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Demineralization Treatment Technologies

for the Seawater Demineralization Feasibility Investigation

Technical Memorandum B.7
Demineralization Treatment Technologies

For the

Seawater Demineralization Feasibility Investigation
Contract #SE459AA

by

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FINAL

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1.0 INTRODUCTION

1.1 General

Desalination, or demineralization is a treatment process that removes salt and other minerals from brackish water and seawater to produce high quality drinking water. Various desalination technologies have been in practice for more than 50 years, with nearly 1500 facilities worldwide, according the International Desalination Association (IDA). Geographically, the greatest number of desalination facilities is in the Middle East, followed by the US for the second greatest number of desal plants. There are also desalination facilities in North Africa, Singapore, Spain, Thailand, Mexico and the Caribbean Islands. The application of desalination processes has been essential to improve the livability in these parts of the world. The first desalination plant in the US was installed in the Florida Keys in the early 1970s, using brackish groundwater demineralization technologies.

Today, there are more than 50 brackish water demineralization systems in Florida, with hundreds more located in California. Due to concerns over continued population growth and depletion of our nation's water resources, finding alternative drinking water sources has been a problem faced by many water utility companies, municipalities and water management districts. This is especially true for those in the states with the greatest population growth, such as California, Florida and Texas. Traditional groundwater and surface water sources have been over-pumped and are showing signs of environmental stress. Some coastal regions, particularly in south Florida, have experienced salt-water intrusion into groundwater supplies causing municipalities to turn to brackish water demineralization to supplement their traditional water supply systems.

Large seawater desalination plants are also being considered to meet significant water demands of the larger municipalities. The largest seawater desalination plant in the US is currently under construction in Tampa Bay. The facility is expected to be complete in early 2003 and will initially produce 25 million gallons per day (mgd) of drinking water. Other large-scale (25 to 50-mgd) seawater desalination facilities are currently being planned in southern California and Texas.

1.2 Purpose

The St. Johns River Water Management District (SJRWMD) is proactively addressing the water supply needs in the northeast region of Florida, which includes several counties from Jacksonville to Vero Beach. SJRWMD manages water resources to ensure their continued availability while maximizing both environmental and economic benefits.

Their objectives are to:

- Increase available water supplies and maximize overall water use efficiency to meet identified existing and future needs;
- Minimize damage from flooding, using non-structural approaches where feasible;
- Protect and restore floodplain functions;
- Protect and improve surface water quality;
- Protect and improve groundwater quality;
- Maintain the integrity and functions of water resources and related natural systems;
- Restore degraded water resources and related natural systems to a naturally functioning condition; and
- Ensure proper use of tax and other public revenue by focusing on priorities that further the District's mission and by maintaining a high level of organizational efficiency.

The SJRWMD's location is:

St. Johns River Water Management District
P.O. Box 1429
Palatka, Florida 32178-1429
Telephone: (386) 329-4500
www.sjrwmd.com or sjr.state.fl.us

R.W. Beck, and its subconsultants, PB Water and PBS&J, has been contracted by SJRWMD to investigate the feasibility of constructing seawater demineralization facilities within this region to meet growing water demands. This technical memorandum is prepared to provide SJRWMD with information on current desalination technologies and an update on advancements in the industry.

1.3 Early Desalination Technologies

Most early desalination processes were thermal distillation-type processes, which were common in the Middle East due to the availability of low cost steam at power plants. By the 1970s commercial membrane processes were available. These included electrodialysis (ED) and reverse osmosis (RO). ED was determined to desalt brackish water more cost-effectively than thermal distillation processes, which was a breakthrough in the industry at that time. Reverse osmosis processes were expensive to operate due to the high-energy requirement of these systems. However, there have been significant improvements to membrane technologies in the past 10 years, which have made reverse osmosis a more viable, cost-effective water supply alternative.

The most common desalination technologies that have experienced commercial success are shown in **Table 1.** These include thermal processes such as multi-stage flash, multi-effect distillation and vapor compression and membrane processes such as electrodialysis and reverse osmosis.

Table 1. Desalination Technologies
Thermal
- Multi-stage Flash Distillation
- Multiple-Effect Distillation
- Vapor Compression
Membrane
- Electrodialysis
- Reverse Osmosis

A brief description of theses processes is provided in the following section along with a discussion of system improvements in current demineralization technologies.

2.0 THERMAL DESALINATION PROCESSES

2.1 History

The first desalination facilities were thermal processes that use heat to distill seawater and produce high quality product water. According to various references, more than 50% of the world's desalination plants are thermal desalination plants. In a thermal process, water is heated; creating a vapor that is condensed to form fresh water. Thermal processes are traditionally high-energy systems and have high operational costs, unless low-cost steam energy is available. To keep energy requirements down, distillation is usually accomplished by conducting boiling in multiple successive vessels operating at a low temperature and low pressure.

A common problem in thermal processes is the formation of a scale inside the process piping. Hardening of minerals in the seawater, especially calcium sulfate, forms a scale. Scale is difficult to remove and reduces the efficiency of the process. Chemicals are often added to reduce scale precipitation.

2.2 Multi-stage Flash Distillation


Illustration 1. Multi-stage Flash Distillation Plant

Most of the thermal plants in the world use a multi-stage flash (MSF) distillation process (Illustration 1.) In MSF, seawater is heated inside a vessel called a brine heater. Seawater that passes through the vessel in a bank of tubes is condensed and flows to another vessel or "stage", where the ambient pressure is lower, thus causing the water to boil. When heat is added into this stage, water boils rapidly and instantly "flashes" into steam. However, only a small portion of the water is converted to steam, depending on the operational pressure. MSF plants have been built since the 1950's and can have up to 25 stages, which makes them costly and complex to operate. Operating the plant at temperatures higher than 110 ^oF can increase the system's efficiency, but also increases the formation of scale and potential corrosion.

2.3 Multi-effect Distillation

The first multi-effect distillation (MED) processes were submerged tube evaporators used aboard ships to produce drinking water and boiler make-up water during long sea voyages. These plants were determined to have more scale build up than MSF plants and have since decreased in their commercial use. The basic MED process consists of multiple vessels that undergo condensation and evaporation to produce water, similar to the MSF process. However, in the MED process, the feedwater is added to various stages (or effects) by spraying water onto heated tubes filled with steam. The vapor from the outside of the tubes passes from the boiling chamber through a wire mesh mist eliminator to a condensing chamber. The mist eliminator coalesces droplets of concentrate in the vapor stream and returns them to the boiling chamber. The remaining vapor is almost pure water. In the condensing chamber, the vapor condenses on the outside of tubes. The product water pump extracts the condensed vapor as distilled product water. In this process, the vapor generated in the first effect becomes the heating steam in a second effect and so on.

The process design uses large temperature differences to enhance the heat transfer in the submerged tube evaporator. The thermal efficiency of the process depends on the number of effects. Lower operating temperatures reduce the potential for scale formation. Therefore, the limited operating temperature range and the large temperature difference required by the submerged tube evaporator process limits the number of effects that can be used in multi-effect evaporators. Some improvements to the efficiency of the MED process have led to an increasing number of these systems commercially; however, the total number of MED systems is much lower than MSF systems.

2.4 Vapor Compression

Another distillation technology known as vapor compression (VC) is used for smaller-scale desalination facilities. This process is based on the Carnot refrigeration cycle, in which a mechanical compressor (rather than a heat source) is used to compress the vapor from the evaporator to a higher pressure. As the compressed vapor condenses on one side of the tube heat transfer surface, seawater boils on the other side creating more vapor. This process uses electric energy rather than steam. The VC evaporator is more efficient than the previously described steam driven evaporators, but electric power is significantly more expensive than steam energy.

VC evaporators operate either at atmospheric pressure (215ºF) or under a vacuum (140ºF) depending on the design. The lower temperature evaporators must be larger to accommodate the higher specific volume of water vapor at lower temperatures. These low temperature units have a reduced tendency to scale or corrode and require less heat recovery between the feed seawater and the concentrate and distillate streams.

VC units are commonly used at drilling sites and for some small industries since they are more compact than other thermal processes and electric power is readily available. The number of VC units currently in operation is very small (4% worldwide) as compared to multi-stage flash systems, which are estimated at 44% worldwide, according to IDA, 1998.

2.5 Thermal Plant Performance Enhancements

The most important advancements in thermal desalination over the past 10 years have been increasing system efficiency and operational reliability. The operational enhancements have included scale control improvements, automation and controls, further operator training and better materials of construction. Additionally, increases in standard-unit sizes have increased the economies of scale for larger systems. But still these systems have very high-energy requirements and can be cost prohibitive unless low cost steam energy is available from a power plant.

3.0 MEMBRANE TECHNOLOGY

3.1 General

Desalination through the use of membranes was introduced in the 1960s as an alternative to distillation. A membrane process is a physical separation process, where salt is separated from seawater or brackish water to produce drinking water. These membrane processes include electrodialysis (ED) and reverse osmosis (RO). These process produce the same result, however, ED uses voltage to separate the salts, where RO operates under pressure for the separation process.

3.2 Electrodialysis

Electrodialysis was the first membrane process put into commercial application, even before RO. As mentioned above, ED is a voltage driven process that uses an electrical current to move salts through the membrane, leaving behind freshwater that is collected as the product water. ED is common in brackish water demineralization systems, where most of the dissolved salts are ionic in nature. The dissolved ions such as chlorides, sodium, calcium and carbonate move to the electrodes with an opposite electric charge. ED membranes can also achieve selective passage of either anions or cations. The membranes are arranged with alternating anion-selective membranes followed by cation-selective membranes. A spacer channel is placed in between each membrane, one carries feedwater, while the next carries the concentrate. The spaces bound by the two membranes are called cells. Each ED unit consists of hundreds of cell pairs, and is called a membrane stack. An example of and ED system is shown below (Illustration 2.)

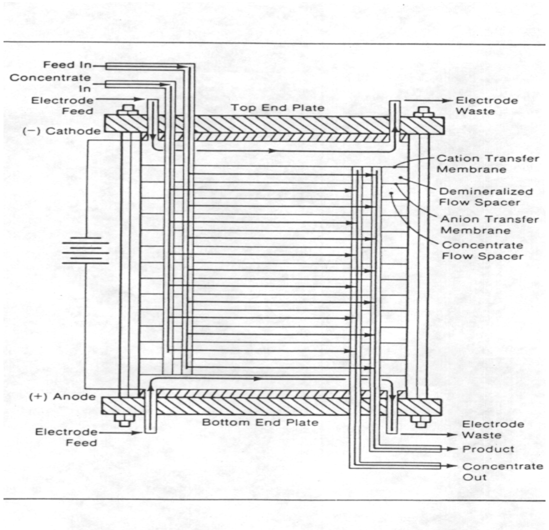

Illustration 2. Electrodialysis Cell

After years of operating ED processes, an electrodialysis reversal (EDR) process was developed. In an EDR process, the polarity of the electrodes is reversed causing the flows in the product and brine channels to be switched. The reversal process helps to breakup and flush out any scaling material that develops on the cells, minimizing membrane fouling. The ED and EDR processes have a high recovery of product water and are capable of treating waters with high-suspended solids. These systems also have low chemical usage. The required energy is dependent on the desired salt removal.

3.3 Reverse Osmosis Membranes

3.3.1 History

RO is relatively new as compared to the distillation and ED processes. The first commercial unit was installed in the Florida Keys in 1971. The RO membrane separation process separates freshwater from saltwater under high pressure. The freshwater passes through the membrane layer while the salt content remains outside the membrane. (This is the opposite of ED, where the demineralization concentrate passes through the membrane and the freshwater stream remains outside the membrane and is collected.) The amount of freshwater produced varies from 30 to 80% depending on the salt content of the water, pressure and the type of membranes used. Brackish water membrane systems typically have higher recoveries and operate under lower pressures, ranging from 225 psi to 375 psi. Seawater RO systems typically have lower recoveries due to the higher salt content and their operating range is typically 800 to 1200 psi.

Illustration 3. Yuma Reverse Osmosis Plant

The majority of the reverse osmosis plants in the US are brackish water treatment systems. By the early 1980's, the world's largest brackish water membrane treatment system was installed in Yuma, Arizona (Illustration 3.) There are more than 50 brackish water systems located in Florida and hundreds more in California, Arizona, and Texas.

Commercial membranes are available in four configurations: plate-and-frame, spiral wound, tubular and hollow fiber. The tubular and plate-and-frame arrangements were the original designs, but have a high capital cost and a high volume requirement. The hollow fiber membranes are no longer very common since the primary manufacturers, DuPont and Dow, have discontinued the product. Currently, the most common commercial membrane configuration is the spiral-wound element. The original standard membranes were made of cellulose acetate (CA) and had a life expectancy of only 1 year and a salt rejection of 90%. Now, membranes are typically made of thin-film composite polyamide, which a life expectancy of up 5 to 7 years and a salt rejection of as high as 99.6%.

3.3.2 Pretreatment Systems

The success of membrane desalination is dependent on the performance of the membranes. Pretreatment to improve the quality of the feed water is an important first-step in the overall success of the process. Conventional pretreatment typically includes a combination of the following processes:

- Gravity sand filtration
- Flocculation
- Settling
- Cartridge filtration
- Chlorination, ultraviolet irradiation, or ozonation
- Dechlorination
- Acidification
- Anti-scalant dosing
- Softening
- Activated-carbon-bed filtration
- Multi-media filtration
- Green sand (Magnesium Hydroxide) filtration
- Degasification.

The filtration steps are intended to remove suspended solids, colloids, or dissolved metals from the feedwater. Chlorination, ultraviolet irradiation and ozonation are intended to kill algae and prevent biofouling of the membranes. Sulfuric acid, anti-scalant dosing, and softening reduce the tendency of the feed water to create scale on the membrane surface. Degasification is used to remove dissolved gases from the feed such as carbon dioxide and hydrogen sulfide. The constituents in the raw water determine the specific pretreatment processes needed for a specific site. Therefore, a complete chemical analysis of the water source is recommended prior to design of the system.

Within the last several years, microfiltration (MF) and ultrafiltration (UF) membrane systems have begun to replace conventional water treatment processes for the pretreatment of surface water and seawater supplies. The use of these technologies is projected to extend the life of the seawater reverse osmosis (SWRO) elements an additional 3 to 5 years.

3.3.3 Current Membrane Systems

Today's membranes are susceptible to damage from chlorine and temperatures above 45ºC (113ºF). Spiral wound elements are subject to excessive fouling if the feed water contains too high a level of suspended solids. Therefore, pretreatment using one of the above-described pretreatment methods is essential. Plugging tendency is measured in units of silting density index (SDI). Membranes typically require an SDI of 5 or less.

The key performance parameters for RO are permeate (or product water) flux and salt rejection. The permeate flux is the flow rate of water through the membrane per unit area, usually expressed as gallons per day per square foot. The salt rejection is expressed in terms of a percentage and is the ratio of the concentration of the salt in the product water divided by the concentration of the salt in the feed water. Permeate flux and salt rejection are impacted by operating pressure, temperature, product water recovery and feedwater salt concentration. Recovery is the amount or percentage of product water that can be produced from the feedwater flow. The key membrane system performance trends are described in Table 2.

Table 2. Membrane System Performance

As Operating Pressure Increases	Flux Increases and Salt Rejection Increases
As Recovery Increases	Flux Decreases and Salt Rejection Decreases
As Temperature Increases	Flux Increases and Salt Rejection Decreases
As Salinity in Feedwater Increases	Flux Decreases and Salt Rejection Decreases

RO membranes work best when provided with a consistent feed water quality. However, in most applications the feed water quality varies either hourly, daily or seasonally. As feed water quality varies, plant operation must be altered to obtain optimum performance. While computer controlled operating programs can handle expected variations, trained operators must be available to handle unexpected variations and equipment failures along with periodic maintenance. Membranes are still a fragile component that can be ruined in less than an hour by incorrect operation. In addition to monitoring plant operation, operators must regularly refill chemical dosing day tanks, replace cartridge filters, monitor plants for leaks and rotating equipment for unusual sounds, and periodically perform chemical cleaning of membranes.

3.4 Membrane System Improvements

Many advances in membrane technology have occurred since membranes were first developed. The most significant improvements have occurred in the last 10 years. These improvements have included the development of more efficient membranes that can operate at higher temperatures, have higher salt rejection, and greater product water recoveries. Membranes now have higher flux rates (flow rate per unit area), lower fouling potential, lower costs and longer lives than ever before. Manufacturing plants have implemented automated systems, which have improved production and quality control resulting in lower element costs. The cost of membrane elements has been reduced from more than $750 per element to $400 to $450 per element. This trend may continue with further membrane system advancements.

Another industry improvement has consisted of the development of nanofiltration (NF) membranes for water softening. NF membranes have a much lower rejection of chlorides than RO membranes. However, NF operates at lower pressures and has a higher percentage of product water recovery as compared to RO. Using NF or other membrane systems such as microfiltration or ultrafiltration as a pretreatment to distillation or RO has driven the desalination industry away from chemical pretreatment processes and more toward all-membrane treatment systems.

Additionally, there have been advancements in energy recovery devices. The new devices now have greater efficiencies, which result in more energy recovery and lower operational costs. These improvements in both membrane technology and energy recovery have yielded significant reductions in desalination system capital and operational costs.

3.5 Energy Recovery Systems

Energy recovery is now a key component of membrane desalination processes. This has been a significant improvement in the desalination industry. Because seawater RO operates at pressures from up to 1200 psig, significant energy is required for the process. Energy recovery devices recover most of this energy and transfer it to the feedwater to reduce the overall process energy requirements. Typical devices and efficiencies consist of reverse running pumps (70% efficiency), turbines (77% efficiency), Pelton wheel turbines (83% efficiency), and work exchangers (90% efficiency). In addition, pump manufacturers are designing large centrifugal pumps with efficiencies approaching the efficiency of positive displacement pumps of 90% as compared to previously typical efficiencies of 70%. With optimum design, energy usage as low as 11.4 kWh/kgal is now reported possible, where typical electrical consumption by the high-pressure pumps has been 16 kWh/Kgal historically.

Of the proven, commercialized energy recovery technologies, the positive displacement technologies such as the ERI Pressure Exchanger and Desalco Work Exchanger appear to be most efficient.

There are also new emerging energy recovery devices such as the Vari-RO Direct Drive (DDE), Vari-RO ISB and IPER systems recently tested by the United States Bureau of Reclamation. The Vari-RO energy recovery systems appear to be technically viable systems, but have not yet been used in a full-scale commercial application.

Energy recovery is a very important component of the overall desalination facility since it can help reduce energy requirements and the operating costs of a desalination facility. Therefore, continued monitoring of most efficient energy recovery systems is important to the desalination facility design.

4.0 MULTI-STAGE FLASH VS. SEAWATER REVERSE OSMOSIS

Although there have been many desalting technologies tested over the years, RO and thermal processes have had the greatest commercial success. Based on available literature, the total number of RO facilities (both brackish and seawater RO) at nearly 40% of all demineralization facilities. The total number of thermal plants in the world is slightly greater than 50% (IDA, 1998). The choice between multi-stage flash and seawater RO needs to be based on a number of site-specific factors. The inherent advantage of RO is that it has much higher energy efficiency. Since the cost of energy is usually the major cost of producing water, RO will usually be preferred, but some factors may overrule this.

First is the feed water quality. As the total dissolved solids (TDS) concentration in the seawater increases, RO becomes more costly because of the increased osmotic pressure required to separate the salts. Additionally, if the source water is high in suspended solids, colloidal material, organic material, or dissolved metals, it would require extensive pretreatment if RO was used. This could be cost prohibitive in some cases.

The second factor that influences the choice of MSF vs. RO is the availability of low cost energy. If there is an abundance of low cost steam available to operate the desalination plant, the energy-efficiency advantage of RO becomes less important. This can be seen in a dual-purpose power and water plant (or co-generation facility) where exhaust steam from the power plant is used to operate a desalination plant to produce high quality water.

One last factor to consider is the availability of skilled operators. While skilled operators are important for both MSF and RO plants, the relative fragility of RO membranes requires more skillful attention by the operators to protect the investment cost of the RO plant. MSF evaporators are relatively hardy and can usually be restored in spite of negligent operation.

5.0 HYBRID SYSTEMS

Hybrid systems use a combination of two or more desalination processes. These systems usually are combined with the intent to obtain some advantage over either process alone. The advantage may be improved efficiency or reduced feedwater flows, which in turn result in lower costs, or possibly better product water quality. The disadvantage of hybrid systems is that they are typically more complex to operate. An example of a hybrid system is a "membrane distillation" process that uses membranes to separate salty water from fresh water and uses evaporation to transport the fresh water from the membrane surface. Membrane distillation processes claim to have high efficiencies, but they have not yet been commercially proven.

6.0 NEW CONCEPTS

There are new emerging desalination technologies in the development stages that will likely revolutionize the desalting industry once proven and put into commercial application. An example of such emerging technologies currently being developed is described in a new, Department of Energy (DOE)-sponsored project entitled "A Modified Reverse Osmosis System for Treatment of Produced Water", New Mexico Research and Economic Development, 2001. Scientists developing this water treatment system claim that they can economically demineralize water, produce a solid salt waste, and yield 100% water recovery. In June 2000, the proposed project was awarded $1.2 million from the DOE, with 25% matching funds from New Mexico Tech.

Similarly, AquaSonics has developed a "Rapid Spray Evaporation™ (RSE) system", which is based on the principle that saltwater can be ejected at such high velocities that, as rapid evaporation occurs, solids separate out and are trapped. The resulting vapor is condensed into pure water. According to AquaSonics, the added benefit of the RSE process is that the demineralization concentrate is evaporated and the salt precipitates out as a solid and remains crystalline, which reduces controversial and costly concentrate disposal options. The salt product is said to be a commercially viable raw material. Based on information provided by AquaSonics, the RSE is claimed to achieve in one step what RO and MSF require in four or more steps and have a 95% recovery of fresh water as compared to 40% achieved by RO and MSF on seawater. In essence, the Aquasonics RSE is alleged to require one-fourth the capital investment and supposedly generates three times the volume of fresh water for the same, or less energy input as compared to MSF at 30 kwh/m^3 (or 113.4kWh/1,000 gallons). However, it should be noted that this is still significantly more energy use than reverse osmosis systems. The claims that Aquasonics makes are interesting, but still need to be proven viable at a commercial-scale.

Another emerging improvement in desalination is the development of larger RO membrane elements to make the process more efficient and improving the economies of scale. Recently, Koch Membrane Systems, Inc. has introduced the world's largest reverse osmosis element, the Fluid Systems MegaMagnum (Illustration 4).

The MegaMagnum membrane has a 17-inch diameter and 60-inch length, having more than 2,400 square feet of membrane surface area. According to Koch Membrane Systems, customers can achieve a footprint space-savings of up to 15 percent, have fewer manifolds and pressure vessels, and can cut capital costs by more than 20 percent. The MegaMagnum element is designed for seawater and brackish water demineralization applications.

Illustration 4. MegaMagnum Pressure Vessels

Historically, the standard spiral wound element has an 8-inch diameter and length of 40-inches, yielding up to 440 square feet of membrane surface area. In the 1980s, Fluid Systems introduced the Magnum, an 8 x 60-inch long element. In recent years, Koch Membrane Systems has also developed and sold more than 300 15-inch-diameter elements for various research projects worldwide.

Another firm, NATE-International, is currently developing the "DesalNATE" technology. This technology uses 16-inch diameter membranes compared to the standard 8-inch diameter. The DesalNATE process has three channels that feed the water to membranes in series in a common pressure vessel.

These large diameter elements are shown in Illustration 5.

Illustration 5. 16-inch Reverse Osmosis Element

Another new technology by a company called MWD claims to have a unique flow distributor applying an electro-magnetic field innovation, which prevents foulants from settling on the membrane surface and clogging the membranes. Unlike conventional RO systems, this process claims to use no chemical pretreatment, nor any chemicals during the desalination or membrane cleaning processes.

In summary, the current emerging technologies in desalination are primarily focusing on today's biggest challenges in desalination: 1) producing a dry salt product from RO concentrate and 2) producing larger-sized elements such that bigger facilities can be constructed at lower unit costs (or the cost per 1000 gallons of water produced) to take advantage of the economy of scale. Many of these advancements are still under study and have not had full-size commercial application. Should these systems be proven commercially viable, they will result in significant improvements to the desalination industry and lower process costs.

7.0 REGULATIONS

In addition to technology improvements, regulations for better product water quality have resulted in advancements and additional use of membrane desalination technologies. This has particularly been seen in the reclaimed water reuse field to further treat wastewater prior to discharging to surface water or groundwater that may ultimately flow to drinking water sources. The recently revised drinking water rules by the United States Environmental Protection Agency (EPA) and the Florida Department of Environmental Protection (FDEP) have included more stringent requirements regarding cryptosporidium and Giardia removal and the reduction of disinfection by-products in water treatment industry. This has resulted in an increased usage of membrane-treatment processes at surface water treatment plants and on the back-end of wastewater treatment plants to provide greater removal of the finest of molecules in the water. This has also enhanced the use of nanofiltration, ultrafiltration and microfiltration systems versus conventional filtration systems.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Desalination processes has been in use for nearly half a century for desalting brackish and seawater sources. Most of the world's desalination facilities are thermal (>50%) plants, with reverse osmosis in second with nearly 40% of the total facilities. However, most of the RO plants to date are brackish water desalination plants. The first desalination processes were used in arid regions in the Middle East, followed by Africa, the US and the Caribbean islands. With depleting drinking water supplies in the coastal areas of the US, desalination is increasingly being used as an alternative to conventional drinking water systems, especially where the economics of desalination can favorably compare to the increased costs of traditional drinking water treatment systems under current regulations.

While MSF distillation and RO processes are more often used for seawater desalination, ED and low pressure RO are commonly used for brackish water desalination. The choice of processes is highly dependent of site-specific conditions. Thermal distillation processes have mainly been used overseas, where low-cost steam from power plants has been available. Traditionally, these systems are not as efficient as compared to RO processes. RO plants utilize electric energy, and can be costly to treat seawater with very high salinities such as those in the Middle East. The reduced cost of RO systems over the last 10 years has increased the use of RO for seawater demineralization. These reduced costs are due to more efficient membranes, greater product water recovery and energy recovery.

There are several emerging technologies that appear to have potential for significant advancements in the desalination field. These advancements relate to evaporation of concentrate to a dry salt for commercial use or disposal, and increased membrane sizes to improve the economies of scale for larger membrane plants.

Based on the water supply needs in SJRWMD, the following conclusions and recommendations are provided for consideration in the feasibility investigation of demineralization on the northeast coast of Florida:

1. Brackish water desalination using ED or RO may prove to be a viable alternative for this coastal region.

2. Seawater desalination using RO can be cost-effective for larger municipal water supplies (>5 mgd).

3. Co-location with power generation facilities should be considered for dilution of concentrate from the desalination process. The possibility for negotiated-lower energy rates should also be investigated.

4. Continue to monitor the development of emerging technologies for advancements related to evaporation technologies for producing a dry salt from the RO concentrate.

5. Continue to monitor the development of pretreatment system improvements, particularly microfiltration, and other processes for their ability to handle fluctuating raw water qualities with high turbidities.

6. Consider new, proven technologies that have been demonstrated at a commercial scale. Some new technologies, which claim less energy or greater product water recovery, must be proven in a full-scale, operational facility, where treatment effectiveness, energy efficiency and costs can be proven. Some emerging technologies currently in development may prove to be great advancements in the desalination field; others may not.

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