit 3 in lieu of well water. The alternative raw water source would be Chesapeake Bay brackish water. Desalinating the Chesapeake Bay brackish water will allow Constellation Energy to provide a reliable alternate source to the groundwater supply for potable water, demineralized water, miscellaneous services, fire protection systems, and make-up to the Ultimate Heat Sink (UHS) System Tower for the new Unit 3.

1.2 Scope

The proposed Desalination Plant will treat Chesapeake Bay brackish water to produce 1,750,000 gallons per day of desalinated water. This includes the water demand for the new Unit 3 (1,250,000 gallons per day) and for additional capacity usage (500,000 gallons per day). Implementation of the recommendations in this Study will require the design and construction of a complete system, including process equipment, instrumentation, controls, electrical equipment, building, chemical feeds, desalinated water storage tank, chemical storage tanks, and other appurtenances. The production of potable water and additional equipment required to produce demineralized water for the three units are excluded from this study. It is proposed that the desalination technology be based on sea water RO treatment, with energy recovery to lower energy costs as an option for future evaluation.

The recommendations of this study are based on Bechtel's experience with seawater and brackish water desalination applications, as well as worldwide industry experience.

1.3 Objectives

The objectives of this study are:

1.3.1 Provide sufficient information so that Constellation Energy can make the decision regarding installation of a desalination plant in lieu of well water that may not be available.

1.3.2 Provide sufficient technical and design data to develop a cost estimate (the cost estimate is not part of the scope of this study).

1.3.3 Develop wastewater characterization data to be used in environmental permitting.

1.4 Background

It is assumed that the presently used Aquia Aquifer for Units 1 and 2 may not be sufficient for the new unit, since it is being reserved for residential growth (Ref. 6.10). There is also County and State pressure to find alternate supplies even for the existing Units 1 and 2. There is the option of deep aquifers, such as the Patapsco Aquifer. This would require digging wells, as well as extensive testing. Constellation Energy believes that this would require approximately six wells, 1,000 feet deep that will be dispersed around the plant site.

It is for the above reasons that Constellation Energy is considering the use of a desalination plant to provide plant make-up water for potable water, demineralized water, miscellaneous services, fire protection systems, and Ultimate Heat Sink (UHS) System Tower for the new Unit 3. The availability of desalinated water from Chesapeake Bay will also positively impact the new Unit 3 licensing process with respect to water availability.

2.0 STUDY BASES

2.1 Criteria

2.1.1 Water Analysis Bases

Chesapeake Bay water is brackish, having a wide variation of salinities or total dissolved solids (TDS). For designing a seawater RO system, the water quality with the highest probability of occurrence should be selected, with provisions for high and low spikes. Salinities in the Chesapeake Bay are typically in the 10-15 parts per thousand (ppt) or 10,000-15,000 ppm (mg/l) TDS. The maximum salinity observed since 2004 is 19.94 ppt (Ref.5.5). Therefore, for this study a design TDS of 20,000 mg/l has been selected. This is a somewhat conservative approach for sizing the RO membranes, but the design of the SWRO system will be flexible and will allow for the lower TDS raw water to be treated effectively to meet the RO product water quality.

Although salinity is generally sufficient to perform a rough conceptual design of a SWRO system, the other major constituents are also important for an optimized design. Since the wastewater characterization is required by Constellation Energy, a more complete water analysis was developed. Bechtel has further requested that Constellation Energy take a number of samples of the Chesapeake Bay water to help develop the design water analysis for future use.

Four sets of bi-weekly samples were tested by Constellation Energy between February 2007 and April 2007: two samples were taken on February 19 and 20, 2007, respectively (Ref. 5.3),two on March 5 and 6, 2007, respectively (Ref. 5.4), two on March 20, 2007 (Ref. 5.11) and two on April 17, 2007 (Ref. 5.12). In addition, one sample taken on January 14, 2005 by General Electric (Ref. 5.3) was also included. These data were evaluated and adjusted to a TDS of approximately 20,000 mg/l TDS to determine a design water analysis. The results are shown in Table 2.1.1 below.

Per Ref. 5.1 a number of spikes in TSS and TOC are noted. However, they are not part of the design water analysis for this Study, as they are considered infrequent.

Table 2.1.1 Chesapeake Bay Design Water Analysis

Constituents	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	4.3 (Note 1)
Total Dissolved Solids (TDS), mg/l	20,000 (approx.)
Total Suspended Solids (TSS), mg/l	28 (Note 2)
Turbidity, NTU	8.5

Note 1: The higher TOC spikes were not considered in this design water analysis as they were considered to have a low probability of occurrence and were potentially the result of a sampling error.

Note 2: 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.

2.1.2 Applied Technologies

Below is a summary of the technology that would apply to the Calvert Cliffs Desalination Plant. There are two proven methods for treating saline water: membrane treatment (e.g. SWRO) and thermal treatment. The economics of thermal systems such as MED, or MSF, lend themselves to moderate to large plants treating salt water sources, particularly the high salinity of the Mediterranean and Red Seas.

2.1.2.1 Multi-Stage Flash (MSF) Evaporation Desalination

Multi-stage flash distillation is a desalination_process that distills sea water by flashing a portion of the water into steam in multiple stages. First, the seawater is heated in a container known as a brine heater. This is usually achieved by condensing steam on a bank of tubes carrying sea water through the brine heater. Thus heated, the water is passed to another container known as a "stage", where the surrounding pressure is lower than that in the brine heater. It is the sudden introduction of this water into a lower pressure "stage" that causes it to boil so rapidly as to flash into steam. The MSF process is performed most effectively by raising the seawater temperature from ambient to a temperature of ~110°C. However, the higher temperature seawater causes corrosion of steel and other metals in the heat exchanger equipment. This high temperature also causes calcium, magnesium and sulfates to precipitate and scale the heat exchanger equipment. This scaling leads to a reduction in the heat transfer rate and an increase in the system losses unless antiscalants are added to alleviate scaling. High alloy steels are therefore used to reduce corrosion, and chemicals are used to reduce scaling. These increase system costs. For the desalinated water required for Unit 3, the MSF technology is not a feasible alternative because the output is not large enough to justify the increased system capital and operating costs.

Any thermal evaporation option would require extraction of steam from the main cycle or an auxiliary boiler. These two considerations overwhelmingly disfavor the thermal technologies in this case

2.1.2.2 Multiple Effect Distillation (MED) Desalination

Multiple Effect Distillation is a process for efficiently using the heat from steam to evaporate water. In a multiple-effect evaporator, water is boiled in a sequence of vessels, each held at a lower pressure than the last. Because the boiling point of water decreases as pressure decreases, the vapor boiled off in one vessel can be used to heat the next, and only the first vessel (at the highest pressure) requires an external source of heat. While in theory, evaporators may be built with an arbitrarily large number of stages, evaporators with more than four stages are rarely practical. The MED process is performed with lower temperature seawater (~70°C) which reduces the steam demand and leads to less corrosion and scaling in the heat exchanger equipment. However, with the lower temperature comes a need for a larger surface area to reach the same amount of fresh water production. The larger surface area leads to a physically larger structure, which increases the system costs. The MED process also requires nozzles to spray seawater; therefore, filtration or straining of the seawater is typically required prior to the desalination process. For the required output flow rate, this method is not feasible because the output is not large enough to justify the increased system capital and operating costs.

MED would similarly require extraction of steam from the main cycle or an auxiliary boiler. These two considerations overwhelmingly disfavor this process.

2.1.2.3 Seawater Reverse Osmosis (SWRO) Desalination

A third type of desalination process is seawater reverse osmosis (SWRO). This process requires a significant pretreatment system, such as fine filtration (depending on the water quality). The costs associated with this process are starting to decrease with technological developments in pretreatment and RO systems resulting in lower capital and operating costs. Recent developments in membrane pretreatment technologies provide a number of very robust alternates at competitive costs. These include different types of ultrafiltration and microfiltration membranes. The trade off in size, production capacity, high alloy metallurgy, and pretreatment requirements results in the ongoing competition between these technologies in capital cost and operating costs. This process, although expensive in large scales, is the best fit for the required flow rate and water quality output required by this project.

2.1.2.4 Process Selected

The SWRO system detailed in this Study has been selected as a treatment process to treat Chesapeake Bay brackish water to provide desalinated water for makeup to the Unit 3 process users. The Bay water salinity varies between 8,000 to 15,000 mg/l to an upper level of 20,000 mg/l, which necessitates that this water source be desalinated prior to supply to the users mentioned.

Since the 1990's, seawater RO has captured a very large segment of the desalination market. The 2004-2005 installed capacity of seawater RO was 5 billion gallons per day. This was expected to double by 2025. Key factors driving this growth are:

- Performance of RO membranes : more efficient, more durable, and less expensive
- Improvements in RO pretreatment technologies
- The RO plant sizes (per train) are now significantly larger (up to 2.6 MGD single RO train is feasible)

2.2 Assumptions

The following assumptions have been made for this Study:

2.2.1 The desalinated water production is 1,750,000 gallons per day (1,215 gpm continuous). For calculation purposes 1,225 gpm was used.

2.2.2 A 50% RO recovery was used for wastewater characterization. This is the conservative approach for waste characterization. It may be possible to optimize the system to achieve 55% recovery, resulting in a more concentrated waste stream. However, this has not been considered. In fact the recovery rate does not affect the total solids in pounds per day leaving the RO system in the reject stream.

2.2.3 For equipment sizing, 40% recovery was used to maximize the size of the RO equipment to handle any loss of recovery due to unavoidable operating conditions. This is the more conservative approach with respect to equipment sizing.

2.2.4 Membrane filtration waste is 10% of the influent.

2.2.5 The Desalination Water Storage Tank is sized for eight hours of storage (rounded up to 600,000 gallons).

2.2.6 Membrane filtration and RO reject wastes will be diverted to the Waste Water Retention Basin prior to discharge to the Chesapeake Bay.

2.2.7 It is assumed that a separate facility will be provided to produce demineralized water for Unit 3.

2.2.8 The sizing of the Desalination System includes the potable water demand for Unit 3. This may require special testing, operator training, and FDA approved chemicals for the entire SWRO process. This matter should be explored further with the Maryland Department of the Environment (MDE) and other licensing authorities.

2.2.9 Influent for the desalination plant will be supplied by a branch line extending from the CWS cooling tower makeup supply, located adjacent to the proposed location for the desalination plant.

2.2.10 The desalination system and any supporting structures are assumed to be classified as non-safety-related.

2.3 Methodology

The methodology utilized is based on typical steps used in the development of any process technology:

- Comparison of feasible technologies
- Cost of feasible technologies

- Technical advantages and disadvantages
- Impact on licensing process
- Wastewater disposal and handling

3.0 DESCRIPTION OF ALTERNATIVES

3.1 Alternate Desalination Processes

3.1.1 Desalination Processes

See Section 2.1.2 for the other desalination processes discussed. Further consideration of the thermal desalination options was dropped due to process considerations discussed in Section 2.1.2.

3.1.2 Energy Recovery Options for RO

The information provided below was extracted from Reference 5.10.

Use of mechanical energy recovery devices has been the key to success of the SWRO systems. These can reduce the energy requirements by 10 to 50%. There are four major types of seawater energy recovery devices:

- Pelton wheels or impulse turbines directly connected to electrical generators
- Reaction turbines such as Francis Turbine or reverse running pump turbines
- Pressure Exchangers
- Turbochargers

Configuration of SWRO with Recovery Turbines

The most efficient configuration is called the Three Center Design (TCD) consisting of a centralized pump center, an energy recovery center, and a RO membrane center.

The energy recovery system (ERS) should change the brine flow smoothly across a broad range of flows, keeping the pump flow constant and no net loss in pump efficiency.

To achieve the above objectives the system should be designed to mechanically separate the energy recovery system from the pump system. This would allow changes in flow without the peak power demands associated with starting and stopping equipment.

Efficiencies of Energy Transfer

The pressure losses from RO feed to RO brine are very small and the brine retains almost 50% of the energy that was used for desalination. Therefore, the transfer of energy from brine to feed is critical.

In Pelton wheels, the energy transfer is indirect: with brine jets hitting the turbine buckets and energy being transferred to a shaft and from the shaft to the pump. The Pelton wheel efficiency is about 87%. Coupled to this is a pump efficiency of 70% that leads to an overall hydraulic energy transfer efficiency (HETE of about 61%. However, if a pump with 85% efficiency is selected, the HETE can be 74%.

In pressure exchangers where the transfer of energy is direct from brine to feed, the pressure exchanger is also a high pressure pump for flow equal to brine flow. The feed pump therefore pumps only the feed flow equal to the permeate flow plus brine losses due to internal leakage. A small booster pump is required for the “pressure exchanged feed” to build up the pressure losses (3 to 4 bars). The energy recovery efficiency of pressure exchangers is about 96%. The HETE efficiency is much lower (approximately 70%).

The turbocharger is comparable to pressure exchangers in HETE. In some cases the HETE of the turbocharger may even be higher than pressure exchangers.

The costs today for RO systems with pressure exchangers or turbochargers are around 2.0 Kwh/ m^3 of product water or 7.6 Kwh per 1000 gallons.

The decision to include energy recovery devices is a result of comparing the additional capital cost with the savings in operating costs. The larger the desalination plant, the greater the benefit to the energy recovery devices.

3.2 Pretreatment Alternatives

For any reverse osmosis process, pretreatment is essential to prevent fouling and scaling the membranes. The silt density index (SDI) is a field test for the plugging tendencies a membrane can expect. The SDI is generally expected to be less than 5, in some cases less than 3. To achieve this, several options are available:

- ***Particle Filtration*** (sand, dual media and multimedia filters) in a gravity or pressure arrangement.

  For desalination, to meet the SDI would require two stages of filtration (a primary and secondary stage in series) with enhanced coagulation. The filters would also require frequent backwashing, which are operator-intensive. This equipment can generally meet the RO SDI requirements. However, they are not as effective as membrane filters. Although they tend to be cheaper than membrane filters, the gap is narrowing. Depending on the nature of the suspended or colloidal particles, it is possible that the required SDI would not be met all the time.

- ***Ultrafiltration (UF)***

  UF is a separation process using membranes with pore sizes in the range of 0.1 to 0.001 micron. Typically, ultrafiltration will remove high molecular-weight substances, colloidal materials, and organic and inorganic polymeric molecules. Low molecular-weight organics and ions such as sodium, calcium, magnesium, chloride, and sulfate are not removed. Because only high-molecular weight species are removed, the osmotic pressure differential across the membrane surface is negligible. Low applied pressures are therefore sufficient to achieve high flux rates from an ultrafiltration membrane. Flux of a membrane is defined as the amount of permeate produced per unit area of membrane surface per unit time. Generally flux is expressed as gallons per square foot per day (GFD) or as cubic meters per square meters per day.

- ***Microfiltration (MF)***

  MF is similar to UF, except it removes particles down to only 0.1 microns.

The selection process (UF or MF) depends on the characteristics of the water, particularly TSS and TOC, colloidal particles such as silica and metals, and BOD when located near a sewage treatment plant discharge. Owner's experience, vendor experience and cost are also determining factors.

3.3 Chemical Conditioning

The following chemicals are fed at various points to achieve the desired effects, keep the desalination system clean and mitigate corrosion in pipes and equipment. The chemicals used are as follows:

3.3.1 Sodium hypochlorite – fed upstream of the membrane filtration units. Other feed points and disinfection methods may be considered, such as ultraviolet light (UV) disinfection.

3.3.2 Coagulant – ferric chloride, ferric sulfate or alum – fed upstream of the membrane filtration units. This is to increase the filtration efficiency.

3.3.3 Caustic Soda – fed upstream of the membrane filtration units if required to neutralize the pH depression due to the addition of coagulant.

3.3.3 Sulfuric Acid – fed upstream of the RO units if required to reduce alkalinity, pH adjustment, and scale control.

3.3.4 Scale Inhibitor – fed upstream of the RO units to prevent scaling in the reject stream.

3.3.5 – Sodium Bisulfite – dechlorination chemical, since membranes are not tolerant to chlorine.

3.3.5 – Clean In Place (CIP) chemicals – depends on the nature of the scale or foulant.

3.3.5 – Corrosion Inhibitors – fed as required to mitigate corrosion of service water equipment and pipes.

3.4 Reverse Osmosis Process

The information provided below was extracted from Reference 5.9.

To understand the Reverse Osmosis process, one must begin by understanding the process of osmosis, which occurs in nature. In living things, osmosis is frequently seen. The component parts include a pure or relatively pure water solution and a saline or contaminated water solution, separated by a semi-permeable membrane, and a container or transport mechanism of some type.

The semi-permeable membrane is so designated because it permits certain elements to pass through, while blocking others. The elements that pass through include water, smaller molecules of dissolved solids, and most gases. The dissolved solids are usually further restricted based on their respective electrical charge.

In osmosis, naturally occurring in living things, the pure solution passes through the membrane until the osmotic pressure becomes equalized, at which point osmosis ceases. The osmotic pressure is defined as the pressure differential required to stop osmosis from occurring. This pressure differential is determined by the total dissolved solids content of the saline solution or contaminated solution on one side of the membrane. The higher the dissolved solids content, the higher the osmotic pressure. Each element that may be dissolved in the solution contributes to the osmotic pressure, in that the molecular weight of the element affects the osmotic pressure. Generally, higher molecular weights result in higher osmotic pressures. Hence the formula for calculating osmotic pressure is very complex. However, approximate osmotic pressures are usually sufficient to design a system. Common tap water as found in most Western lands may have an osmotic pressure of about 10 psi, or about 1.68 Bar. Seawater at 36,000 mg/l typically has an osmotic pressure of about 376 psi (26.75 Bar).

Thus, to reach the point at which osmosis stops for tap water a pressure of 10 psi would have to be applied to the saline solution, and to stop osmosis in seawater, a pressure of 376 psi would have to be applied to the seawater side of the membrane.

Several decades ago, U.S. Government scientists had the idea that the principles of osmosis could be harnessed to purify water from various sources, including brackish water and seawater. In order to transform this process into one that purifies water, osmosis would have to be reversed, and suitable synthetic membrane materials would have to be developed. Additionally, ways of configuring the membranes would have to be engineered to handle a continuous flow of raw and processed water without clogging or scaling the membrane material.

These ideas were crystallized and fueled by U.S. Government funding, which led to the development of usable membrane materials and designs. One of the membrane designs was the spiral wound membrane element. This design enabled the engineers to construct a membrane element that could contain a generous amount of membrane area in a small package, and to permit the flow of raw water to pass along the length of the membrane. This permits flows and pressures to be developed to the point that ample processed or purified water is produced, while keeping the membrane surface relatively free from particulate, colloidal, bacteriological or mineralogical fouling. The design features a perforated tube in the center of the element, called the product or permeate tube, and wound around this tube are one or more "envelopes" of membrane material, opening at the permeate tube. Each envelope is sealed at the incoming and exiting edge. Thus when water penetrates or permeates though the membrane, it travels, aided by a fine mesh called the permeate channel, around the spiral and collects in the permeate tube. Permeate or product water is collected from the end of each membrane element, and becomes the product or result of the purification process.

Meanwhile, as the raw water flows along the "brine channel" or coarse medium provided to facilitate good flow characteristics, it gets more and more concentrated. This concentrated raw water is called the reject stream or concentrate stream. It may also be called brine if it is coming from a salt water source. The concentrate, when sufficient flows are maintained, serves to carry away the impurities removed by the membrane, thus keeping the membrane surface clean and functional. This is important, as buildup on the membrane surface, called fouling, impedes or even prevents the purification process.

The membrane material itself is a special thin film composite (TFC) polyamide material, cast in a microscopically thin layer on another, thicker cast layer of Polysulfone, called the microporous support layer. The microporous support layer is cast on sheets of paper-like material that are made from synthetic fibers such as polyester, and manufactured to the required tolerances. Each sheet of membrane material is inspected at special light tables to ensure the quality of the membrane coating, before being assembled into the spiral wound element design.

To achieve Reverse Osmosis, the osmotic pressure must be exceeded, and to produce a reasonable amount of purified water, the osmotic pressure is generally doubled. Thus with seawater osmotic pressure of 376 psi, a typical system operating pressure is about 800 psi. Factors that affect the pressure required include raw water temperature, raw water total dissolved solids (TDS), membrane age, and membrane fouling.

The effect of temperature is that with higher temperatures, the salt passage increases, flux (permeate flow) increases, and operating pressure required is lower. With lower temperatures, the inverse occurs, in that salt passage decreases (reducing the TDS in the permeate or product water), while operating pressures increase. Or if operating pressures do not increase, then the amount of permeate or product water is reduced. In general, RO systems are designed for raw water temperatures of 25° C (77° F). Higher temperatures or lower temperatures can be accommodated with appropriate adjustments in the system design.

Membranes are available in "standard rejection" or "high rejection" models for seawater and brackish water. The rejection rate is the percentage of dissolved solids rejected, or prevented from passing through the membrane. For example, a membrane with a rejection rate of 99% (usually based on Na (Sodium)) will allow only 1% of the concentration of dissolved solids to pass through into the permeate. Hence product water from a source containing 10,000 mg/l would have 100 mg/l remaining. Of course, as the raw water is processed, the concentrations of TDS increase as it passes along the membrane's length, and usually multiple membranes are employed, with each membrane in series seeing progressively higher dissolved solids levels. Typically, starting with seawater of 36,000 mg/l, standard rejection membranes produce permeate below 500 mg/l, while high rejection membranes under the same conditions produce drinking water TDS of below 300 mg/l There are many considerations when designing RO systems that competent engineers are aware of. These include optimum flows and pressures, optimum recovery rates (the percentage of permeate from a given stream of raw water), prefiltration and other pretreatment considerations, and so forth.

Membrane systems in general cannot handle the typical load of particulate contaminants without prefiltration. Often, well designed systems employ multiple stages of prefiltration, tailored to the application, including multi-media filtration, microfiltration or ultrafiltration and one or more stages of cartridge filtration. Usually the last stage would be 5 micron or smaller, to provide sufficient protection for the membranes.

RO systems typically have the following components: A supply pump or pressurized raw water supply, prefiltration in one or more stages, chemical injection of one or more pretreatment agents may be added, a pressure pump suited to the application, sized and driven appropriately for the flow and pressure required, a membrane array including one or more membranes installed in one or more pressure tubes (also called pressure vessels, RO pressure vessels, or similar), various gauges and flow meters, a pressure regulating valve, relief valve(s) and/or safety pressure switches, and possibly some form of post treatment. Post treatment should usually include a form of sterilization such as Chlorine, Bromine, Ultra-Violet (U-V), or Ozone. Other types of post treatment may include carbon filters, pH adjustment, or mineral injection for some applications.

Some very low cost RO systems may dispense with most of the controls and instruments. However, systems installed in critical applications should be equipped with a permeate or product flow meter, a reject, concentrate or brine flow meter, multiple pressure gauges to indicate the pressure before and after each filtration device and the system operation pressure in the membrane loop, preferably both before and after the membrane array. Another feature found in better systems is a provision to clean the membranes in place, commonly known as a Clean In Place (CIP) system. Such a system may be built right into the RO system or may be provided as an attachment for use as required.

Reverse Osmosis has proved to be the most reliable and cost effective method of desalinating water, and hence its use has become more and more widespread. Energy consumption is usually some 70% less than for comparable evaporation technologies. Advancements have been made in membrane technology, resulting in stable, long lived membrane elements. Component parts have been improved as well, reducing maintenance and down time. Additional advancements in pretreatment have been made in recent years, further extending membrane life and improving performance. Reverse Osmosis delivers product water or permeate having essentially the same temperature as the raw water source (an increase of 1° C or 1.8° F may occur due to pumping and friction in the piping). This is more desirable than the hot water produced by evaporation technologies. RO Systems can be designed to deliver virtually any required product water quality. For these and other reasons, RO is usually the preferred method of desalination today.

3.5 System Description of the Proposed Process

Reverse osmosis requires pretreatment for removal of suspended material that foul RO membranes, as well as organics and scaling salts. As scaling salts are not an issue with the Bay water, membrane filtration was selected for its reliable high quality effluent, as well as simplicity in operation. This was in lieu of media filtration with enhanced coagulation where the quality varies based on the operator attention to chemical processes.

The system presented in this study is conceptual in nature. The design detail provided is based on estimates, good engineering judgment, and past experience with these types of systems. This detail is sufficient for the study and selection of various schemes, however it does not represent detailed engineered system, and as such, some components or equipment sizing may change in actual application.

Refer to Drawing SK-FD-00001 Process Flow Diagram for the Desalination Process (Appendix 6.1) for a depiction of the process. Also refer to Drawing SK-

WB-00001 Water Balance Diagram (Appendix 6.2) for the proposed arrangement as related to the various services.

The treatment process selected consists of pretreatment membrane filtration followed by reverse osmosis treatment which will reduce the salinity of the Bay water to a level of about 200 to 300 mg/l, with the general characteristics of softened well water. It should be noted that the system described herein is conceptual in nature. The basic process will not change significantly during the detailed design and execution phased. However, some of the components and their arrangement could potentially change.

First the raw water is pumped from the plant intake to the membrane filtration system. The water will be fed from the discharge of the Cooling Tower Makeup Pumps. Sodium hypochlorite (NaOCl) is injected into the feed for reduction of BOD and biological activity. The capability to add coagulant is provided to assist in filter efficiency during high TSS periods, as well as sodium hydroxide (NaOH) addition to counter the acidic effect of the coagulant. The chemically treated feed then enters the membrane filtration system, where solids are rejected and purged from the system in the reject stream. Membrane filtration product water is then routed to a break tank that provides surge capacity between the MF trains and the reverse osmosis (RO) trains. Any addition of chemical in the feed is controlled via flow pacing.

Given the size of the system, the membrane filtration portion of the system has been configured as 4 x 33% to provide a true spare train. Each of the trains is periodically backflushed, therefore there is a short duration where production is reduced during the back flush step. Surge capacity in the break tank accounts for the deficit, which is then made up between backflush steps. Alternatively, the spare train may be placed in service to maintain a steady volume in the surge tank. This is the preferred method, as the spare train does not require layup chemicals, more even wear of the membranes is established, which allows for standby readiness of the spare train.

Given enough service time, the membrane filtration trains will experience fouling which is not removed through back-flushing, and a chemical cleaning will be required. A chemical clean in place (CIP) system is used to perform this cleaning. The membrane train to be cleaned is taken out of service, and then cleaning solution is introduced and recirculated for a given time (usually 4 to 6 hours).

The premise of this process is that the membrane filtration system normal operation concentrate, periodic back flush solutions are routed to the Waste Water Retention Basin. It is expected that periodic CIP spent cleaning solutions are hauled off-site. Treating on site and discharging to the Waste Water Retention Basin can be achieved, however, it will presents additional licensing and operational concerns.

After treatment in the membrane filtration portion of the system, the raw water is then pumped from the break tank by the RO booster pumps (which provide minimum suction pressure to the RO feed pumps) to the RO treatment portion of the system. The water is first treated with sulfuric acid (H_2SO_4) and an inhibitor (scale and dispersant) to reduce the scale index of the feed stream. It is then routed through a set of cartridge filters, which are included as final protection for the RO units.

After going through the cartridge filters, sodium bisulfite is injected to remove any residual chlorine in the feed water, it is then routed to the suction of the RO feed pumps, where the pressure of the feed is raised above the natural osmotic pressure. Due to the wide variation in salinities and temperature, pumps may be provided with variable frequency drives (VFDs) for the motors. This would allow for running the motors at variable speeds and optimize the power usage. The high pressure feed water then enters the RO trains, where the water is passes through the membranes, and the dissolved salts are rejected. A reject stream carries the concentrate from the RO trains to the Waste Water Retention Basin under pressure.

The acid addition is automatically controlled via a pH control loop, the addition of the inhibitor and the bisulfite are controlled via flow pacing.

The premise of this study is that the RO reject stream is routed to the Waste Retention Basin. The RO reject is high in quality, with salinity comparable to ocean seawater.

Given the size of the system, the RO portion of the system has also been configured as 4 x 33% to provide a true spare train. The RO trains are periodically back-flushed, and the spare train is normally placed in lay-up. To avoid purging the spare train of lay-up solution in the event of a problem, the trains may be rotated in and out of service.

Drawback tanks are provided to give a source of makeup water to the RO product header to account for the reverse flow caused by natural osmosis.

Given enough service time, the RO trains will experience fouling which is evident by a rise in trans-membrane pressure drop, and a chemical cleaning will be required (usually recommended after a rise of 10%). A chemical clean in place (CIP) system is used to perform this cleaning. The membrane train to be cleaned is taken out of service, and then cleaning solution is introduced and recirculated for a given time (up to 24 hours).

The premise of this process is that periodic CIP spent cleaning solutions are hauled off-site. Treating on site and discharging to the Waste Water Retention

Basin can be achieved, however, it presents additional licensing and operational concerns.

The RO product water, which now has a salinity in the 200 to 400 pm range, is routed to a forced draft decarbonator tower, where carbon dioxide evolved from the acid addition is stripped via air contact and collected in the decarbonator catch well. Two 100% blowers are provided to supply stripping air to the tower.

The decarbonated water will be pumped to a Desalinated Water Storage Tank for distribution to Unit 3 services. The tank is sized for 600,000 gallons, which provides storage for eight hours at maximum demand.

A set of two 100% pumps is provided to transfer water to the demineralized water system. It is assumed that this facility will be adjacent to the Desalination Plant. A pressure control valve on the discharge maintains a pressurized header at various flow demands. At low storage tank level the pumps will trip, causing loss of system pressure to the demineralizer system users.

A set of two 100% pumps is provided to transfer water to the service water users of Unit 3. A pressure control valve on the discharge maintains a pressurized header at various flow demands. At low storage tank level the pumps will trip, causing loss of system pressure to the service water system users. A corrosion inhibitor injection system has been accounted for. The necessity of this will need to be evaluated during operation, as the RO product water will have characteristics of very soft well water (i.e., slightly corrosive in carbon steel portions of the system piping).

3.6 Control Philosophy

The control philosophy to be implemented will insure maximum reliability, automation to the maximum extent possible for ease of operation. This will include instrumentation and controls to properly monitor and control the system and alert the operator when maintenance is required.

The Desalination Plant will be provided with a full complement of on-line analyzers such as: temperature, pH, turbidity, conductivity, oxidation reduction potential to insure proper monitoring and reliability of the process.

3.7 Power Supply

Power supply to the Desalination plant equipment has not been determined at this time. It is recommended that Constellation explore the possibility of powering this load from the Unit 3 power block to determine if adequate margin exists in the standard plant design.

3.8 Equipment List

Table 3.8.1 below includes the major components.

Table 3.8.1

Equipment List

Equipment Name	Number Installed	Number Operating	Sizing Criteria	Notes
Coagulant Storage Tank	1	1	1 x 100%	
Coagulant Metering Pumps	2	1	2 x 100%	
Caustic Storage Tank	1	1	1 x 100%	
Caustic Metering Pumps	2	1	2 x 100%	
Hypochlorite Storage Tank	1	1	1 x 100%	
Hypochlorite Metering Pumps	2	1	2 x 100%	
Membrane Filtration Modules	4	3	4 x 33%	
MF Cleaning System Skid (Tank, cartridge. filter, pump)	1	1	1 x 100%	Intermittent
MF Flush Pumps	2	1	1 x 100%	Intermittent
MF Break Tank	1	1	1 x 100%	
RO Booster Pumps	4	3	4 x 33%	
RO Cartridge Filters	3	2	2 x 50%	
Sulfuric Acid Storage Tank	1	1	1 x 100%	
Sulfuric Acid Metering Pumps	2	1	2 x 100%	
Scale Inhibitor Storage Tank	1	1	1 x 100%	Fed from totes
Scale Inhibitor Metering Pumps	2	1	2 x 100%	
Sodium Bisulfite Storage Tank	1	1	1 x 100%	Fed from totes
Sodium Bisulfite Metering Pumps	2	1	2 x 100%	
RO Feed Pumps	4	3	4 x 33%	
RO Modules	4	3	4 x 33%	
RO Flush Pumps	2	1	1 x 100%	Intermittent
Drawback Tanks	4	3	4 x 33%	
Decarbonator	1	1	1 x 100%	
Decarbonator Blowers	2	1	2 x 100%	
Decarbonator Forwarding Pumps	2	1	2 x 100%	
Desalinated Water Storage Tank	1	1	600,000 gal Lined tank	8-hour storage
RO CIP System Skid (Tank, cartridge filter, pump)	1	1	1 x 100%	Intermittent
Corrosion Inhibitor Storage Tank	1	1	1 x 100%	Fed from totes
Corrosion Inhibitor Metering Pumps	2	1	2 x 100%	
Desal Water Transfer Pumps to Demin System (Units 1, 2 and 3)	2	1	2 x 100%	
Desal Water Transfer Pumps to Potable Water System (Units 3)	2	1	2 x 100%	
Desal Water Transfer Pumps to Service Users	2	1	2 x 100%	
Control System	1 Lot			

3.9 Electrical Load List

Table 3.9.1 below includes the major loads. These loads are estimated. Detailed list can be provided for the final draft of this Study. It is estimated that the continuous load require for this process is in the range of 1,000-1500 kWh.

Table 3.9.1

Electrical Load List

Equipment Name	Number Installed	Number Operating	Power Per Unit, kW	Total Operating Power, kW	Notes
Coagulant Metering Pumps	2	1	1	1	
Caustic Storage Tank Heater	1	1	5	5	Intermittent
Caustic Metering Pumps	2	1	1	1	
Hypochlorite Metering Pumps	2	1	1	1	
MF Cleaning System Skid (Tank, cartridge filter, pump)	1	1	10	10	Intermittent
MF Flush Pumps	2	1	1	15	Intermittent
RO Booster Pumps	4		30	90	
Sulfuric Acid Metering Pumps	2	1	1	1	
Scale Inhibitor Metering Pumps	2	1	1	1	
Sodium Bisulfite Metering Pumps	2	1	1	1	
RO Feed Pumps	4	3	375	1125	
RO Flush Pumps	2		1	15	Intermittent
Decarbonator Blowers	2		5	5	
Decarbonator Forwarding Pumps	2	1	40	40	
RO CIP System Skid (Tank, cart. filt., pump)	1	1	10	10	Intermittent
Corrosion Inhibitor Metering Pumps	2	1	1	1	
Desal Water Transfer Pumps to Demin System (Units 1, 2 and 3)	2	1	5	5	
Desal Water Transfer Pump to Potable Water System	2	1	5	5	
Desal Water Transfer Pumps to Service Users	2	1	15	15	
Control System	1		15	15	

3.10 General Arrangement

See Drawing SK-GA-00001 (Appendix 6.3) for a conceptual layout of the proposed equipment.

The layout is arranged to accommodate most of the equipment indoors or under weather protection. It is arranged to allow for ease of operation, access and maintenance.

The area required for the proposed equipment is approximately 150 feet by 110 feet. This does not include electrical equipment.

The structure that will enclose the equipment is assumed to be classified as non-safety-related.

3.11 *Operational Considerations*

It is anticipated that at full capacity one membrane filtration skid, as well as the RO module will be in a standby mode. The units will be rotated for even usage for maximum efficiency. They can also be operated to account for unanticipated increases in desalinated water demand. However, in this case the entire system will have to be designed to accommodate the increased flows. The system is arranged for ease of operation, including chemical deliveries.

3.12 *Special or Unique Features*

The following features are unique to the system proposed and, in some cases, different than other (fresh water) reverse osmosis systems:

- Enhanced coagulation (prior to membrane filtration)
- Membrane Filtration
- RO Drawback Tanks
- Seawater RO membranes
- Lower RO recovery rate than conventional RO, due to salinity of the feed
- Decarbonator

4.0 RESULTS, CONCLUSIONS AND RECOMMENDATIONS

4.1 Recommended Process

The process recommended is depicted in Appendices 6.1, 6.2, and 6.3. The major pieces of equipment are listed in Table 3.8.1. The electrical loads are listed in Table 3.9.1. The system is based on sea water RO that will produce desalinated water with a quality equal to or better than well water. The process is described in Section 3.5.

4.2 Alternates Processes

The following items should be considered before the system configuration is finalized:

- Energy Recovery Devices
- UV for disinfection
- Other disinfection chemicals

4.3 Product and Wastewater Characterization

The product and wastewater chemistry is listed in Table 4.4.1. The figures highlighted represent the parameters obtained from the Filmtec ROSA 6 program. For illustration purposes 50% and 40% RO recovery numbers are shown. The former is the most conservative with respect to higher waste concentration. The latter is more conservative with respect to equipment sizing. Additional cases can be developed, based on the requirements of Constellation Energy.

The figures in the table do not include the wastes from the membrane filtration equipment. This waste is essentially Chesapeake Bay water having a TSS content ten times that of the feed water.

It should be noted that at 50% recovery, the waste will be twice as concentrated as the feed. This will essentially be the same as the blowdown from the Circulating Water Cooling Tower. For reference, permeate and reject (waste water) qualities are provided for the 40% and 50% RO recovery cases.

Table 4.4.1

Expected RO Permeate and Wastewater Quality

Constituents	**Values in Feed**	**Permeate Values at 50% Recovery**	**Permeate Values at 40% Recovery**	**Reject Values at 50% Recovery**	**Reject Values at 40% Recovery**
Barium, mg/l	0.05	0.0	0.0	0.1	0.08
Calcium, mg/l	350	1.8	1.57	698.31	582.31
Magnesium, mg/l	700	3.64	3.18	1395.58	1164.59
Potassium, mg/l	250	6.7	5.92	493.4	412.73
Sodium, mg/l	6,041*	131.76	116.16	11951.2	9990.56
Strontium, mg/l	4	0.02	0.02	7.98	6.65
M Alkalinity, mg/l as $CaCO_3$	150	4.02	3.55	287.92	242.46
Ammonia, mg/l	1	0.37	0.34	1.63	1.44
Chlorides, mg/l	11,000	217.98	192.13	18972.2	18205.99
Fluorides, mg/l	0.6	0.02	0.01	1.18	0.99
Nitrates (as NO_3), mg/l	<10	2.16	1.98	16.07	15.35
pH, standard units	7.7-7.8	6.32	6.31	7.54	7.56
Silica (total), mg/l	3	0.1	0.09	5.9	4.94
Sulfates, mg/l	1,500	3.01	2.63	2,997.45	2498.35
Total Dissolved Solids (TDS)	19973.6	371.56	327.6	39658.9	33137.34

5.0 SOURCES (REFERENCES AND BIBLIOGRAPHY)

5.1 Guide to Using Chesapeake Bay Program Water Quality Monitoring Data, CBP/TRS 78/92, March 1993

5.2 2007 Data (1/2/2007 to 2/1/2007) by GE for Specific Conductivity, Salinity and Dissolved Oxygen

5.3 Chesapeake Bay Water Analysis by GE (1/14/05)

5.3 Table X Summary of Analytical Results (February 20-21, 2007 by Constellation)

5.4 Table X Summary of Analytical Results (March 5-6, 2007 by Constellation)

5.5 Surface Water Salinity (ppt) Chesapeake Bay Mainstem/Cove Point (CB4.4) – data from 2004 and 2005

5.6 Bechtel Cooling Tower and Circulating Water Study, September 2006 Issue

5.7 ROSA Program 6.0 by Dow Filmtec

5.8 Miscellaneous Vendor Information

5.9 Reverse Osmosis System Technical Discussion from Global EnviroScience Technologies (from Internet) http://www.get-inc.com/ROTechDisc.htm

5.10 Miscellaneous Manufacturer Information and Private Conversations

5.11 Table X Summary of Analytical Results (March 20, 2007 by Constellation) (two samples)

5.12 Table X Summary of Analytical Results (April 17, 2007 by Constellation) (two samples

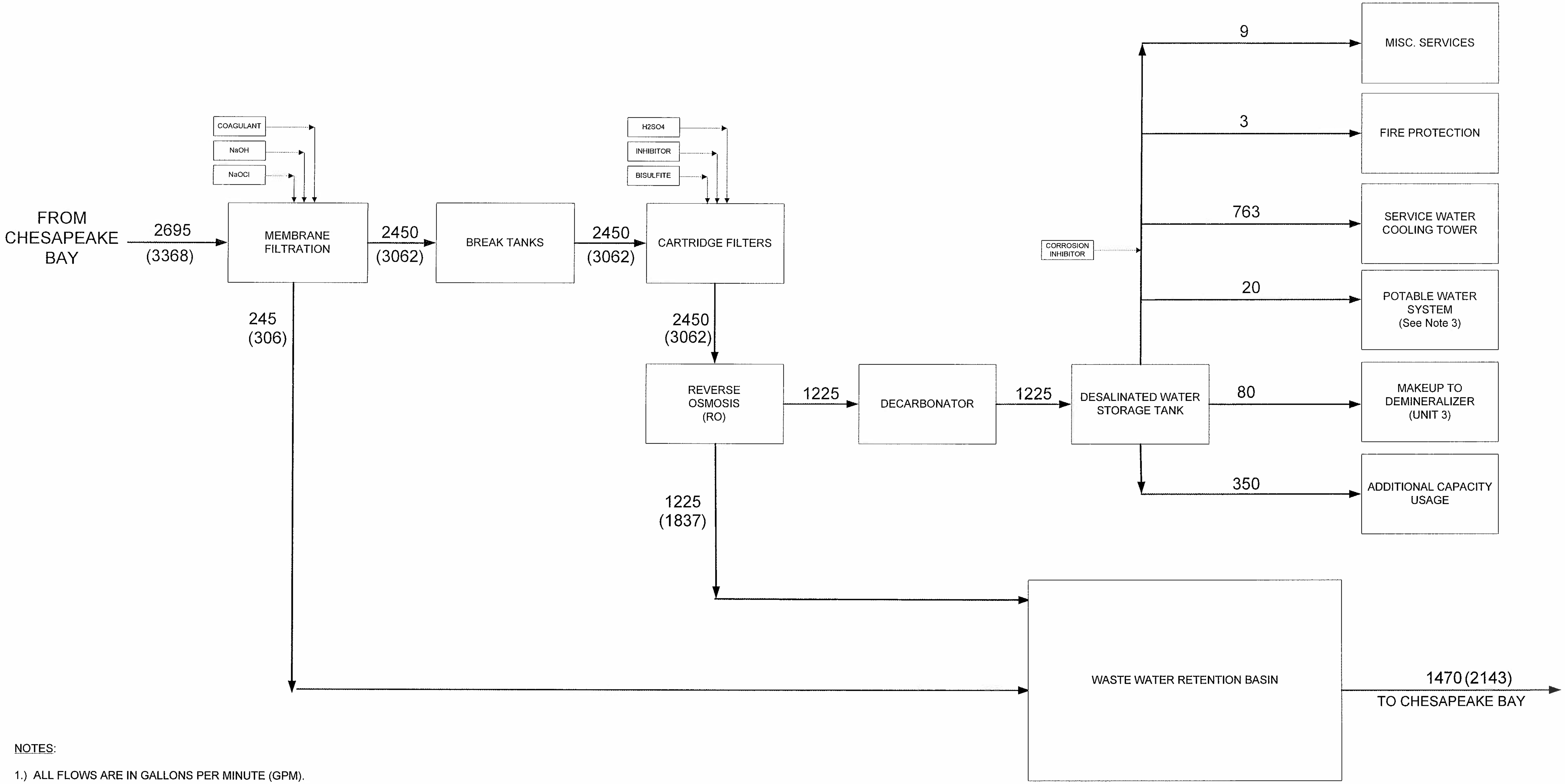
6.0 APPENDICES

6.1 Process Flow Diagram, Drawing SK-FD-00001, Rev. 00B

6.2 Water Balance Diagram, Drawing SK-WB-00001, Rev. 00B

6.3 Conceptual Layout Diagram, Drawing SK-GA-00001, Rev. 00B

CONCEPTUAL



NOTES:

1.) ALL FLOWS ARE IN GALLONS PER MINUTE (GPM).
2.) ONLY FLOWS PERTAINING TO THE DESALINATION PLANT ARE SHOWN.
3.) THE DESALINATION PLANT IS SIZED TO INCLUDE THE DEMAND FOR POTABLE WATER. HOWEVER, FOR OPERATIONAL AND SAFETY/HEALTH REASONS, WELL WATER MAY BE BENEFICIAL.
4.) THE RO SYSTEM IS BASED ON 50% RECOVERY. THIS IS THE CONSERVATIVE APPROACH WITH RESPECT TO EFFLUENT WATER CONCENTRATIONS. 40% RECOVERY IS THE CONSERVATIVE APPROACH WITH RESPECT TO PROCESS DESIGN, RESULTING IN HIGHER FLOWS. THE CORRESPONDING FLOWS FOR THE 40% RECOVERY CASE ARE SHOWN IN PARENTHESES.

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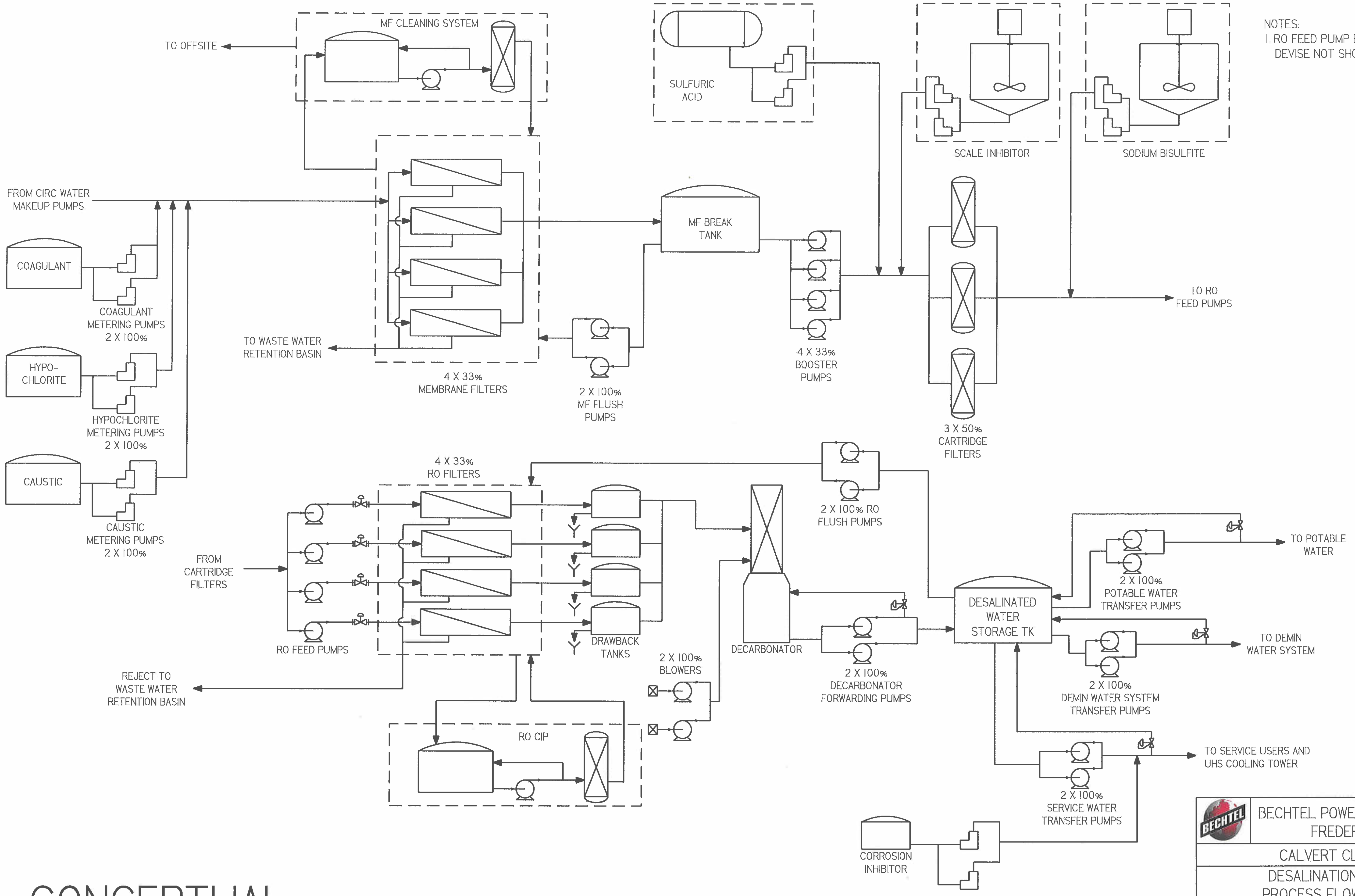
DESALINATION PLANT
WATER BALANCE DIAGRAM

JOB NO.	DRAWING NO.		REV.
25237	SK-WB-00001	05/09/07	00B



NOTES:
1 RO FEED PUMP ENERGY RECOVERY DEVISE NOT SHOWN

CONCEPTUAL

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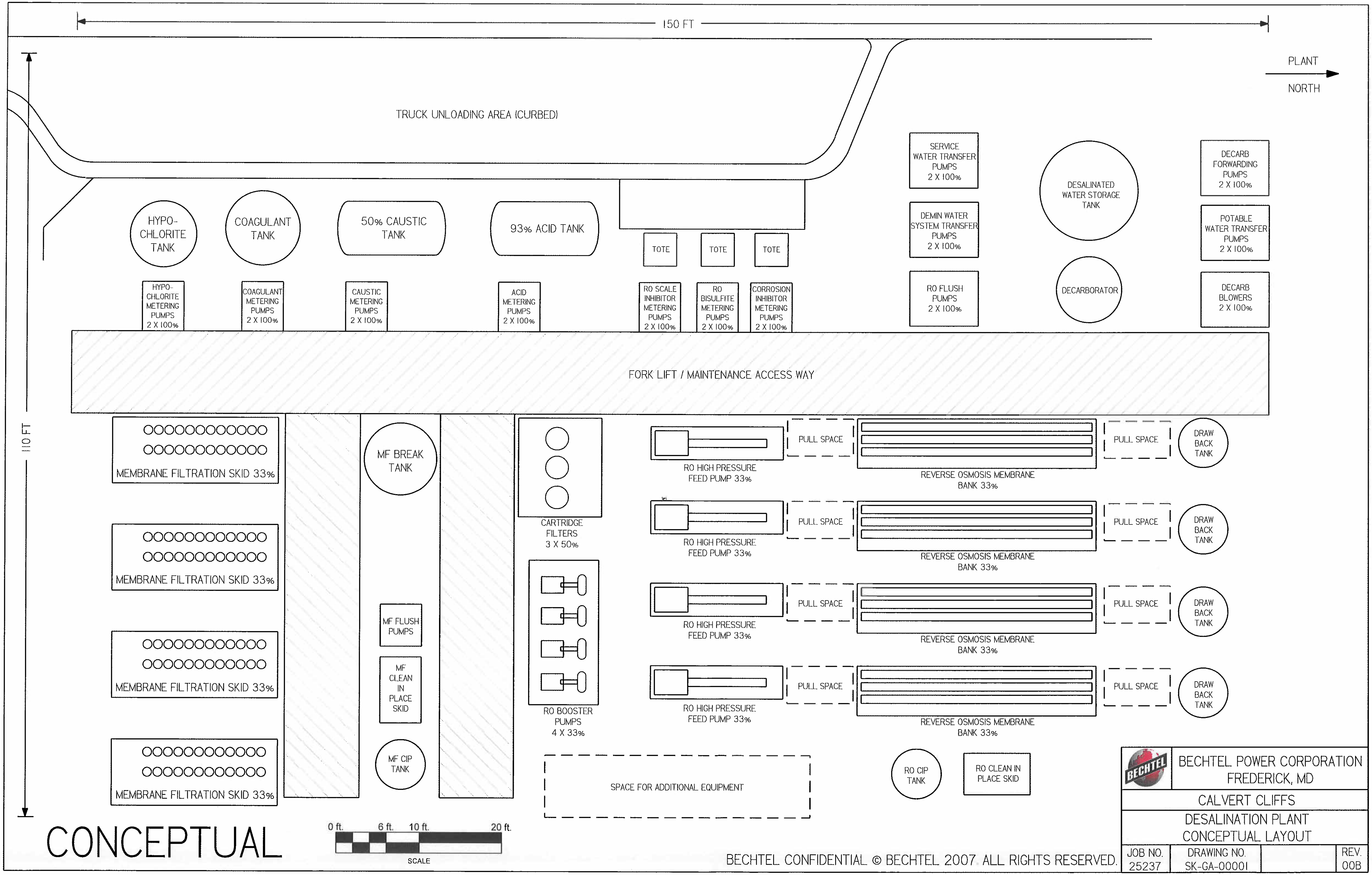
DESALINATION SYSTEM
PROCESS FLOW DIAGRAM

JOB NO.	DRAWING NO.	REV.
25237	SK-FD-00001	00B



CONCEPTUAL

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DESALINATION PLANT
CONCEPTUAL LAYOUT

JOB NO.	DRAWING NO.	REV.
25237	SK-GA-00001	00B

Desalination Plant Study Comments Resolution
Study Number 25237-000-G65-GGG-00006, R00A

Comment No. (Page X of 28)	**Status**	**Comment**	**Proposed Resolution**	**Remarks**
1 (Page 4 of 28)	Resolved	Delete in Para 1, Line 2 "that was originally envisioned"	Incorporated	
2 (Page 4 of 28)	Resolved	Replace in Para 1, Line 3 "Well water was" with "Freshwater needs".	Incorporated	"Fresh water" used, in lieu of "freshwater."
3 (Page 4 of 28)	Resolved	In Para 2, Line 3 replace "to meet the demand of demineralized water for the existing Units 1 and 2" with "for additional capacity usage".	Incorporated	
4 (Page 4 of 28)	Resolved	In Para 4, Line 9 Delete references to Units 1 and 2.	Incorporated	Reworded to read "…Unit 3 as described above, including the demineralized water system for Unit 3.
5 (Page 5 of 28)	Resolved	Delete Para 2 and 3.	Incorporated	
6 (Page 6 of 28)	Resolved	Delete in Para 1, Line 2 "that has been previously considered".	Incorporated	
7 (Page 6 of 28)	Resolved	Delete in Para 1, Line 8 "as well as feed to the demineralized water system for existing Units 1 and 2."	Incorporated	
8 (Page 6 of 28)	Resolved	Replace in Para 2, Line 3 "the existing units 1 and 2" with "additional capacity usage".	Incorporated	
9 (Page 7 of 28)	Resolved	Delete in Para 2, Line 3 " and replace some of the well water currently being used in the existing units 1 & 2 "	Incorporated	
10 (Page 9 of 28)	Resolved	In Para 4, Line 17 Delete references to Units 1 and 2.	Incorporated	
11 (Page 10 of 28)	Resolved	Delete in Section 2.1.2.4 Para 1, Line 3 "as well as make up to Unit 1 & 2 demineralized system in lieu of well water".	Incorporated	
12 (Page 11 of 28)	Resolved	In Para 2.2.7 Delete references to Units 1 and 2.	Incorporated	

Desalination Plant Study Comments Resolution
Study Number 25237-000-G65-GGG-00006, R00A

Comment No. (Page X of 28)	Status	Comment	Proposed Resolution	Remarks
13 (Page 21 of 28)	Resolved	Delete Section 3.6, Para 3 "More details will be provided in the final report "	Incorporated	
14 (Page 24of 28)	Resolved	Delete Section 4.3 and renumber subsequent sections accordingly	Incorporated	
15 (Page 27of 28)	Resolved	Delete Section 5.0 (5.1, 5.2 and 5.3)	Incorporated	