Desalination

Issue Definition and Background

Considering that 97% of the Earth's water is salt water, water providers around the world are turning to desalination as a drought-proof supply for drinking water or industrial supply purposes. Desalination is the process by which salt is removed from seawater or brackish water. Two water streams are created by desalination: (1) desalinated freshwater for potable use; and (2) concentrate, which is a stream of water containing the salts. The freshwater is then further conditioned for drinking purposes and pumped into the distribution pipes for use in our homes and businesses. The concentrate is blended back into the sea where it originated, in the case of seawater desalination. In a brackish water desalination plant, the concentrate can be blended into the sea, injected deep underground, or in the case of a small plant, placed into surface drainages, sewerage systems, blended with reclaimed water to be used for irrigation, or into evaporation ponds.

Today there are more than 12,300 desalination plants operating on six continents around the world, producing over 12 billion gallons per day of desalinated water. Florida was the first state to embrace desalination over 30 years ago, and today leads the nation in the number of long-term successfully operating desalination plant at over 130 facilities. Desalination has become a reliable strategy by which communities are augmenting their water supply, as traditional supplies have been depleted, or have become contaminated. Desalination can be achieved by either distilling seawater with heat (producing salt-free steam followed by condensation), or by permeating freshwater through a man-made synthetic polymeric membrane. Thermal distillation processes are predominantly used in the Middle East, whereas, synthetic membranes are used globally as polymeric membrane processes are significantly more energy efficient than distillation-based desalination.

The more common membrane-based desalination process utilizes reverse osmosis (RO) technology. In the RO process, seawater or brackish water is forced through a synthetic membrane using a pump to pressurize the saline water. The majority of the salts are left behind in the concentrated saline stream, i.e. the concentrate, and water flows through the plastic and is purified in the process.

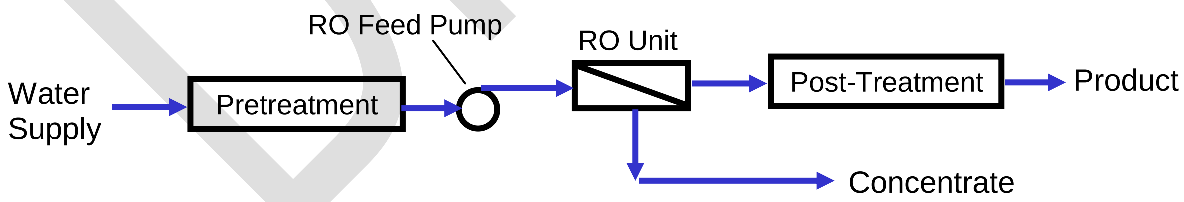

Figure 1 - Basic components of a RO desalination process

Water supply to a desalination plant is typically via an ocean or surface intake or well system. The pretreatment system is used to prepare the water source for desalination and generally consists of filtration and conditioning of the water prior to pumping into the membranes. This is a very critical stage if the source of water comes from surface water where water quality conditions may be frequently changing. The high pressure RO Feed Pump pressurizes the water to a suitable point to overcome the natural osmotic pressure of the saline water and to produce sufficient quantities of desalinated water.

Specific issues pertinent to the public regarding use of desalination include the following:

- The cost of desalination relative to other water supply alternatives;
- The amount of energy used for desalination; and
- Environmental considerations of desalination primarily concerning concentrate discharge.

<u>The cost of desalination relative to other water supply alternatives</u>

Thermal desalination has been in use since the late 1940’s in the Middle East. It was not until the development of RO membrane-based desalination in the 1970’s that the cost of desalination could be significantly reduced. In the period between 1990 - 2005 seawater desalination became more economical as a result of increased energy efficiencies of the membrane system and reduced capital costs. Significant advances have been made with regards to energy efficient membrane elements and membrane production costs. Many manufacturers today use advanced computerized automated systems for the production of membrane elements. Total costs as low as $1.80/1000 gallons of desalinated water were experienced during the time period of 2000 - 2005 in some countries. Since 2005 desalinated water costs have gradually escalated due to global competition for many materials of construction and increased power costs from global oil and raw materials mining price escalations. Today’s total cost of desalination is generally in the range of $2.50 – $4.50/1000 gallons for seawater and $0.50-1.50/1000 gallons for brackish water. A good rule of thumb for Florida cost of water is the 1-2-3 rule: groundwater $1/1000 gals; surface water $2/1000 gal; and seawater desalination $3/1000 gal.

Desalination should be considered as a water supply option relative to other alternatives in terms of capital costs, operating costs and a life-cycle cost analysis. Costs for energy, labor, permitting and some capital expenditures vary greatly with location. In many communities today, desalination is less expensive than storage/transfer of surface supply across long distances. Traditional groundwater supplies in Florida are becoming less available for use by the water management districts and surface supplies are often burdened with a high treatment and environmental cost that must be factored into the comparison. Water recycling is a supply alternative that must be included in the evaluation and inherently utilizes less energy than seawater desalination due to the lower salinity of wastewater. For example, the Orange County Water District, California water recycling plant will produce up to 70 million gallons per day that is pumped and blended in the drinking water aquifers. In addition, conservation methods must also be factored into overall cost of water supply options.

The largest contributor to the costs of a desalination plant is generally the cost of power and the amortized cost of the capital investment, as shown in Figure 2.

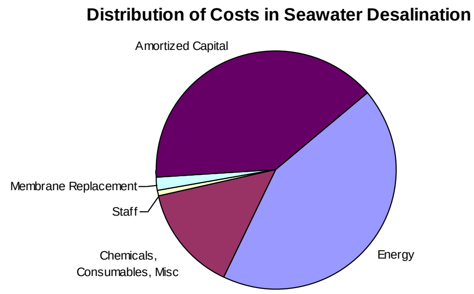

Figure 2 - Comparative distribution of costs in seawater desalination

<u>The amount of energy used for desalination</u>

Table 1 describes the relative amount of energy for desalination relative to other water supply choices. Though desalination energy requirements are higher relative to conventional supply options, energy usage continues to decrease as the technologies improve and more effective energy recovery systems are incorporated into the designs of modern facilities. Power requirements in seawater RO desalination have decreased by a factor of 75% since the 1980's primarily due to improved membrane properties and recovery of energy from the concentrate stream. For an appreciation of the amount of energy used in desalination, the Perth Seawater Desalination plant, an efficient modern facility treating relative cold seawater, utilizes approximately 20 mega watts of power to produce 37 million gallons per day of desalinated water. Thinking in terms of relative household energy usage, a family of 3-4 uses the same amount of energy to operate their household refrigerator as that required to produce their water supply using seawater desalination.

	Energy Intensity Range kWh/1000g (kWh/m^3)	
Water use Cycle Segments	**Low**	**High**
Water supply & conveyance	0	14.0 (3.7)
Water treatment (conventional)	0.1 (0.03)	0.2 (0.05)
Brackish water desalination	3.79 (1.0)	11.25 (2.97)
Seawater desalination	13.25 (3.5)	16.0 (4.23)
Water distribution	0.7 (0.19)	1.2 (0.32)
Wastewater collection/treatment	1.1 (0.29)	4.6 (1.22)
Wastewater discharge	0	0.4 (0.11)
Recycled treatment & distribution	0.4 (0.11)	1.2 (0.32)

Energy Intensity of the Water Use Cycle IDA/GWI 2007 Yearbook

Table 1 - Comparison of energy consumption associated with different water supply sources.

More importantly, many large-scale seawater desalination plants are now being developed completely powered by renewable energy, in order to eliminate any generation of greenhouse gas emissions associated with desalination. The Perth plant mentioned above is indirectly fully-powered by wind energy with no associated greenhouse gas emissions.

Environmental considerations of desalination

Desalination facilities are designed, constructed and operated in an environmentally sensitive manner. There are three primary areas where the opportunity exists for incorporation of desalination as a water supply option meets and enhances environmental requirements:

- The intake structures are designed to prevent or minimize impingement and entrainment of marine species;
- The energy demands are minimized through efficient design/components and power can be provided via renewable sources to eliminate greenhouse gas emissions;
- The disposal of concentrate and other potential effluents, such as neutralized cleaning or backwash water, are managed to ensure discharge standards are met and a strict monitoring practice is adopted to protect the environment.

The desalination industry has demonstrated, particularly in large-scale plants in Florida and as far away as Australia, that desalination can meet all the above requirements and hence protect the environment and public. For instance, the Tampa Bay Seawater project offsets groundwater pumping and provides water for growth in conjunction with the surface water system.

Issue Criticality for Water Supply

As Florida's population and water demands continue to grow and stress the existing water supply options, desalination should rank very high in criticality to the State's future water plan. Brackish water desalination in Florida has been successfully demonstrated for two decades; seawater desalination will become an increasing part of Florida's future water supply treatment portfolio. Not only can desalination play a role to meet the increased water demand, it can also greatly reduce environmental impacts from over-pumping groundwater or over-utilization of surface supply. More importantly, desalination is for the most part drought independent. Environmental impacts from desalination can be minimized and even eliminated (as presented above) with diligent attention to design and operation.

Global communities are recognizing that without desalination to bridge the gap in their water supply strategy, the community's economic welfare can deteriorate. An example is Melbourne, Australia where the long-term drought has greatly reduced the beauty of the garden city, thereby reducing tourism. Melbourne is presently developing a 120 million gallon per day desalination plant. Singapore is also a good example demonstrating the value of diversification of a water supply across '4 taps': seawater desalination, surface supply, water recycling, and import of water. This diversification which includes large-scale desalination ensures provision of a secure water supply to meet the Singaporeans' residential and commercial water needs and sustain their public and economic welfare. The same can be said for the Tampa Bay Water system, where its '4 taps' are seawater desalination, surface supply, water recycling and wellfields.

In Florida, steps have been taken on a regional basis to diversify supply with fresh surface water and seawater to reduce reliance on traditional groundwater supplies, most notably in the Tampa Bay region. A state-wide or district water supply strategy should be developed which includes desalination as a keystone feature to ensure adequate water supply as the state continues to grow and prosper. As a secure drought-independent water supply, it can be relied upon to augment traditional water supply options throughout any event or reduction in other water supplies. This security will ensure Florida citizens public health, environment and economy are protected as we progress into an uncertain future of global warming and economic downturns.

Florida 2030 Vision

Looking forward to 2030, desalination will become a proven and reliable water supply feature of the Florida 2030 Vision. Like many cities and communities in the world today, traditional renewable water supplies are insufficient to meet the needs of a stable and growing economy. Desalination from both the sea and additional brackish sources must be tapped:

- to provide additional supply needed to meet 2030 water demands,
- to protect the groundwater and surface water resources environment, and
- to provide diversification of supply for security and insulation from climatic or localized events.

It should be noted that even existing fresh groundwater sources in Florida, particularly in marginal coastal areas, will continue to see the salinity of these sources increase.

Using cities/regions such as Tampa Bay, Singapore, Sydney and Perth, Australia, and Cartagena, Spain as examples today, combining demand management, traditional supplies, water recycling, and desalination provides a comprehensive water supply solution which can successfully take Florida to 2030 and beyond. Because of the many small-medium sized communities and utilities within Florida, it will be necessary to band into 'joint action' utilities or consortiums of utilities in order to cost-effectively develop large-scale desalination facilities. This is similar to the Coquina Coast Suppliers' union developed to achieve greater common goals and the partnership of utilities developed in the Tampa Bay Water system, and is a likely model for Florida 2030 relationships between utilities.

Without desalination, Florida will be required to 1) more heavily rely on finite ground and surface water sources leading to environmental impacts and resulting economic impacts; 2) move toward potentially strict demand management and conservation measures; 3) rely heavily on water recycling for primary water supply needs; and 4) have little flexibility regarding response to climatic changes and localized weather events. Examples of economically-strong cities which have not adopted measures to provide alternative water supply options to meet growing or changing demands include Barcelona, Spain and Melbourne, Australia. These cities are presently undergoing severe water rationing and have had to quickly move toward desalination and in the case of Barcelona, shipping in tankers of water from overseas as emergency rations. The economic impact is severe as is potential long-term effects. For instance, Melbourne has lost many of its beautiful large trees which have greatly contributed to its image as the Garden City of Australia. It is likely that many more will be lost prior to reinstatement of a stable water supply for this city.

Options and Path Forward to Achieve Florida 2030 Vision

To achieve the Florida 2030 Vision, a number of actions should be taken:

1. Educate the public, legislators, regulators and other stakeholders:
    - Provide accurate costing information;
    - Collate and provide environmental study results and case studies in digestible format;
    - Provide information on energy-efficient sustainable desalination facilities and approaches; and
    - Frame in context of overall water ‘4 taps’ strategy – one tool in the toolbox.
2. Facilitate creation of joint action utilities to achieve greater common goals, which can be fully public entities or a combination of public/private partnerships;
3. Facilitate use of renewable energy sources and reduced energy designs;
4. Develop permitting model to streamline and expedite project permitting; and
5. Develop coastal/inland county water grid to enhance water supply efficiencies and improve overall supply security.

Advantages and Disadvantages of Path Forward Actions

Action	Advantages	Disadvantages
Education	Non-threatening; improves communication and relationships with all stakeholders Expedites public acceptance and needed legislation Reduces legal costs and long lead schedules	Upfront cost for development of material PR strategy is needed to effectively communicate the information with resulting cost Some additional local environmental studies may be required
Joint Action Utilities	Can achieve broader goals at lower cost due to larger facilities Will have more political strength to facilitate legislation Lower cost to consumers due to economy of size	Legal framework required Competing goals create challenges which must be resolved
Renewable/ Low Energy Approaches	Reduces environmental impact (GHG emissions) Encourages environmental stakeholder support	Renewable energy currently more costly than fossil fuel

Action	Advantages	Disadvantages
Permitting Model	Streamline process between multiple agencies Expedites project timeline Reduces legal and projects costs	Agency hesitancy to change Challenge to bring together multi-agency agendas
Water Grid	Provides supply security Improves supply efficiency Enhances cross-district relationships long-term Provide inland counties with access to seawater sources	Costly to implement Regulatory framework required Requires cross-district cooperation and resolution of short-term issues

Issues for Consideration

- A streamlined and consistent permitting process is needed between Florida Department of Environmental Protection, the regional water districts, the local health departments, local environmental agencies and the Department of Community Affairs. One-stop shopping is the objective with consistent requirements.

- Need regulations updated to deal with pretreatment, disposal and concentrate issues.

- Need outreach programs that will educate the public and other stakeholders on the costs and environmental advantages and sensitivity of technologies.

- Evaluate how to disperse the cost of desalination across users with multiple supply sources.