Texas Water Development Board

The Future of Desalination in Texas
Biennial Report on Seawater Desalination

December 2008

The Future of Desalination in Texas

Texas Water Development Board

Section 16.060 of the Texas Water Code, directs the Texas Water Development Board to undertake or participate in research, feasibility and facility planning studies, investigations, and surveys as it considers necessary to further the development of cost-effective water supplies from seawater desalination in the state. The Texas Water Development Board shall prepare a biennial progress report on the implementation of seawater desalination activities in the state and shall submit it to the Governor, Lieutenant Governor, and Speaker of the House of Representatives not later than December 1 of each even-numbered year.

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Special Report
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TEXAS WATER DEVELOPMENT BOARD

To: The Honorable Rick Perry, Governor of Texas
The Honorable David Dewhurst, Lieutenant Governor of Texas
The Honorable Tom Craddick, Speaker of the Texas House of Representatives

Enclosed for your consideration is the third Biennial Report on Seawater Desalination submitted to you in compliance with Texas Water Code §16.060. This report examines progress toward the goal of creating water supplies in Texas through seawater desalination and discusses the vital role the state must play to achieve what would be an unprecedented and historic water supply breakthrough for Texas.

As traditional water supply sources become scarcer and less reliable, water desalination may become a competitive alternative for providing the next increment of water supply for Texas. Since 2002, when Governor Rick Perry first stated his vision for developing a new drought-proof source of water for Texas, contracted water desalination capacity in the world has increased to 10.3 billion gallons per day.

In Texas, the Texas Water Development Board (TWDB) has been directed to take all necessary actions to further the development of cost-effective water supplies from seawater desalination in the state. Currently, the greatest opportunity for Texas to begin large-scale development of seawater desalination in the near future is provided by the Brownsville Public Utilities Board.

The Brownsville Public Utilities Board proposes to implement the first phase of a 25 million-gallon-per-day facility by installing a 2.5 million-gallon-per-day production prototype on the south bank of the Brownsville Ship Channel. The proposal includes designing and building some of the facilities to the project's ultimate 25 million-gallon-per-day production capacity. The cost of the proposed initial phase is $67.5. The funding package consists of three essential components: grants, State Participation Program Funding, and Water Infrastructure Funding. However, securing each one of these funding elements will be challenging, and there are no guarantees that the funding will be secured and/or that a clear legislative priority will be assigned to funding the project.

On behalf of the citizens of Texas, TWDB respectfully submits to Governor Rick Perry, the Lieutenant Governor, the Speaker of the House, and members of the 81st Texas Legislature this document, consisting of a progress report and recommendations on the next steps to advancing the development of large-scale seawater desalination water supplies in Texas.

Chairman, James Herring

Executive Administrator, J. Kevin Ward

Our Mission
To provide leadership, planning, financial assistance, information, and education for the conservation and responsible development of water for Texas.

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Executive Summary

The joint efforts of the Brownsville Public Utilities Board and the Texas Water Development Board over the last biennium have effectively moved the Seawater Desalination Initiative one substantial step closer to its primary goal of installing a production and demonstration seawater desalination facility in Texas.

The greater goal of this initiative is to effectively assist in the development of a new, abundant and drought-proof water supply source for the state. Although it is hard to fully quantify the economic benefits of an entirely new supply of water, its value is unquestionable when considered against the projected needs for new water supplies in Texas, starting at 3.7 million acre-feet per year in 2010 and increasing to 8.8 million acre-feet per year by the year 2060.

The Brownsville Public Utilities Board, in partnership with various desalination equipment manufacturers, conducted and completed an 18-month seawater desalination pilot plant study at the Brownsville Ship Channel. The study collected ocean water data and evaluated the performance of different treatment approaches for desalinating seawater by use of reverse-osmosis membranes. Based on the results of the study, the Brownsville Public Utilities Board has determined key characteristics and cost estimates for a 25 million-gallon-per-day seawater desalination facility.

The preferred location for a seawater desalination facility is on the south bank of the Brownsville Ship Channel at a point located approximately 11 miles from the Gulf of Mexico. The raw water system that will feed the plant will consist of a side canal located off the ship channel. The recommended treatment process will consist of a conventional settling system followed by a membrane pretreatment and reverse-osmosis filtration. The concentrate will be transported back to the ocean via a 14-mile pipe and discharged 0.5 miles into the Gulf of Mexico. The estimated cost of this project is $182.4 million.

The Brownsville Public Utilities Board, although committed to further diversifying its water supply sources by adding seawater desalination to its portfolio, does not presently have the water demand nor the financial resources to implement the full-scale project. Nevertheless, to continue advancing the development of seawater desalination supplies, it has formulated a phased approach which entails building an initial 2.5 million-gallon-per-day production and demonstration facility that would eventually be expanded into the full-scale 25 million-gallon-per-day facility originally envisioned. These expansions will be based on demand growth over the next 40 years.

The projected cost of the first phase is approximately $67.5 million, with $31.1 million or 46 percent of that cost targeted for installing components large enough to accommodate a 25 million-gallon-per-day plant in the future. To finance this project, the Brownsville Public Utilities Board will apply for a combination of grants and loans from State Participation and Water Infrastructure Funds. The grant component is contingent on appropriations by the 81st Texas Legislature, and the loan components require additional legislative appropriations as well as successful prioritization by the TWDB in awarding funds from the State Participation Program and Water Infrastructure Fund. In the absence of a clear legislative priority for State Participation or Water Infrastructure Funds, this project will need to compete with other projects.

The proposed facility and the recommended phased implementation approach can serve as a prototype for large seawater desalination development in Texas by demonstrating the permitting process and providing a tangible reference point for the design, construction, and operation of a seawater desalination facility at a ship channel location in Texas.

Key Findings and Recommendations

A. Findings

Results of the pilot plant study

The focus of seawater desalination activities at TWDB for the past two years has been on collecting water quality data and pilot testing the reverse-osmosis process to treat ocean water from the Brownsville Ship Channel. The pilot plant study confirmed and improved on the recommendations for a desalination treatment process developed in the 2004 feasibility study (BPUB, 2004) as follows:

Project location: Two sites are available for implementing a full-scale seawater desalination facility for Brownsville. One is in the vicinity of Boca Chica which is located close to the open ocean while the other is located on the south shore of the Brownsville Ship Channel, close to the City of Brownsville. Costs and site conditions favor a plant on the south shore of the Brownsville Ship Channel.

Intake: Ship traffic significantly impacted the pilot plant operations by raising turbidity levels of the feed water. The intake for the full-scale project will be designed to mitigate these effects. Specifically, the intake will consist of a side canal located off the south bank of the ship channel, designed to transport a minimum of 50 million gallons per day of feed water to the seawater desalination facility. This is the feed volume needed for a 25 million-gallon-per-day production.

Treatment: The pilot plant study indicates that at least one of the membrane pretreatment methods was able to provide a sustainable stream of adequate water quality for the reverse osmosis process. However, the study report recommends adding an additional layer of pretreatment to increase the plant's ability to treat the wide range of water quality that may be encountered in a full-scale plant.

Cost and fundability of a full-scale facility

Using knowledge gained from the pilot plant study, the Brownsville Public Utilities Board updated the cost of a 25 million-gallon-per-day facility and now estimates the cost at $182.4 million. The Brownsville Public Utilities Board estimates grant financial assistance needs of $100 million in order to implement the full-scale project today. The Brownsville Public Utilities Board met with the U.S. Army Corps of Engineers, Bureau of Reclamation, members of the Texas congressional delegation, and TWDB to seek and explore potential sources of financial assistance to execute a full-scale project. Given the magnitude of the assistance needed, it is unlikely that grants can be secured in the near future to execute the full-scale project.

Therefore, to begin creating seawater desalination capabilities that benefit the most from the work carried out to date, the Brownsville Public Utilities Board is proposing a phased implementation strategy.

Phased implementation of seawater desalination in Brownsville

The Brownsville Public Utilities Board proposes to initially install a 2.5 million-gallon-per-day production and demonstration seawater desalination facility with the goal of expanding this facility to meet the project's ultimate production capacity of 25 million gallons per day. With this in mind, the raw water intake and portions of the concentrate discharge system in the 2.5 million-gallon-per-day facility would be designed for the full-scale plant. Pretreatment would consist of parallel bays to allow for ongoing comparison of a membrane microfiltration process and a more robust process consisting of rapid mix and clarifiers followed by membrane microfiltration. The desalination phase would consist of a single-pass, reverse-osmosis filtration.

The Brownsville Public Utilities Board recognizes the importance of collaborating with researchers and equipment manufacturers to allow for continuous, cost-effective improvements to the water treatment process. Therefore, the initial phase of the seawater desalination project would include bench- or pilot-testing capabilities to continue exploring and improving the desalination operations.

The estimated cost of the initial 2.5 million-gallon-per-day plant is $67.5 million. Of this, $31.1 million or 46 percent will be targeted for system components that will be needed to meet the full production capacity (25 million-gallon-per day) in the future. The Brownsville Public Utilities Board proposes to fund this phase through grants and loans from the state.

B. Recommendation

Through the Texas Seawater Desalination Initiative, the state has demonstrated the technical feasibility of seawater desalination and advanced the process of developing a new, substantial drought-proof source of water supply for Texas. It is imperative that we continue our efforts in this direction. We have proven seawater desalination to be technically feasible, and, although it is still a relatively expensive source of supply, technological improvements will undoubtedly help reduce costs in the future while the cost of more conventional water supplies will continue to increase. If not pursued to fruition now, the Initiative will suffer a serious setback not only in terms of lessons learned and experience gained but also our ability in the future to garner support from a broad coalition of partners whose cooperation and participation have been critical for successfully conducting the pilot plant study.

The next, most effective step toward implementing a large-scale demonstration seawater desalination facility in Texas is to install a 2.5 million-gallon-per-day production prototype on the south shore of the Brownsville Ship Channel. Therefore, TWDB respectfully requests the 81^{st} Texas Legislature to continue its support for the Seawater Desalination Initiative by considering the TWDB Legislative Appropriations Request, Fiscal Years 2010–2011, for a $28.2 million grant from general revenue to assist the Brownsville Public Utilities Board implement the first phase of a proposed large-scale demonstration seawater desalination facility.

TWDB also requests additional State Participation and Water Infrastructure bonds necessary for the project, as well as sufficient appropriations from general revenue to pay the required associated debt service.

I. Introduction

Seawater desalination, for many years relegated to water-scarce but energy-rich areas, is today a recognized, cost-competitive tool for providing the next increment of water supply to water supply portfolios in many areas of the world.[1] At a time when conventional water sources are more difficult or even unfeasible to develop, advanced desalination technologies, often implemented by means of alternative and more efficient project procurement and funding methods, are proving to be a flexible and expeditious solution to address water needs.

Seawater desalination, however, faces unique challenges that must be carefully considered. The State of Texas, with access to a practically limitless source of seawater, is committed to developing new water supplies from seawater desalination. The strategy to advance this goal is to implement Texas' first large-scale seawater desalination project and, in the process, identify and address the technical, financial, and regulatory challenges to desalinating seawater in the state.

In April 2002, Governor Rick Perry requested a proposal from the Texas Water Development Board (TWDB) for a large-scale demonstration of seawater desalination in Texas. Since then, TWDB has identified potential sites for seawater desalination (TWDB, 2002); completed feasibility studies for the leading sites (TWDB, 2004); developed a funding allocation criterion for future seawater pilot plant studies (TWDB, 2006); and conducted a seawater pilot plant study at the Brownsville Ship Channel (2007–2008). Appendix B is a comprehensive list of the program's actions and milestones.

This report describes the actions, analyses, and findings of TWDB for developing large-scale demonstration seawater desalination projects in Texas. The report also examines the challenges to their implementation, the role of the state in overcoming those challenges and identifies next steps, including funding requirements.

The report consists of four sections and three appendices that specifically address the four items required in Texas Water Code, Section 16.060(b) directing TWDB to prepare this biennial progress report. The four items are:

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[1] Please refer to Appendix A

"(1) Results of the board's studies and activities relative to seawater desalination during the preceding biennium;

(2) Identification and evaluation of research, regulatory, technical, and financial impediments to the implementation of seawater desalination projects;

(3) Evaluation of the role the state should play in furthering the development of large-scale seawater desalination projects in the state; and

(4) The anticipated appropriation from general revenues necessary to continue investigating water desalination activities in the state during the next biennium."

Supplementing the report are the following appendices:

A. A brief overview of the state of the desalination industry

B. Chronology and milestones of the Seawater Desalination Demonstration Initiative

C. Brownsville Public Utilities Board's proposal for a 2.5 million-gallon-per-day production/demonstration seawater desalination facility

II. TWC 16.060(b) (1) Results of Studies and Activities

Texas Water Code, Section 16.060, requires TWDB to undertake necessary steps to “further the development of cost-effective water supplies from seawater desalination in the state.” Section 16.060(b) (1) also requires TWDB to report the “results of [its] studies and activities relative to seawater desalination during the preceding biennium.”

In its six years of existence, the Seawater Desalination Initiative has evolved through three distinct stages:

> Request for a statement of interest for feasibility studies. TWDB received ten proposals for seawater desalination sites in August 2002 (TWDB, 2002).
>
> Feasibility studies. Three feasibility studies were completed in 2004 for sites that showed the most promise for developing large-scale seawater desalination. The three sites were Brownsville, Corpus Christi, and Freeport (TWDB, 2004).
>
> Pilot plant study. TWDB considered financial assistance applications for pilot plant studies for the three sites and, in April 2006, selected Brownsville as the host site for a seawater desalination pilot plant study (TWDB, 2006). Brownsville completed its pilot plant study during the present biennium.

Figure 1 illustrates key milestones of the Seawater Desalination Initiative, and Appendix B provides a detailed chronological list of its activities and results.

In the current biennium, the focus of the Seawater Desalination Initiative has been on designing and planning for the permitting, procuring, constructing, and operating of a seawater desalination pilot plant study at the Brownsville Ship Channel by the Brownsville Public Utilities Board. Thus, the primary subject of this section is the pilot plant study and how it has effectively advanced the Seawater Desalination Initiative.

As part of the pilot plant study, the Brownsville Public Utilities Board issued two interim reports (BPUB, 2006b; BPUB, 2008a) that provide updates on the projected cost to implement a 25 million-gallon-per-day seawater desalination facility, also referred to in this report as the full-scale facility.

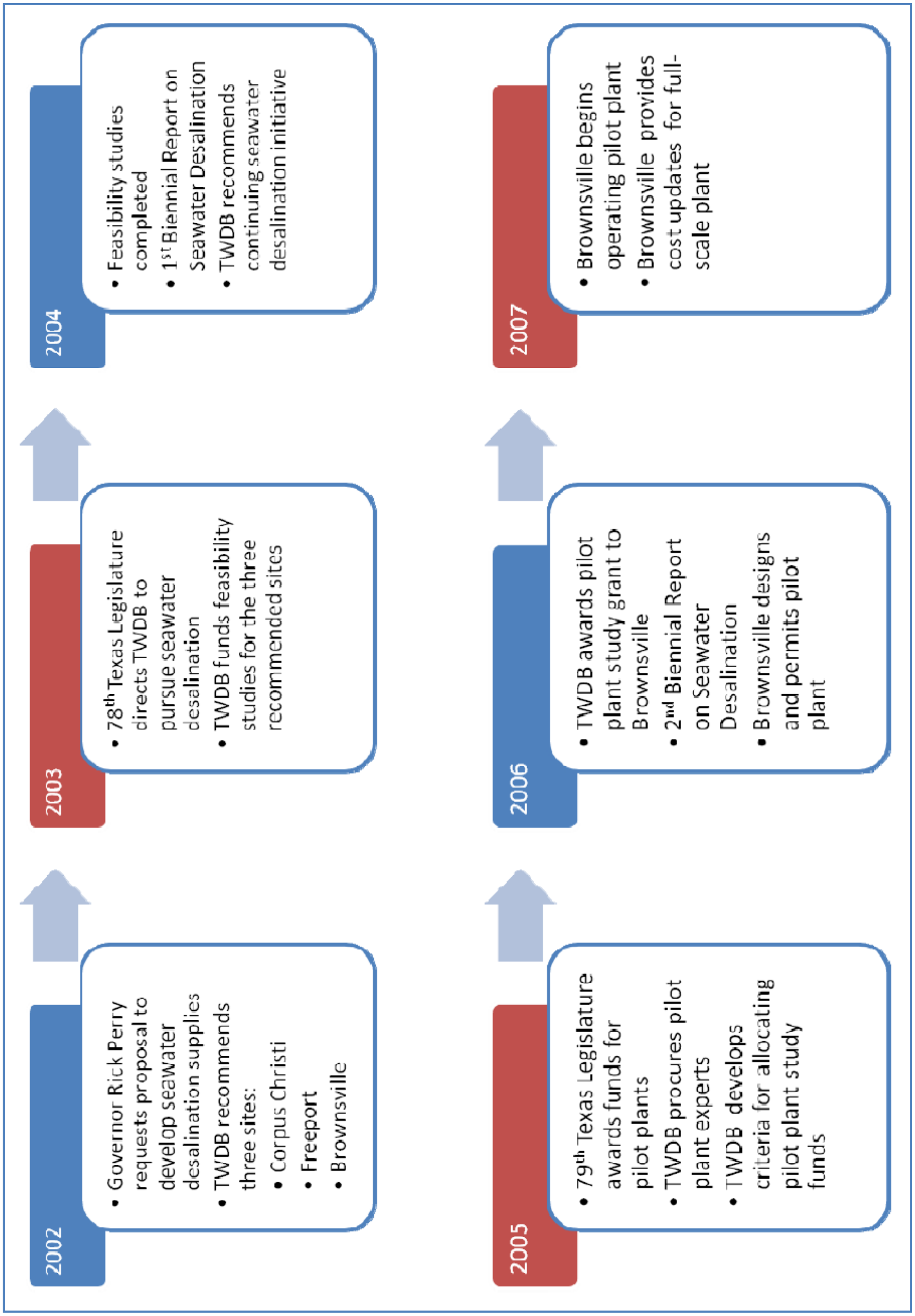


Figure 1 - Key milestones 2002-2007

A. Advancing the Seawater Desalination Initiative by conducting a pilot plant study in Brownsville

This subsection describes seawater desalination technology and the process leading to the selection of Brownsville as the host site for a seawater desalination pilot plant study. It also examines the goals and key outcomes of the pilot plant study, presents an updated cost for a 25 million-gallon-per-day facility, and describes the resulting recommendation to implement a 2.5 million-gallon-per-day production demonstration facility.

Seawater desalination by reverse-osmosis and pilot plant studies

There are several water desalination methods currently available to produce potable water from saline sources (Reclamation, 2003). Currently, the preferred method is pressurized filtration through reverse-osmosis membranes (Pankratz, 2004). This is the desalination method used in the Brownsville pilot plant study.

In the reverse-osmosis process, energy is used to remove dissolved salts from a saline water source by forcing the water through a permeable membrane. While the filtered water is relatively free of dissolved salts, the unfiltered water gains a higher concentration of salts. This water, along with its high load of dissolved salts, is known as the concentrate.

> "Proper pretreatment of feed water is the most important factor in the successful operation of a reverse-osmosis plant, and pilot testing of the pretreatment process is a critical part of plant design."
>
> National Research Council
> Desalination – A National Perspective (NRC, 2008)

The greatest energy requirement in the desalination process is for pressurizing the saline feed water. In seawater desalination, operating pressures can range from 800 to 1,000 psi (Buros, 2000).

A critical issue in seawater desalination by the reverse osmosis process is ensuring that water of an acceptable quality is consistently delivered to the reverse-osmosis membranes. This is usually achieved by pre-treating the feed water. Successful pretreatment removes suspended solids and organic constituents that cause fouling of the membranes. Figure 2 illustrates the key unit processes and the sequence involved in this type of desalination.

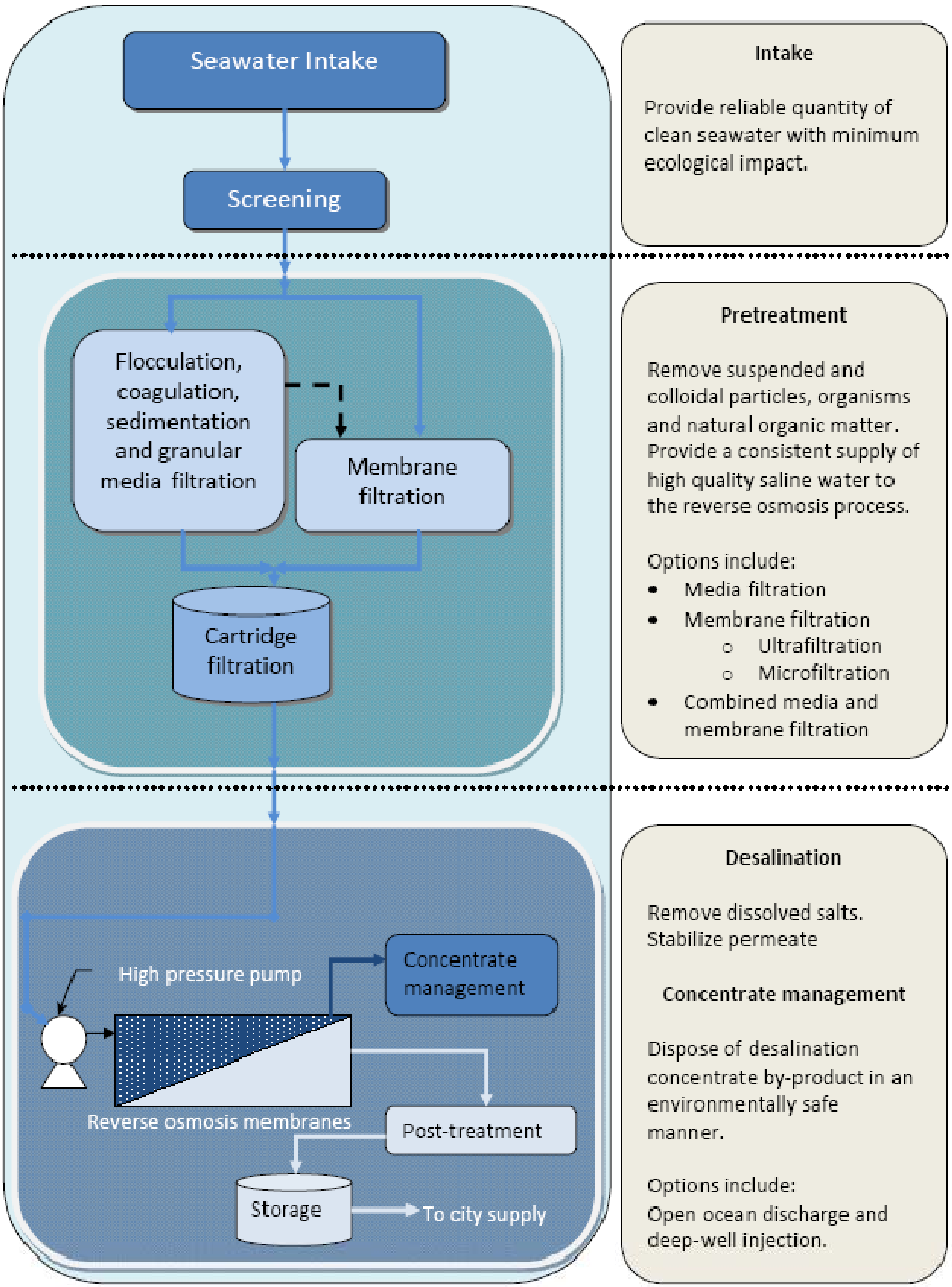


Figure 2 - Components of the seawater desalination by reverse-osmosis process

Pilot plant studies provide crucial data on source water conditions and the performance of different unit treatment processes that constitute a seawater desalination facility (Reiss, 2004). It is also required in Texas. When permitting innovative technology water supply projects, the Texas Commission on Environmental Quality requires piloting to demonstrate the performance of the treatment process (TCEQ, 2004).

Selecting Brownsville as the site for a seawater desalination pilot plant study

In 2004, the TWDB recommended pilot plant studies as the next effective step in advancing the Seawater Desalination Initiative. A pilot plant study would help gather crucial information required to design and estimate costs for a 25 million-gallon-per day facility (TWDB, 2004). In 2005, the 79th Texas Legislature appropriated funds to TWDB to implement seawater desalination pilot plant studies (79th Texas Legislature, 2005).

On April 17, 2006, TWDB considered applications and proposals for developing seawater desalination pilot plant studies at Brownsville, Corpus Christi, and Freeport. While all three applicants showed that their sites could potentially host a seawater desalination demonstration facility, the Brownsville Public Utilities Board demonstrated a greater need for a diversified water supply portfolio and preparation to pursue a large-scale seawater desalination project in the more immediate future. Consequently, TWDB selected the Brownsville Public Utilities Board to conduct a pilot plant study in Brownsville as the next step toward implementing the Seawater Desalination Initiative. TWDB awarded the utility $1,340,000 to conduct a 12-month pilot plant study to supplement the applicant’s contribution of $885,369 for a total original budget of $2,225,369.

The Brownsville Public Utilities Board budget included costs for testing two pretreatment options: a conventional pretreatment system and a microfiltration membrane pretreatment system. However, through partnering with equipment manufacturers, the scope of the project was expanded to include two more pretreatment systems for a total of two ultrafiltration membranes, one microfiltration membrane and a conventional process. The budget was increased by $1,000,000, which the Brownsville Public Utilities Board funded, bringing the total applicant’s contribution to $1,885,369 and the study budget to approximately $3.23 million.

The next subsections of the report provide a summary overview of the pilot plant study and its key results. Appendix C is an executive summary of the Brownsville Public Utilities Board Pilot Plant Study Report submitted to the TWDB on October 24, 2008.

Pilot plant study location and process components

The overarching goal of the Brownsville Seawater Desalination Pilot Plant Study (BPUB, 2006a) was to test and verify the water treatment approach recommended in the 2004 feasibility study (BPUB, 2004) and to collect data to design and develop a cost budget for a 25 million-gallon-per-day seawater desalination facility.

The pilot plant was located in a secured location provided by the Port of Brownsville on the north bank of the Brownsville Ship Channel, approximately 11 miles from the Gulf of Mexico (Figure 3).

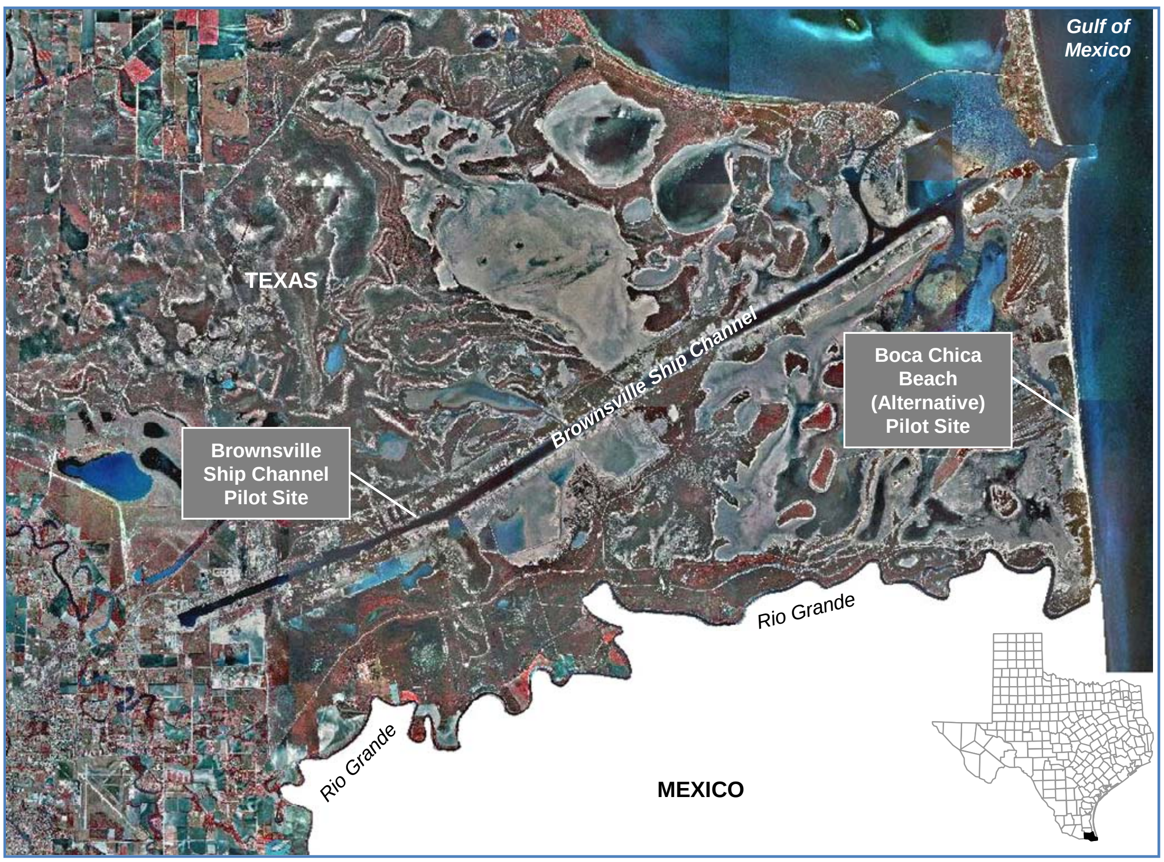


Figure 3 - Brownsville Ship Channel and Boca Chica sites

Figure 4 illustrates the pilot plant layout and its relevant components:

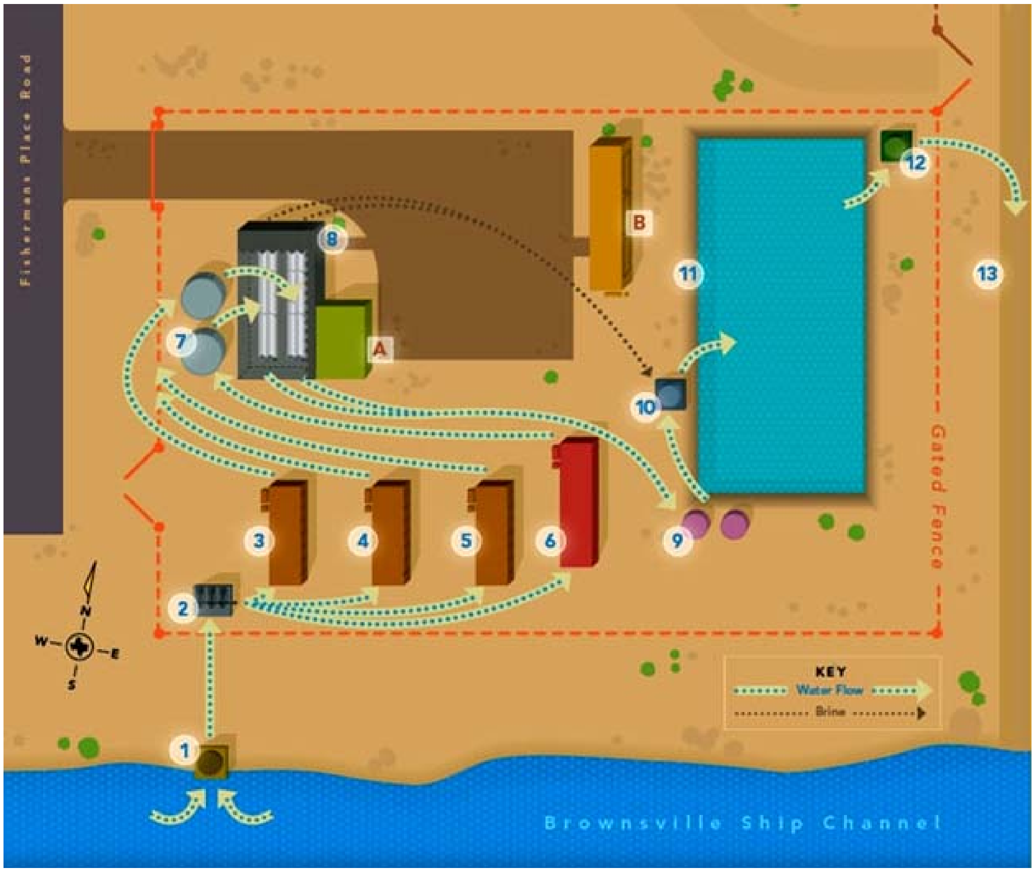


Figure 4 - Brownsville pilot plant layout

#1 Open intake and 0.125” screen
#2 Intake pumps
#3, #4, #5 Membrane pretreatment units
#6 Granular media pretreatment unit
#7 Pretreated water storage for reverse osmosis feed
#8 Reverse-osmosis membranes
#9, #10 Storage and remixing tanks
#11 Storage lagoon for final disposal to the ship channel
#12, #13 Discharge facilities

A: Chemical storage
B: Control room

Each membrane pretreatment unit was directly and/or remotely monitored by the individual equipment supplier. Their performance was monitored and recorded to determine their individual operating efficiency. All pretreated water was stored, pressurized and then forced through the reverse osmosis membranes. Both treated and concentrated effluents were then remixed and disposed back into the ship channel.

Pilot plant study goals and results

Following is a brief summary of the specific study goals (BPUB, 2006a) and the results for the pilot plant study as reflected in the final Pilot Plant Study Report, submitted on October 24, 2008 (BPUB, 2008b).

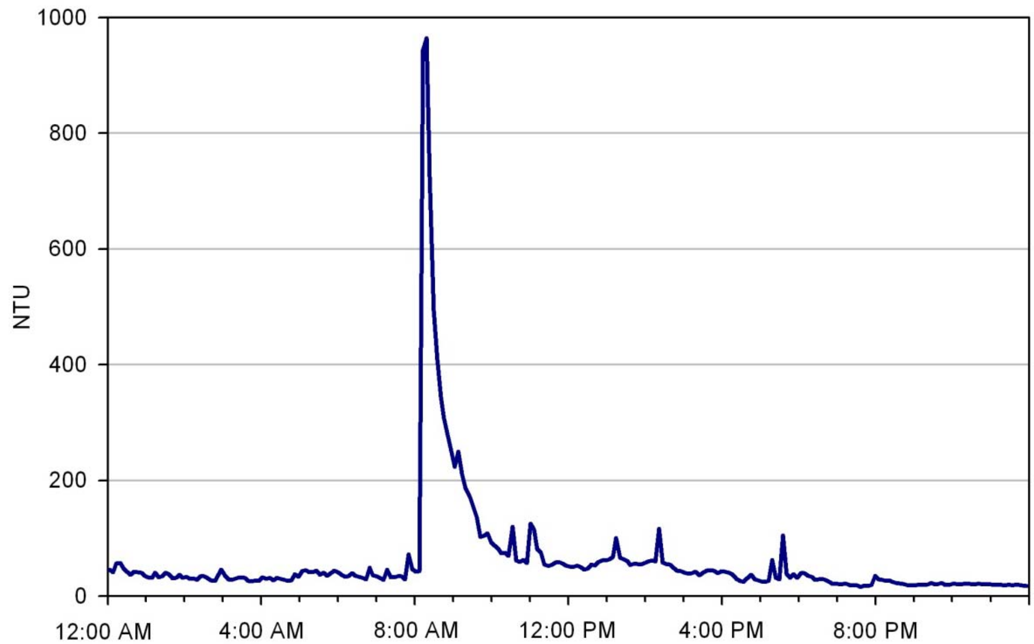
Intake system
Goal: Verify the performance of the open intake system recommended in the 2004 Feasibility Report (BPUB, 2004).

Results: Early in the study, the Brownsville Public Utilities Board conducted exploratory discussions with the U.S. Army Corps of Engineers and determined that the cost of constructing the recommended intake and the time it would take to permit it would have delayed the pilot plant study by approximately 12 months. The pilot plant study did not evaluate the type of open intake recommended in the 2004 Feasibility Report (screened side canals on the Brownsville Ship Channel). Instead, the Brownsville Public Utilities Board opted for a screened stilling well (large-diameter well installed in the ship channel to help sediments settle) intake on the north shore of the Brownsville Ship Channel.

Figure 5 - Pilot plant stilling well intake on the Brownsville Ship Channel (north bank)

The location of the pilot plant allowed for a more precise understanding of the substantial impact of wind and ship traffic on the quality of the feed water. The prevailing wind patterns (southeast to northwest) resulted in higher turbidities on the north shore of the channel where the pilot plant intake was installed. Similarly, the data showed that traffic from large cargo ships generated raw water turbidity spikes with episodes lasting up to three hours (Figures 6 and 7) This information resulted in a recommendation for moving the intake location for the full-scale project to the south bank of the channel and an intake system design that is capable of reducing the impact of ship traffic on the raw water feed quality.

Figure 6 - Ship traffic and turbidity at the pilot plant site



Source: Brownsville Public Utilities Board

Figure 7 - Snapshot of raw water turbidity spike caused by a passing cargo ship, 12/26/07.

Source water characterization

Goal: Document and characterize the source water at both the Brownsville Ship Channel and the Boca Chica sites.

Results: A pilot plant study is designed to collect data and test the source water at or reasonably near the location of the proposed full-scale facility. Although the Brownsville Public Utilities Board had considered two siting options for the 25 million-gallon-per-day facility (the Brownsville Ship Channel and Boca Chica), as described below, it selected the ship channel as the preferred location (BPUB, 2008a); Figure 3).

Important considerations in the decision making process included source water quality, concentrate disposal options, proximity to a water distribution system and availability of and control over existing electric utility service.

Although the source water quality at the Brownsville Ship Channel is more challenging (higher turbidity levels and greater concentrations of total and dissolved organic carbon; Table 1) than at the Boca Chica site, there are practical and important advantages to siting the project at the Brownsville Ship Channel that outweigh the source water quality issues.

The Brownsville Ship Channel site is in a developed and secure area, located relatively close to the city of Brownsville water distribution system and within the electric utility service area of the Brownsville Public Utilities Board. This is a critical advantage because the Brownsville Public Utilities Board would then have direct electric tariff control over the seawater desalination facility and the ability to manage the power/water production cycles to an economic optimum.

On the other hand, the Boca Chica site, although having better quality source water and being located closer to the ocean (easier for disposing of the concentrate) is more vulnerable to hurricane storm surges than the Brownsville Ship Channel site. Moreover, the site is not easily accessible and lacks any infrastructure, including roads and electric service.

Table 1 – Average raw water quality, Gulf of Mexico (periodic grab samples) and Brownsville Ship Channel (daily grab samples)

Parameter	Gulf of Mexico (Boca Chica)	Brownsville Ship Channel
Turbidity in Nephelometric Turbidity Units	4.89	44.7
Total organic carbon in milligrams per liter	2.08	3.53
Dissolved organic carbon	1.99	3.25
Ultraviolet_{254} in centimeters^{-1}	0.0231	0.047
Alkalinity in milligrams per liter	124.8	141.0
Temperature in centigrade degrees	14.5	25.0
Total dissolved solids in milligrams per liter	34,170	30,514

Source: Brownsville Public Utilities Board (BPUB, 2008b)

Pretreatment and treatment systems

Goals:

- Evaluate the long-term performance of four alternative pretreatment systems to reliably and consistently reduce the fouling potential of seawater for reverse-osmosis filtration; document overall performance of the pretreatment systems, including removal of suspended solids and organic matter and the amount of water generated and energy consumed.

- Assess the energy requirement and performance of the seawater membrane treatment, the rate of membrane fouling, and the frequency of membrane cleanings; through testing, establish optimum operational settings for the system; develop a model to predict membrane replacement frequency for the large-scale project.

- Document and characterize the quality of the permeate and evaluate post-treatment stabilization and disinfection requirements; document and characterize the quality of the concentrate and waste streams generated by the seawater desalination process.

Results: Pretreatment is the first and most critical process in seawater desalination by reverse osmosis. Its purpose is to prevent suspended matter from reaching the reverse-osmosis membranes. The optimum performance of the reverse-osmosis system depends heavily on the ability of the pretreatment process to provide a water stream that consistently meets or exceeds the manufacturer specifications for the reverse-osmosis membrane. Failure to do so results in scaling and/or biological fouling of the membranes which then requires more frequent cleanings, leading eventually to prematurely replacing costly membranes.

Pretreatment may be provided by conventional means (flocculation, sedimentation, and granular media filtration) or by more recently developed microfiltration or ultrafiltration membranes. Membrane pretreatment is gaining acceptance and market share in reverse-osmosis desalination processes because of its ability to provide consistent quality streams from highly variable water sources on a sustainable basis.

The decision to include two more pretreatment options to supplement the study was a significant enhancement to the original proposed effort. Coupled with the challenging water source, it placed the Brownsville project in an exclusive category of projects that have pilot tested multiple cutting-edge pretreatment systems. Although the exercise provided a substantially superior experience with pretreatment options, it also increased the complexity, duration, and cost of the study.

The pilot plant study findings indicate that at least one of the membrane pretreatment systems, a microfiltration process, provided a consistent and acceptable stream of water for the reverse-osmosis system. However, in view of the documented variability of the source water quality, including frequent turbidity spikes, it is highly advisable for the full-scale project to incorporate a conventional unit process (rapid mix and contact clarifier) before the microfiltration process. By providing an extra layer of pretreatment, the membrane-based process will likely operate at a much higher efficiency than was noted during the pilot study.

The pilot plant tested two different brands of reverse-osmosis filters and they both performed adequately under varying temperature and salt content in the feed water to produce water that would meet or exceed drinking water quality standards.

In conclusion, the pilot plant study confirmed the technical feasibility of seawater desalination by reverse osmosis and provided a basic measure of the performance of the different types of treatment processes.

A requirement of the pilot plant study was to provide a data-based estimate of the energy required to produce desalinated water under the test conditions. The pilot plant study report projects an energy usage equivalent to 5,320 kilowatts-hour per acre-foot of water produced for the full-scale facility; this level of energy consumption is at the high-end of the range for these types of facilities (CDWR, 2003).[2]

Absent from the pilot plant study report is an explicit analysis of the permeate characteristics and the required post-treatment stabilization that would likely be required for a full-scale facility. This shortcoming has been brought to the attention of the Brownsville Public Utilities Board and will be addressed as part of the final report acceptance process. In the meantime, the projections for the full-scale facility include provisions (contact basins and chemical dosing facilities) for adjusting the permeate's pH prior to distribution.

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[2] Recent work by the Affordable Desalination Collaboration in developing high efficiency seawater reverse osmosis processes has lowered the energy consumption to a range between 1,900 to 3,900 kilowatt-hour per acre-feet of water produced. Although this range does not account for transmission and other energy demands, it is nevertheless and indication of upcoming and improved practices (MacHarg, 2007).

The Brownsville Public Utilities Board performed computer modeling of the concentrate discharge method recommended in the 2004 feasibility study and determined that this means of disposal is feasible and free of environmental impacts. However, additional, more detailed modeling and environmental impact studies will need to be conducted as part of the permitting process for a full-scale project.

Project development
Goal: Examine funding mechanisms, including federal/state legislative appropriation and/or the need for changes to existing funding programs; develop alternatives for the most cost-effective manner to implement the project; and explore inclusion of other customers in the Lower Rio Grande Valley.

Results: Concurrent with the plant study, the Brownsville Public Utilities Board implemented an outreach program to demonstrate its commitment to implementing a large-scale seawater desalination plant. Its efforts included meetings with neighboring utilities, providing tours of the pilot plant to elected officials, meeting with funding agencies and exploring options for implementing the full-scale project.

Implications for the large-scale seawater desalination plant in Brownsville

In its long journey to the Gulf of Mexico, the Rio Grande is consumed, depleted, replenished, stored, and reused. Shortly before it reaches its final destination in the Gulf of Mexico, the Brownsville Public Utilities Board is entitled to draw its share from the river.

Currently, the Rio Grande accounts for 78 percent of the Brownsville Public Utilities Board’s water supply. However, the river is over allocated, has a history of treaty compliance issues with the Republic of Mexico, and is vulnerable to recurring droughts. In times of crises, water users have relied on shifting water from agricultural to municipal uses. As water demand continues to grow, the questionable reliability of this source constitutes a strategic threat to Brownsville and helps explain the Brownsville Public Utilities Board’s - and the Rio Grande Regional Water Planning Group’s - drive to strengthen its water supply through diversification, including desalination.

By successfully implementing the Southmost Regional Water Authority’s Brackish Groundwater Desalination Treatment Plant (Southmost), the Brownsville Public Utilities Board has already made its mark as a leader in developing water desalination supplies in

Texas. Southmost has a production capacity of 7.5 million-gallons-per day and, depending on aquifer sustainability, can be expanded to 12.5 million gallons per day. Increasing the production capacity of Southmost and/or modernizing old surface water treatment plants are viable and affordable options to meet Brownsville's projected water demand growth. However, none of these options would have the long-term, drought-proof reliability of a seawater desalination supply.

Seawater desalination is more costly; therefore, Brownsville's deliberations on seawater desalination have focused on its additional financial requirements as compared to more conventional options. Toward this end, the Brownsville Public Utilities Board has issued two reports addressing the issues of cost and ability to fund a large-scale seawater desalination facility.

In November 2006, the Brownsville Public Utilities Board provided a preliminary update to the cost of the proposed full-scale facility (25 million-gallons-per day), estimating the cost of the project at $150 million. In the report, they would require a combination of grants and low interest loans to finance the project. The report acknowledged the fact that customers of the Brownsville Public Utilities Board could be served by other less expensive, albeit more vulnerable, options (BPUB, 2006b).

The TWDB's 2006 Biennial Report on Seawater Desalination included the Brownsville Public Utilities Board's recommendation that the Texas Legislature consider appropriating funds to narrow the funding gap and encouraged the more expeditious implementation of a 25 million-gallon-per-day seawater desalination plant in Brownsville (TWDB, 2006). The 80th Texas Legislature did not award additional funds for seawater desalination grants but did fund the Water Infrastructure Fund, which may provide financing for desalination projects recommended as water management strategies in regional water plans.

In June 2008, nearing the completion of the pilot plant study, the Brownsville Public Utilities Board provided a revised project cost of $182.4 million. Part of the cost increase reflected the rising costs of materials and construction, but it was also the result of the recommendation arising out of the pilot plant study to add an additional layer of pretreatment to the process. The Brownsville Public Utilities Board reiterates that it would need a substantial portion of grants and low interest loans in order to implement a full-scale plant (BPUB, 2008a).

The financial requirements to implement seawater desalination in Texas, regardless of the site, are challenging. During the biennium, the Brownsville Public Utilities Board met with the U.S. Army Corps of Engineers, Bureau of Reclamation, members of the Texas congressional delegation in Washington, D.C. and TWDB to explore financial assistance programs and mechanisms that could be applied to the Brownsville project. These efforts confirmed the sense that it would be extremely difficult to obtain grant financial assistance to enable Brownsville to build a 25 million-gallon-per-day facility in the near future.

Nevertheless, the Brownsville Public Utilities Board is committed to further diversifying its water supply sources by adding seawater desalination to its portfolio and will continue advancing the development of seawater desalination supplies. Toward this end, the Brownsville Public Utilities Board is looking for ways to increase its funding options for the project and to implement it within its customers' ability to pay.

Brownsville Public Utilities Board's current proposal is to pursue a phased approach, starting with a 2.5 million-gallon-per-day production and demonstration facility and eventually expanding into the full-scale 25 million-gallon-per-day facility as originally envisioned. This proposal is summarized in the following section and is expanded in Appendix C.

Proposal: A 2.5 million-gallon-per-day production and demonstration seawater desalination plant

The pilot plant study provided a quantitative measure of the challenges involved in desalinating ocean water from the Brownsville Ship Channel. The study clearly demonstrated that drinking water can be produced from seawater drawn from the Gulf of Mexico by means of reverse-osmosis desalination. The information gained about source water turbidity and level of organic matter resulted in the recommendation to provide an intake designed to mitigate ship traffic impacts on the source water quality and an additional layer of (conventional) pretreatment.

Additional testing could provide a more reliable means for projecting the costs of a full-scale facility. However, rather than investing in continued piloting efforts, it might be more useful and efficient to apply those efforts to achieving sustainable drinking water production at a relatively smaller-scale facility than the originally proposed 25 million-gallon-per-day plant.

By building a smaller 2.5 million-gallon-per-day plant initially, the Brownsville Public Utilities Board is seeking to lower the financial impact to its customer base while at the same time setting the stage to facilitate access to greater seawater desalination supplies in the future as demand increases. Figure 8 illustrates the proposed phasing of the seawater desalination supply and its impact in the overall water supply system.

As detailed in Appendix C, the Brownsville Public Utilities Board proposes implementing a production and demonstration facility with a drinking water production capacity of 2.5 million gallons per day at a capital cost of $67.5 million. The estimated cost includes over-sizing the raw water intake and the concentrate discharge facilities to accommodate the eventual production capacity expansions of up to 25 million gallons per day. Approximately $31.1 million or 46 percent of the projected cost corresponds to future capacity.

The proposed feed water intake will consist of a side canal located off the south bank of the Brownsville Ship Channel; it will be designed to transport a minimum of 50 million gallons per day, the feed required for a 25 million-gallon-per-day operation. The proposed location and type of intake will buffer the impact of ship traffic on the feed water quality.

The proposed facility will include two pretreatment trains. One will consist of a microfiltration pretreatment and the other will be a conventional rapid-mix flocculation and clarification unit followed by a microfiltration unit. The Brownsville Public Utilities Board anticipates that this additional layer of proposed pretreatment will allow the microfiltration unit to operate more efficiently and effectively. The Brownsville Public Utilities Board proposes to allow the ongoing bench testing or piloting of other pretreatment schemes and technology demonstrations.

The disposal of the concentrate is proposed as an open ocean diffused discharge designed to initially dispose about 3.5 million gallons per day of concentrate at a depth of 8 feet, approximately 0.5 mile offshore. The 14.2 miles of pipeline for the concentrate will be installed in a 40 foot-wide easement to accommodate future installation of parallel disposal pipelines, when necessary.

The Brownsville Public Utilities Board proposes to fund the project by securing loans and grant financial assistance from the state, as follows:

Table 2 - Proposed funding sources for 2.5 million-gallon-per day facility

Loan from the Water Infrastructure Fund	$20,000,000
State Participation Program [Oversized intake and easement for disposal system]	$19,279,000
State legislative appropriation (grant)	$28,200,000[3]
Total	$67,479,000

Excluding the portion of the cost attributable to future capacity ($31.1 million or 46 percent), the capital cost for the 2.5 million-gallon-per day facility is estimated at $36,438,660. Although the equivalent capital cost on a per 1,000-gallons basis will depend on the final funding arrangements, assuming a 3 percent interest and a 25-year payback period on capital, the equivalent capital cost is $2.29/1,000 gallons. The Brownsville Public Utilities Board estimates the operation and maintenance at $2.80 per 1,000 gallons with power costs estimated at 6¢ per Kilowatt/hour[4]. Therefore, the estimated production cost for the 2.5 million-gallon-per-day demonstration project would be $5.09/1,000 gallons.

If the requested grant of $28,200,000 is secured and the interest and principal payment on the State Participation component of the debt is not assessed on the project's initial phase, the actual cost of water for the retail customer would be $3.32/1,000 gallons.

The Brownsville Public Utilities Board proposes to begin design, permitting and environmental studies in 2009 and to complete the first phase by 2012. As shown below, the plant's capacity would increase to 12.5 million gallons per day in 2025 and to full capacity in 2050.

[3] The Brownsville Public Utilities Board proposes to spend $12,472,000 of the requested grant during the 2010-2011 biennium and $15,728,000 during the 2012-2013 biennium (BPUB, 2008b).

[4] At 6¢ per Kilowatt/hour, 38 percent of the unit cost of water or $1.05/1,000 gallons corresponds to power costs.

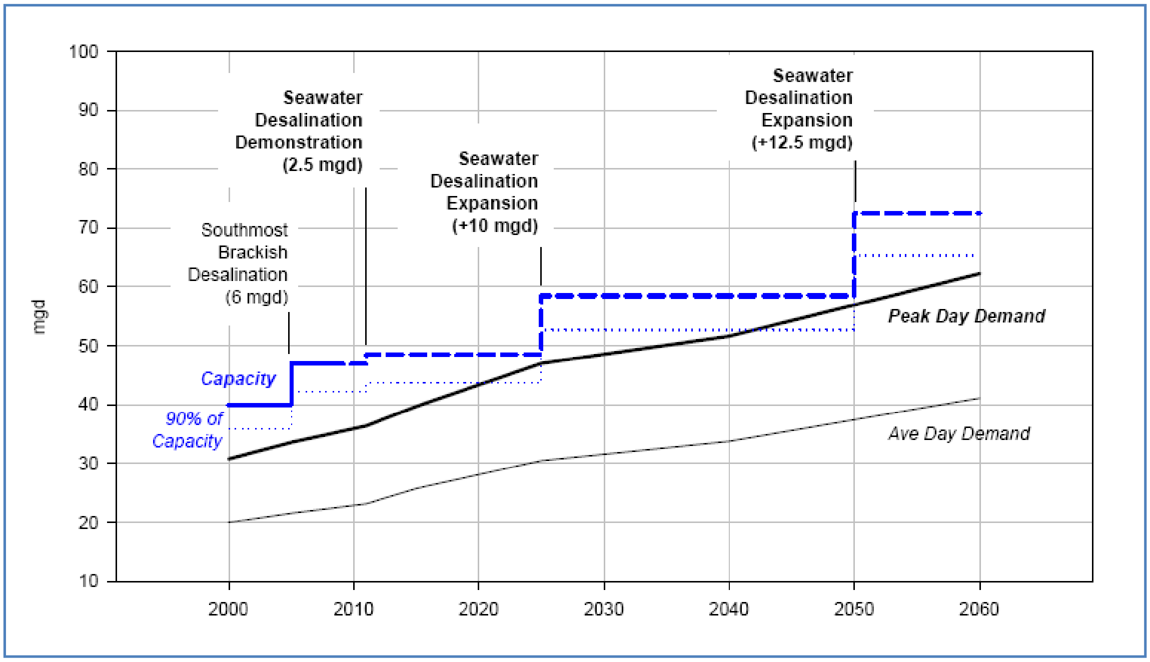

Figure 8 - Demand growth and water supply for the Brownsville system

Conclusion

The pilot plant study provided the Brownsville Public Utilities Board with sufficient information to prepare a pre-design cost estimate of the 25 million-gallon-per-day seawater desalination plant. The projected cost of the facility is $182.4 million.
The Brownsville Public Utilities Board has indicated that to execute the full-scale project today, it would require grant funding assistance in excess of $100 million. Securing that level of financial assistance does not seem feasible.

The Brownsville Public Utilities Board assessed its need for additional water supplies and confirmed its commitment to add seawater desalination to its water supply portfolio. The proposal to implement a first phase consisting of 10 percent of the project's ultimate capacity would require a lesser and more viable level of financial assistance.

By implementing a drinking water production facility equivalent to 10 percent of the originally proposed large-scale facility, the Brownsville Public Utilities Board and the State of Texas can gain experience with a full testing of the permitting process for a seawater desalination drinking water facility, including the environmental reviews necessary for permitting ocean discharge of the concentrate. This facility will allow for additional refinements to the treatment process and/or testing of additional and potentially cost-saving measures.

The proposed 2.5 million-gallon-per-day production facility would provide the state with a tangible test case to demonstrate and advance the development of seawater desalination in Texas.

B. *Other activities undertaken during the 2006-2008 biennium*

South Padre Island pilot plant study

In July 2006, TWDB awarded a regional water facility planning grant to the Laguna Madre Water District to reassess the feasibility of seawater desalination and implement a seawater desalination pilot plant study.

The Rio Grande Regional Water Plan included seawater desalination as a recommended water management strategy to meet future water needs for the Laguna Madre Water District. The proposed full-scale facility will have a production capacity of 1 million gallons per day.

Earlier this year, the Laguna Madre Water District completed the installation of the pilot plant and constructed an open sea intake located 1,500 feet from shore. The intake transmission line was installed by horizontal drilling, which minimized any potential aesthetic impact to the shore.

The Laguna Madre pilot plant is in its initial testing phase and will be operated for a 6-month period.

Figure 9 - Barge installing open ocean intake off South Padre Island and transmission pipe

This project is far less complex than the Brownsville Seawater Desalination Plant: it can be accomplished with off-the-shelf equipment, the source water likely will be of better quality than that at the Brownsville Ship Channel, and its intended production volume and location allow for less involved concentrate disposal options. Nevertheless, this effort is important to the overall seawater desalination initiative because it will provide data on open ocean water quality and on the performance of reverse osmosis desalination under different conditions from those evaluated for the Brownsville project.

Concentrate discharge modeling

In coordination with the Bureau of Reclamation, TWDB offered a training workshop in 2007 to examine options for linking near- and far-field mixing zone modeling for concentrate discharges in coastal waters. TWDB extended invitations to consultants, university researchers, and staff of the Texas Commission on Environmental Quality. Workshop participants received training in the use of CORMIX, a computer program for modeling concentrate discharges.

TWDB staff used this modeling to assess the hydraulics of discharging the concentrate from the proposed first phase of the Brownsville Seawater Desalination Plant directly into the Brownsville Ship Channel through an array of diffusers. The preliminary findings indicate that an appropriately designed discharge would disperse the concentrate to ambient salinity levels within a very small area, estimated at 125 feet radius from the discharge point.

An assessment of environmental impacts would be required to determine the viability of this potential concentrate discharge option for the proposed first phase of the Brownsville project.

Other efforts

Web page

TWDB maintains a desalination Web page with information on its seawater and brackish groundwater projects. Since the launch of the new Web site in October 2006 until the end of September 2008, a total of 47,395 visitors had accessed the desalination site. The information posted on the Web site includes links to all current and past studies on desalination, reports submitted to the Texas Legislature, and other desalination-related resources.

Presentations

During the biennium, TWDB has made numerous presentations on seawater desalination to stakeholder groups, trade organizations, conferences, university research departments, and one presentation before the National Academy of Sciences Committee on Advancing Desalination Technology.

Cooperation with research organizations

Since 2003, a TWDB staff member has participated actively as a board member of the South Central Desalination Association, a non-profit trade organization focused on promoting the use of membrane water treatment by assisting with technology transfer workshops and operator training in Texas.

Also during the biennium, TWDB staff participated as a member of a WateReuse Foundation project advisory committee in a study to explore the value of reliability benefits for reuse and desalination projects (WRF, 2008).

In 2008, a TWDB staff member was awarded the International Desalination Association's First Fellowship Award. The fellowship provides an opportunity to receive hands-on training at the Singapore Public Utilities Board desalination and water reuse facilities.

Other research activities

In July 2008, TWDB awarded a research grant to assess osmotic mechanisms pairing desalination concentrate and wastewater treatment applications. This is an emerging technological issue that could potentially improve the economics of seawater desalination and water reclamation from wastewater flows.

2009 Pre-conference Workshop of the American Membrane Technology Association

The 2009 annual conference of the American Membrane Technology Association will be held in Austin, Texas in July. TWDB staff is coordinating with the South Central Membrane Association, Bureau of Reclamation and the Texas Commission on Environmental Quality to organize a pre-conference workshop focusing on government-funded research products on desalination, reuse and membrane water treatment.

III. TWC 16.060(b) (2) Impediments to Seawater Desalination

Texas Water Code Section 16.060(b) (2) requires this report to address impediments to implementing seawater desalination projects. TWDB considered research, regulatory, technical, and financial challenges to implementing the current proposals for large-scale seawater desalination projects.

There are important challenges to installing a large-scale demonstration seawater desalination project in Texas and to ensuring the most benefit to the state from this pioneering effort. Along with the challenges are opportunities to advance the development of water technologies, improve project delivery methods, and create effective project funding mechanisms that facilitate new, cost-effective supplies from seawater desalination.

Financial viability is the greatest challenge to developing large-scale seawater desalination supplies, whether as a means to provide the next increment of water supply needed or as a substantial insurance tool to drought-proof water supply portfolios along the Texas Gulf Coast or, in some cases, upstream from the coast.

A clear example of the financial challenges to implementing seawater desalination is the proposed funding package for the initial phase of the Brownsville Seawater Desalination Project. The package consists inclusively of three essential components: a grant, State Participation Program Funding and Water Infrastructure Funding. Securing each one of these funding elements will be challenging, and yet necessary for this project to go forward. In addition to the grant component of this financing package, current demands for the State Participation Program Funding and Water Infrastructure Funding will further challenge the successful implementation of this project.

A. Financial

Based on their current financial capabilities, Brownsville's customers cannot by themselves bear the financial burden of implementing a 25 million-gallon-per-day facility today.

The Brownsville Public Utilities Board, with its proposal to implement an initial phase of 2.5 million gallons per day, is striking a balance that will allow it to lessen the financial impact of developing seawater desalination supplies while gaining a foothold in the seawater desalination strategy that could be expanded as demand grows. To compensate for the loss in the economy of scale, Brownsville's current proposal is to size the intake and discharge facilities to meet the needs of the eventual capacity. The project's full capacity will be needed by 2050 or earlier if additional demands from neighboring systems can also be served from the project.

The Brownsville Public Utilities Board proposes to apply for financial assistance in the form of loans from the Water Infrastructure Fund, from State Participation funding for those portions of the project scaled for future capacity, and for a grant in the amount stipulated in the current TWDB Legislative Appropriations Request for Fiscal Years 2010-2011, $28.2 million.[5]

The grant component is contingent on appropriations by the 81st Texas Legislature. Both the State Participation Program and the Water Infrastructure Fund components require additional legislative appropriations as well as successful prioritization by the TWDB in awarding funds from these accounts. In the absence of a clear legislative priority for State Participation or Water Infrastructure Funds, this project will need to compete with other projects.

The Brownsville Public Utilities Board proposal assumes that interest and principal from the State Participation funding will be deferred to a time when the financial capabilities of Brownsville would allow full repayment of the State Participation loan. The State Participation Program has been successfully employed in the past to encourage the development of a <u>facility</u> to its optimum economic and hydrologic capacity. Through the program, the state purchases an interest in the <u>facility</u> equivalent to the excess or future capacity and holds onto this excess capacity until it is needed.

Seawater desalination, which approaches economy of scale benefits at design capacities between 15 to 25 million gallons per day, challenges this concept in that a desalination plant operates from the start at or near 100 percent capacity. A possible answer to this challenge is to revise the State Participation Program to clarify that it may be used to purchase the excess capacity created in the <u>system</u> by the optimum development of a project.

In that case, the program could purchase interest in a system where a large-scale seawater desalination project operating at or near 100 percent of its design capacity creates an

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[5] The Brownsville Public Utilities Board proposal would disburse the requested grant over the FY 2010-2011 and FY 2012-2013 biennia.

optimum degree of system-wide excess capacity for the future. Although this might not be an option for Brownsville, it may be a useful tool to explore and apply to future large-scale seawater desalination projects.

B. Research

Research is a prime example of challenges leading to opportunities.

For the last decade and a half, water desalination has been increasing its market share, thanks, in great part, to the dramatic technological improvements in reverse-osmosis desalination. Research continues, and there is a reasonable expectation that these efforts will lead to new technologies and substantive improvements to existing ones, such as lower energy requirements for membrane-based water desalination and improved membranes.

The pace of research and the proliferation of technology options can be challenging to the average water utility, as new products may render existing ones semi-obsolete or at least not as cost effective. One way to manage this challenge to a beneficial outcome is to create effective opportunities for researchers and equipment manufacturers to team up in the technology development process.

The Singapore Public Utilities Board is an example of how these types of challenges can be creatively managed to maximize benefits. By actively partnering with the research community and engaging equipment manufacturers to bench test or pilot test their inventions at the utility's facilities, the Singapore Public Utilities Board is actively involved in evaluating cutting edge technology which can then be more easily incorporated, resulting in advances to their own water treatment processes.

For example, during a recent visit to the Bedok NEWater Treatment Plant, the Singapore Public Utilities Board's flagship water reuse treatment facility[6], TWDB staff observed several pilot and bench-scale testing operations that were being conducted at the plant by equipment manufacturers and/or engineering consultants in coordination with utility staff. These tests included, for example, long-term evaluation of advanced flow distributors for regular and large diameter reverse osmosis membranes, a technology that could improve the efficiency of reverse osmosis membrane filtration by ensuring that a broader portion of the membrane is used in the salt separation process.

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[6] A TWDB staff member visited the Singapore Public Utilities Board facilities in July 2008 as part of a fellowship award by the International Desalination Association.

The TWDB Seawater Desalination Initiative and the proposed large-scale Brownsville Seawater Desalination facility provide a unique opportunity to create and demonstrate similar cooperative processes in Texas. Examples of this could be testing and demonstrating a chlorine resistant membrane recently developed by researchers at the University of Texas and of large-diameter membranes similar to those demonstrated in Singapore.

C. Regulatory

A practical goal of the Seawater Desalination Initiative is to produce a complete and fully operational seawater desalination project to serve as a reference in the permitting processes. A large-scale project that completes the full project development cycle from the concept phase through the operational phase would set an example and provide guidance on key regulatory issues. Two examples of these issues are pilot testing for future seawater desalination facilities and concentrate disposal.

Currently, a 90-day pilot testing period is required by the Texas Commission on Environmental Quality for any innovative water treatment technology. Ninety days may, however, be an insufficient period to adequately test seawater desalination operations. Based on desalination industry practices, pilot testing for seawater desalination is recommended for at least a 12-month period to better assess the sustainability of operations under seasonal climate and water quality variations (Reiss, 2004). In the case of the recently completed pilot plant study at Brownsville, the study lasted 18 months. TWDB will examine this matter further with the Texas Commission on Environmental Quality and determine if it might be appropriate to extend the 90-day requirement for seawater desalination.

Similarly, existing regulatory guidance on ocean disposal of desalination concentrate has not been tested. Although the preliminary review and computer modeling conducted as part of the Brownsville Seawater Desalination Pilot Plant Study indicates that ocean discharge is technically feasible and environmentally safe, the lack of a precedent for the permitting process is a challenge and could potentially increase the cost of seawater desalination studies and projects.

D. Technical

Although the Brownsville Public Utilities Board has already made its mark in the use of water desalination technology by successfully implementing the Southmost Regional Water Authority Brackish Groundwater Desalination facility, the seawater desalination project constitutes an entirely new challenge.

The pilot plant study addressed a critical need for information regarding the level of pretreatment required for reverse osmosis desalination of ocean water at the Brownsville Ship Channel. However, Brownsville Public Utilities Board has identified several important issues that will need to be addressed in the permitting and operation of the proposed initial phase of the seawater desalination facility; these include the following:

- Environmental studies to ensure that disposing of the desalination concentrate by diffused dispersion can be accomplished in an environmentally safe manner;
- Evaluate the option of interim disposal of desalination concentrate in the Brownsville Ship Channel;
- Assess the actual need for permeate stabilization prior to its delivery to the Brownsville distribution system;
- Assess the actual operating efficiency of the water treatment processes under improved intake and pretreatment conditions (once operation of the 2.5 million-gallon-per day facility begins); and
- Determine whether use of chemical pretreatment (biocides) would be necessary to deter biofouling of the reverse osmosis membranes.

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IV. TWC 16.060(b) (3) Role of the State

Texas Water Code Section 16.060(b) (3) requires this report to evaluate "the role the state should play in furthering the development of large-scale seawater desalination projects in the state."

Section 16.060 of the Texas Water Code defines the role of the Texas Water Development Board in regard to seawater desalination:

> "The board shall undertake or participate in research, feasibility and facility planning studies, investigations, and surveys as it considers necessary to further the development of cost-effective water supplies from seawater desalination in the state."

The leadership and vision of Governor Rick Perry and the Texas Legislature have made it possible to propel seawater desalination from a basic idea to a viable proposal to implement the first phase of a full-scale seawater desalination project.

In 2003, the 78th Texas Legislature directed TWDB to fund seawater desalination feasibility studies ($1.5 million) and, in 2005, the 79th Texas Legislature appropriated $2.5 million for seawater pilot plan studies. The request before the 81st Texas Legislature is to consider appropriating $28.2 million in grant funds to assist the Brownsville Public Utilities Board realize the first phase of the 25 million-gallon-per-day seawater desalination plant.

The state's role for the next biennium is to continue supporting the development of the Brownsville Seawater Desalination Project because it will serve as a production and educational prototype aiding in the development of other large-scale seawater desalination projects along the Texas Gulf Coast. With state support, the Brownsville Public Utilities Board could begin construction of the facility as early as 2010.

Although the immediate role of the state is to assist in completing the first large-scale seawater desalination project, the broader task is to ensure that this effort is of benefit to other areas of the state with interest in developing new water supplies from seawater desalination. Therefore, one role for the state is to continue assessing opportunities to assist in the development of seawater desalination supplies.

An undeniable benefit of seawater desalination in Texas is that it would provide an entirely new and abundant drought-proof water supply. Assessing the economic benefits of regional-scale seawater desalination supplies and developing—or clarifying—financial mechanisms to pay for excess capacity are activities that need to be implemented under the state's leadership. The state may do so through the regional planning process or by soliciting research proposals under the TWDB's Research and Planning Program.

TWDB's approach to implementing the Seawater Desalination Initiative has won it recognition from state, national, and international desalination researchers and organizations focused on promoting cost-effective desalination practices. For example, in 2006, TWDB was ranked number three in the Global Water Intelligence survey of top water agencies in the world for its role in implementing the Seawater Desalination Initiative. The TWDB's Innovative Water Technologies Programs are specifically recognized in the desalination community as both a source of information and a potential research collaborator.

Therefore, TWDB should continue its educational and outreach efforts to assist in the development of alternative water supplies from seawater desalination.

V. TWC 16.060(b) (4) Anticipated Appropriation

Texas Water Code Section 16.060(b) (4) requires this report to address the "anticipated appropriation from general revenues necessary to continue investigating water desalination activities in the state during the next biennium."

The Brownsville Public Utilities Board is proposing to implement the first phase of the large-scale demonstration seawater desalination project. Table 3 is a reproduction of Table ES-2 in Appendix C, Executive Summary of the Pilot Plant Study Report, and provides a cost breakdown and the proposed funding strategy for this initial phase of the project.

Table 3 - Summary of uses and sources of funds for first phase

		Biennium	
	Total	2010-2011	2012-2013
Use of Funds			
Design Determination Studies	$2,967,000	$2,967,000	-
Environmental Review and Permitting	$1,079,000	$1,079,000	-
Final Design and Specifications	$5,935,000	$5,935,000	-
Construction Support Services	$2,698,000	-	$2,698,000
Start-up Support Services	$846,000	-	$846,000
Construction	$53,954,000	$10,791,000	$43,163,000
Total Uses of Funds	$67,479,000	$20,772,000	$46,707,000
Percent of Total	100%	31%	69%
Sources of Funds			
BPUB Loan From WIF	$20,000,000	$8,300,000	$11,700,000
State Grant	$28,200,000	$12,472,000	$15,728,000
Federal			
State Participation Program	$19,279,000	-	$19,279,000
Total Sources of Funds	$67,479,000	$20,772,000	$46,707,000

Source: Brownsville Public Utilities Board

TWDB included an exceptional item request in the Legislative Appropriations Request for Fiscal Years 2010–2011 for $28,200,000 in grants for the Seawater Desalination

Initiative. The Brownsville Public Utilities Board budget implies that a portion of the requested appropriation, if granted, will need to be carried out to the Fiscal Years 2012–2013 biennium.

Also, Water Infrastructure Fund bonds issued would require additional general revenue appropriations of $715,900 for the 2010-2011 biennium and $3,441,014 for the 2012-2013 biennium. State Participation bonds issued would require additional general revenue appropriations of $3,311,459 for the 2012-2013 biennium. In addition, ongoing general revenue appropriations would be required for the bonds issued under both of these programs.

The request will enable TWDB and the Brownsville Public Utilities Board to install a 2.5 million-gallon-per-day permanent production facility to demonstrate and continue finessing the process of desalting ocean water from the Brownsville Ship Channel. This proposal would not only provide a direct benefit to the Brownsville Public Utilities Board, by giving it access to a drought-proof water source, but it would also provide continuity to the state's interest in identifying and addressing risks and challenges related to the wide-scale development of seawater desalination supplies.

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VII. Appendices

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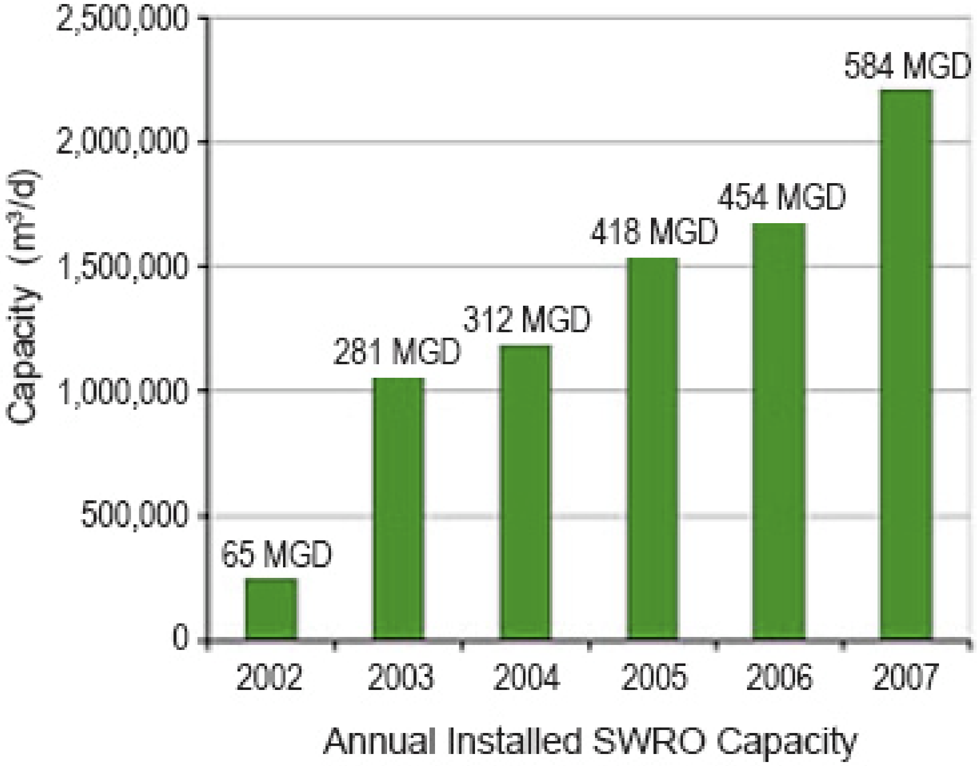
A. A brief overview of the state of the desalination industry[7]

Seawater desalination has had a compound annual growth rate of 55 percent globally over the past five years to a total installed capacity of more than 10.3 billion gallons per day. Nowhere has this growth been more dramatic than in Australia where the country's installed capacity will increase from zero in 2005 to 373 MGD by the end of 2011.



The state–owned Water Corporation of Western Australia began a feasibility study for the 38 MGD Perth Seawater Desalination Plant in 2001 and by 2006 the facility was producing 17 percent of Perth's water supply, winning the 2007 Global Water Award for Desalination Plant of the Year, and setting the world standard for environmentally–responsible seawater desalination. The Water Corporation is now building their second seawater desalination plant.

After some initial start-up problems, the United State's first seawater desalination plant in Tampa has now been fully operational for almost one year and a second large–scale seawater

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[7] By Tom Pankratz, Editor, Water Desalination Report and member of the board of directors of the International Desalination Association.

desalination plant has been permitted in the Carlsbad, California, setting the stage for several more plants that are in the permitting process.

Feasibility or pilot studies are currently underway for up to ten more plants in California, three in Florida, and plants in Georgia, New York, Massachusetts and Rhode Island.

The interest in seawater desalination is the result of several factors:

Technological developments

The advances in reverse osmosis technology are generally considered to be the most significant reason desalination’s growth outside the Middle East, where thermal desalination is integrated in the steam cycle of an electric power generating plant. When reverse osmosis plants are built as stand-alone facilities and are far more energy–efficient and environmentally–friendly than their thermal distillation counterparts.

Volumes have been written on the advances in reverse osmosis membrane and pretreatment technology and the improvements in energy efficiency that have taken place over the last eight to ten years. Other incremental improvements in materials of construction, pump technology and instrumentation and controls have helped bring the cost of seawater desalination down to a point where it has become competitive with traditional water supplies in many areas.

Even as these new technological improvements are being introduced and put into practice, research continues to look at new ways to improve membrane performance, lower energy requirements and mitigate potential environmental impacts.

Adaptation of the Portfolio Theory

Many growing communities are finding their traditional groundwater and surface water supply sources unsustainable or unreliable, and are considering options to increase and diversify their water supply portfolios. While importation may be an option in some cases—although costs to construct pipelines and pump water continue to rise—it leaves communities dependent on a distant supplier.

Water planners now consider seawater desalination as a new ‘local’ water source, providing a reliable, drought-proof hedge against the possible disruption or that could result from an extended drought, the isolation from a remote supply, or a political or economic disagreement.

Environmental Issues

A recent United Nations Environmental Environment Program (UNEP) report concluded that, "There seems to be little reason to object to a desalination project when a clear need has been established and when the facility is carefully regulated and monitored."

Until the late 1990s, details on the environmental impact of seawater desalination plants have largely been anecdotal and supported with little scientific evidence. Because so many early plants employed thermal desalination technologies and were co-located with electric power plants, focus was placed on the power plant and the impact of the desalination facility was largely disregarded.

As plants more and larger plants are being built where they were not previously considered, there is increased emphasis being placed on their potential environmental impacts. Because most plants are being constructed as stand-alone facilities, they face growing environmental scrutiny. Virtually every new plant is preceded by a rigorous environmental assessment, and designed to mitigate all potential environmental impact in addition to considering possible socio-economic, cultural and human health implications of desalination activity.

One example of changing environmental climate is evident in the restrictions placed on seawater intakes and outfalls. All seawater intakes must be designed to minimize marine life impingement and entrainment, while the discharge systems must ensure the rapid assimilation of saline concentrate into the ocean so as not to adversely impact marine flora and fauna.

In some locations, seawater desalination may provide a benefit by helping to preserve the environmental flows of sensitive rivers or creeks that might otherwise become a water supply source.

Public-private Partnerships

Seawater desalination plants are one of most complex and expensive infrastructure projects that most communities will ever undertake and they have significant development, permitting, construction, scheduling and operational issues. To help mitigate these potential risks, almost every seawater desalination plant around the world now employs an alternative project delivery method to shift the risk responsibilities to the team member best qualified for their management.

Private sector participation can range from delivering a project on a design/build basis to financing the entire facility, or operating the plant on a long–term basis. Project delivery models are available to suit virtually every imaginable set of circumstances, and usually credited with reduced construction costs of up to 20 percent of the project costs.

Long-term water supply contracts typical of public-private partnerships also facilitate budgeting and usually lead to rate stabilization by providing a predictable revenue steam that more closely represents the cost of production.

Success

The global success of seawater reverse osmosis installations over the past eight years has demonstrated its viability as reliable fresh water supply alternative for many coastal locations.

B. Chronology and milestones of the Seawater Desalination Demonstration Initiative

Chronology and milestones of the Seawater Desalination Demonstration Initiative

Date	Event
4/29/2002	Governor Rick Perry, Press Release, Announcement in San Antonio on securing abundant water supplies for Texas' future needs.
5/14/2002	TWDB considers and approves plan to develop recommendations for large-scale demonstration seawater desalination.
7/17/2002	Workshop with chairs of Regional Water Planning Groups to set criteria for selecting sites and proposals for seawater desalination.
8/21/2002	TWDB issues a request for Statements of Interest for public and private entities to submit proposals for developing of a large-scale demonstration seawater desalination project.
10/4/2002	TWDB Demonstration Seawater-Desalination Project—Request for Statements of Interest, published in the Texas Register.
11/1/2002	Ten responses to TWDB's request for Statements of Interest.
12/11/2002	TWDB approves "Large-Scale Demonstration Seawater Desalination in Texas"—TWDB Report of Recommendations for the Office of Governor Rick Perry. The report identifies the three proposals with the highest potential for developing demonstration seawater desalination projects: Poseidon Resources and Brazos River Authority, City of Corpus Christi, and Port of Brownsville and the Brownsville Public Utilities Board.
5/15/2003	Governor Rick Perry signs into law HB 1370 by Representative Vilma Luna amending TWC 16.060, which directs TWDB to take all necessary actions to develop seawater desalination supplies. The 79th Texas Legislature directs TWDB to fund $1.5 million in feasibility studies for the three recommended sites.

Date	Event
9/17/2003	TWDB authorizes staff to negotiate and execute contracts with the Brazos River Authority, the Brownsville Public Utilities Board, and the City of Corpus Christi in an amount not to exceed $1,500,000 (total) for grants to prepare regional water facility plans focusing on seawater desalination projects. The studies were to conduct feasibility and regional water facility planning studies, determine the technical and economic viability of demonstration seawater desalination projects in Texas, and identify the users for the proposed projects and the benefits and costs of creating additional drought-proof water supply sources based on seawater desalination at a scale of 25 million gallons per day per project.
11/1/2004	Brazos River Authority, the Brownsville Public Utilities Board and the City of Corpus Christi complete Feasibility Studies.
12/1/2004	TWDB approves 2004 Biennial Report on Seawater Desalination. It recommends that the state continue advancing toward implementing a large-scale demonstration seawater desalination facility in Texas by funding pilot plant studies and formulating state policy regarding the state's role in providing the financial assistance needed for future development of seawater desalination.
05/2005	The 79th Texas Legislature approves TWDB Legislative Appropriations Request for desalination activities, including $2.5 million for up to three seawater desalination pilot plants.
7/18/2005	TWDB approves Desalination Work Plan for the Fiscal Years 2006–07 Biennium.
8/16/2005	TWDB authorizes issuance of a Request for Qualifications from engineering consultants for work related to seawater desalination pilot plant studies and development of large-scale seawater desalination projects in Texas.
10/18/2005	TWDB authorizes staff to negotiate a contract with Reiss Environmental, Inc. to perform work related to seawater desalination pilot plant studies.
12/1/2005	TWDB and Reiss Environmental, Inc. develop a research application checklist for seawater desalination studies.
3/10/2006	Brownsville, Corpus Christi, and Brazos River Authority file applications for financial grant to conduct seawater desalination pilot plant studies.

Date	Event
4/17/2006	TWDB award Brownsville a $1.34 million grant to implement a seawater desalination pilot plant study.
8/2006	Brownsville Public Utilities Board files an interim progress report updating the cost and financial requirements to implement a 25 million-gallon-per-day facility. Cost: $150 million. Financial grant and low-interest loan assistance needed: $70 million
12/1/2006	TWDB files second Biennial Report on Seawater Desalination
2/27/07	Pilot plant construction completed and begins operations
2/15/08	Brownsville Public Utilities Board authorizes additional $1 million funding for the seawater desalination pilot plant study.
6/2008	Brownsville Seawater Desalination Project, Status Report. Updates cost and financial requirements to implement a 25 million-gallon-per-day facility. Cost: $184 million. Financial grant and low-interest loan assistance needed: $100 million.
8/2008	Brownsville Public Utilities Board files draft Pilot Plant Study Report.

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C. Brownsville Public Utilities Board's proposal for a 2.5 million-gallon-per-day production/demonstration seawater desalination facility

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FINAL Pilot Study Report

Texas Seawater Desalination Demonstration Project

BROWNSVILLE PUBLIC UTILITIES BOARD

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Brownsville Public Utilities Board
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Executive Summary

Pilot Study results have confirmed that seawater desalination at the Brownsville Ship Channel is technically feasible. Although the ship channel presents a challenging water source due to extreme variations in quality (especially turbidity, suspended solids, and temperature), a microfiltration pretreatment system followed by reverse osmosis (RO) adequately treated raw seawater to potable standards. The data and information gained during the Pilot Study is sufficient to develop a full-scale, 25 mgd desalination plant. This design, however, must be conservative (and therefore expensive) to accommodate the raw water variability and probable environmental events, such as red tides and hurricanes, that were not experienced during piloting but are likely under long-term production.

The Brownsville Public Utilities Board (BPUB) therefore proposes to construct a 2.5 million gallons per day (mgd) demonstration-scale seawater desalination plant and research facility at the Port of Brownsville. The proposed Demonstration Project would have several advantages. First, the additional water provided by the demonstration facility will provide 9 percent of the total BPUB demand by 2012, further diversifying their water supply sources. Next, this phased approach will allow for an evaluation of system performance over several years of operation prior to an investment in full-scale capacity. This data is expected to yield a more efficient overall treatment system design and lower the cost of future expansions as they occur. Finally, the demonstration facility will include the capability for continued testing of the latest desalination technologies for this and other future seawater desalination facilities along the Texas coast. Such technologies include applications for pretreatment, energy recovery, sustainable energy supply, and larger (potentially more efficient) membranes.

The total estimated cost for the proposed 2.5 mgd Demonstration Project is $67,479,000. Approximately half of this amount reflects an investment in full-scale capacity infrastructure, such as the intake and concentrate disposal systems. This investment is expected to significantly reduce the costs of future expansions at the facility. BPUB proposes to finance a portion of this project using a $20 million loan from the Texas Water Development Board (TWDB). In addition, implementation of the proposed project will also require supplemental funding in the form of a $28.2 million grant from the State and $19.3 million financed under the TWDB State Participation Fund.

BACKGROUND

In 2004, a Feasibility Study determined that the Lower Rio Grande Valley region would be confronted with a water supply deficit by 2050 and that seawater desalination was a viable alternative (Dannenbaum and URS 2004). Based on data and information available at the time, the Feasibility Study estimated the total probable costs for a full-scale 25 mgd facility to be approximately $152 million. The study recognized that some form of supplemental (grant) funding would have to be provided to bridge the gap between what such a facility would cost and what local utilities could afford to pay. Since that time, substantial increases in the costs for fuel, electricity, steel, and petroleum-based products have been observed.

In 2007, BPUB and TWDB partnered together to implement a seawater desalination Pilot Study. The pilot facility was located on the north shore of the Brownsville Ship Channel on land made available by the Port of Brownsville. The primary purpose of the pilot was to provide an opportunity to evaluate actual performance of proposed water treatment systems under site-specific conditions. Piloting results would then be used to refine the designs and cost estimates for a full-scale (25 mgd) seawater desalination facility. The *Brownsville Seawater Desalination Pilot Project* operated from February 2007 to July 2008, and this Final Pilot Study Report presents its results and recommendations.

PILOT STUDY APPROACH

Two alternative site locations were considered for the pilot facility: Boca Chica Beach (coastal) and the Brownsville Ship Channel (inland approximately 11 miles) (Figure ES-1). Although the raw water quality was expected to be generally poorer at the ship channel site, the pilot facility was located there because of power supply, cost, security, and access considerations. As such, the site represents a worst-case source water quality testing scenario.

Because the objective of a seawater desalination project is to produce potable drinking water from the ocean, the Pilot Study established testing protocols approved by the Texas Commission on Environmental Quality. The performance of each pretreatment and primary treatment (RO) process was then evaluated and documented. The original study scope developed by BPUB and TWDB called for the comparison of two types of pretreatment technologies: 1) conventional (rapid mix/flocculation/clarification/filtration), and 2) ultrafiltration (a membrane-based technology). However, at the outset of the project, BPUB decided to increase the scope and value of the Pilot Study by including two additional membrane-based pretreatment units. The project budget was thereby increased by almost $1.0 million and funded by BPUB. This side-by-side comparison of four different pretreatment technologies resulted in an unprecedented level of study complexity (Figure ES-2).

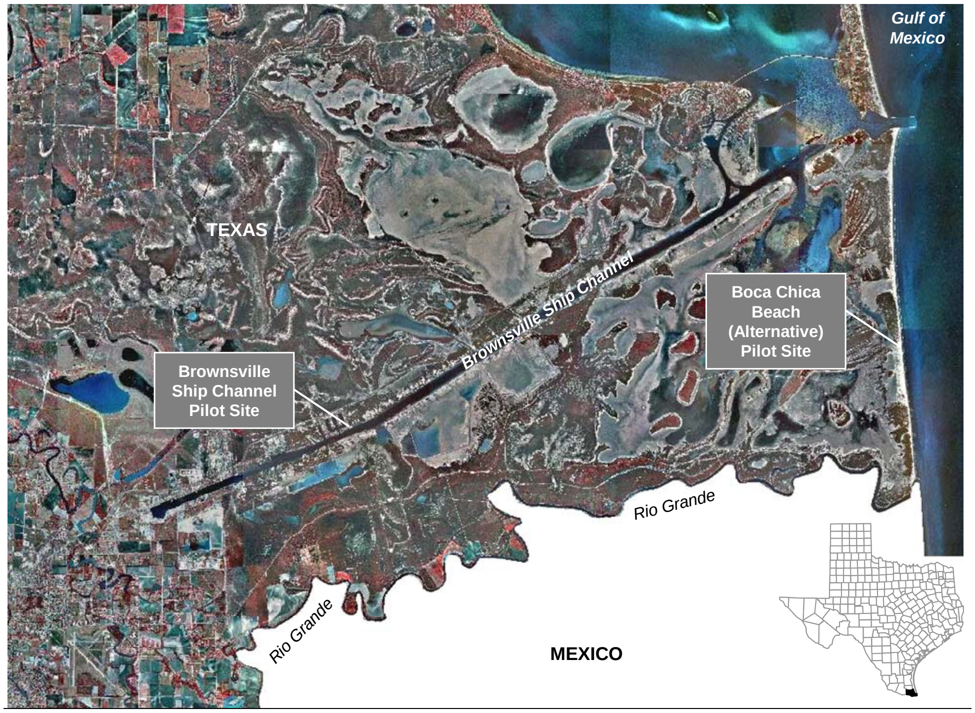

Figure ES-1: Location of the Brownsville Seawater Desalination Pilot Project.

LEGEND

1	Intake
2	Intake pumps
3	Norit ultrafiltration pretreatment unit
4	GE Zenon ultrafiltration pretreatment unit
5	Pall microfiltration pretreatment unit
6	Eimco conventional pretreatment unit
7	Pretreatment filtrate storage tanks
8	Reverse Osmosis treatment
9	Water storage tanks
10	Mixing tanks
11	Lagoon
12	Neutralization tank and discharge point
13	Discharge ditch
A	Chemical storage building
B	Operations building

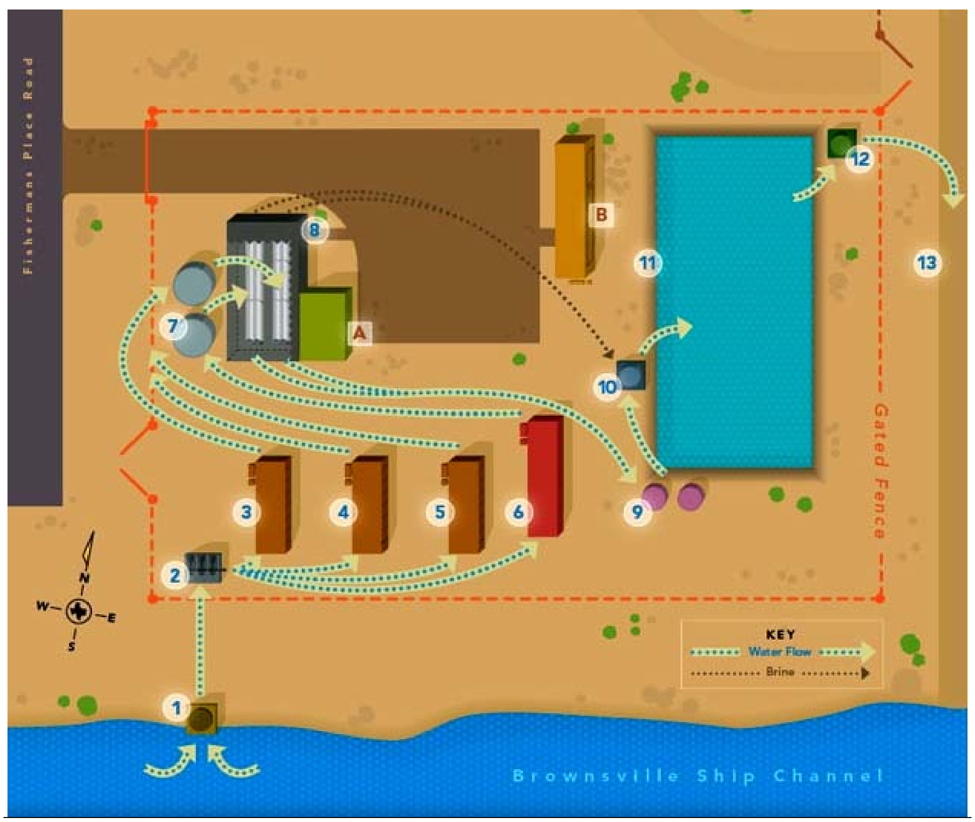

Figure ES-2: Layout of the Brownsville Seawater Desalination Pilot Project.

RESULTS AND CONCLUSIONS

Raw Water Characterization

During the Pilot Study, source water quality was characterized at both potential full-scale site locations, including the inland site on the Brownsville Ship Channel and the ocean site off-shore of Boca Chica Beach in the Gulf of Mexico. In the ship channel, large fluctuations in turbidity and suspended solids were observed. These variations were attributed mainly to the passing of cargo ships in the Brownsville Ship Channel (Figure ES-3) and predominant (southeasterly) wind direction and speed. Water quality in the Gulf of Mexico varied less, but samples were not taken during adverse weather conditions when variability would be expected to increase and overall quality decrease. Therefore, pilot data for the Gulf of Mexico do not reflect the worst-case water quality scenario for the open ocean that would occur during hurricane or other severe storm events.

Figure ES-3: Photograph of the effect of a cargo ship passing on raw water turbidity in the Brownsville Ship Channel.

Intake System

The Pilot Study utilized a wetwell, pumps, and intake screen to provide raw water from the ship channel to the pretreatment systems. Although this configuration was effective at the pilot-scale, a permanent intake system for a seawater desalination production facility will incorporate features that provide sufficient feed volume while minimizing the collection of suspended solids and protecting marine life. The recommended design includes a lengthy and wide constructed intake channel that connects the Brownsville Ship Channel to the intake screen assemblies and raw water pump station. This design would increase raw water settling time, thereby minimizing total suspended solids and turbidity introduced into the pretreatment systems. In addition, locating the facility on the south side of the ship channel may also reduce adverse water quality conditions imposed by prevailing southeasterly winds at the site.

Pretreatment System

It is widely understood that pretreatment is the most critical component of a successful seawater desalination facility. This is especially true given the raw water quality variability observed at the Brownsville Ship Channel. During the Pilot Study, four pretreatment systems were subjected to protocol tests: 1) Eimco Conventional System, 2) GE Zenon Ultrafiltration, 3) Norit Ultrafiltration, and 4) Pall Microfiltration. Each pretreatment system was tested at various operating conditions to document loading rates, pressure losses, water production efficiency, filter backwash rates and frequencies, and chemical types and dosing rates. For each, optimum process settings were established in which water production was maximized while minimizing chemical use and waste generation. The removal efficiency of potential membrane fouling agents (i.e., particulates, total organic carbon, etc.) was also measured and system reliability evaluated in terms of treatment consistency. Robustness was evaluated in terms of raw water quality variations. The overall goal was to maximize runtime by minimizing downtime associated with mechanical and membrane failures, thereby developing a cost effective pretreatment system for the production facility.

Of the four tested, only one pretreatment unit was able to meet the pretreatment objectives (i.e., operate for a minimum of 30 days without performing a clean-in-place, providing high quality filtrate, minimizing chemical consumption, maximizing filtrate flux, and performing without exhibiting irreversible fouling tendencies on the membrane surface). This unit was the Pall Microfiltration system, which successfully operated for periods of 66 days and 72 days during two separate pilot runs. The Norit Ultrafiltration, GE Zenon Ultrafiltration, and conventional pretreatment systems failed to prove sustainable operation without exhibiting significant fouling tendencies and, in the extreme case, irreversible fouling on the membrane surface.

Reverse Osmosis System

Three RO membranes were tested during the pilot: 1) Toray TM820C-400, 2) FilmTec SW30HR LE-400i, and 3) Toray TM820-400. Two RO pressure vessels (Trains A and B) were loaded with seven membrane elements each (Figure ES-4). The RO piloting objective was to determine the optimum operating parameters that could be carried over to the full-scale production facility. This objective included maximizing operation of the RO units while evaluating salt passage, normalized permeate flow, flux, recovery, cartridge filter changeout frequency, and intervals between cleanings. Results of the Pilot Study determined that both FilmTec and Toray were successful in meeting the project goals and would therefore be acceptable for use at the full-scale facility.

Figure ES-4: Photograph showing the loading of an RO element into the pressure vessel.

Finished Water Quality

Pilot Study results indicate that a treatment system consisting of microfiltration followed by RO and post-treatment is capable of treating raw seawater from the Brownsville Ship Channel to a quality that meets all primary and secondary water quality standards without the need for additional treatment. Post treatment requirements include a combination of chemicals such as caustic soda (pH control), sodium bicarbonate for alkalinity, and calcium chloride for addition of calcium. This combination of chemicals will produce stable, non-corrosive water.

Concentrate Disposal

During the Pilot Study, concentrate produced from the desalination process was recombined with the permeate and other filtered materials in an on-site lagoon prior to discharge back into the ship channel. However, for a full-scale facility producing 25 mgd of potable water, approximately 30 mgd of concentrate with salinity twice that of the raw water would require disposal.

Two potential methods of concentrate disposal were evaluated as part of the Pilot Study: 1) Class I injection wells, and 2) diffusion into the Gulf of Mexico. Both methods were determined to be technically feasible, but diffusion was found to be significantly less expensive to construct and operate. The diffusion method would include a transfer pump station and 12-mile pipeline from the desalination plant to a location approximately 0.5 miles into the Gulf of Mexico east of Boca Chica Beach.

A preliminary design for a multi-port diffuser array in the Gulf of Mexico was developed and flow and dispersion characteristics modeled. Based on longshore currents and water depths in the vicinity, the model predicted brine concentrations to be near ambient conditions within 125 feet of the diffuser array. Chemical water quality standards in the Gulf of Mexico exist only for dissolved oxygen and pH, which are not expected to be affected by concentrate discharge. There are no standards for total dissolved solids. Regulatory requirements for the discharge of RO concentrate will likely be focused on avoiding adverse impacts to the coastal ecosystem.

RECOMMENDATIONS

Full-Scale Facility

Based on Pilot Study results, a full-scale (25 mgd) seawater desalination plant at the Brownsville Ship Channel would cost approximately $182 million (2008 dollars) (Table ES-1). To ensure long-term operational success of the plant, about 26 percent of this total accounts for a conservative pretreatment design consisting of conventional treatment elements ahead of the microfiltration pretreatment system.

Table ES-1: Comparison of Feasibility Study and Pilot Study total project cost estimates for a full-scale (25 mgd) seawater desalination plant.

Project Component	**Feasibility Estimate** [a] (2004)	**Pilot Study Estimate** (2008)
Desalination Plant	$90,167,000	$126,612,000
Concentrate Disposal System	$30,583,000	$21,217,000
Finished Water Transmission System	$9,232,000	$12,180,000
Project Implementation Costs	$21,406,000	$22,400,000
Total Capital Costs	**$151,388,000**	**$182,409,000**

[a] *Source*: Dannenbaum and URS (2004).

After considering the costs of other water supply alternatives available for the future needs of Brownsville, BPUB determined that it could afford up to $70 million for a 25 mgd seawater desalination project. This would leave an infeasible funding gap well over $100 million. In addition, the full anticipated regional water demand envisioned for the full-scale facility is not expected to materialize for several years. Therefore, **it is recommended that a full-scale (25 mgd) seawater desalination facility NOT be implemented at this time due to the magnitude of the required funding gap and the current lack of full demand by BPUB and regional partners.**

Demonstration Production Facility

Based on the Pilot Study results and conclusions, **it is recommended that a 2.5 mgd demonstration-scale seawater desalination plant be designed and constructed on the south shore of the Brownsville Ship Channel.** In anticipation of future expansion to full-scale (25 mgd) capacity, several key components of the Demonstration Project would be implemented at full-scale, including the intake system, concentrate disposal system, and land acquisition.

A phased project development approach will best mitigate the risks and uncertainties associated with seawater desalination (Figure ES-5). Such an approach will allow an evaluation of system performance over several years of operation prior to an investment in full-scale capacity. This data is expected to yield a more efficient overall treatment system design and lower the cost of future expansions as they occur. The demonstration facility will also include the capability for continuous testing of the latest desalination technologies for this and other future seawater desalination facilities along the Texas coast. Such technologies include applications for pretreatment, energy recovery, sustainable energy supply, and larger (potentially more efficient) RO membranes.

Project Phase	**FEASIBILITY**	**PILOT**	**DEMONSTRATION**	**PRODUCTION**	**PRODUCTION**
Knowledge of Costs and Process at End of Phase	*Uncertainty*			*Certainty*	
Status of Brownsville Seawater Desalination Project	*Completed (2004)*	*Completed (2008)*	Pending (2012)	Future (2025)	Future (2050)
Production Capacity	-	-	2.5 mgd	12.5 mgd	25 mgd
Percent of Full-scale	-	-	10%	50%	100%

Figure ES-5: Phase project approach and the relative degree of risk and uncertainty associated with seawater desalination.

BPUB is willing to continue their investment in seawater desalination because surface and groundwater sources continue to be limited. Surface water in the Rio Grande is vulnerable to recurring drought conditions and Mexico treaty non-compliance, while brackish groundwater is limited by individual well production and aquifer recharge rates. Up until 2004, BPUB was 100 percent dependent on the Rio Grande as a water supply source. In response to the extreme drought early in that decade, BPUB developed the Southmost Regional Water Project, the largest coastal brackish groundwater desalination project in the state. Brackish desalination accounted for 22 percent of BPUB water production in 2007. The proposed demonstration project would account for 9 percent of BPUB total production in 2012 and further reduce dependency on the Rio Grande to 65 percent (Figure ES-6). The proposed project would also set the stage for subsequent expansions of seawater desalination capacity as BPUB water demands increase and regional partners are developed.

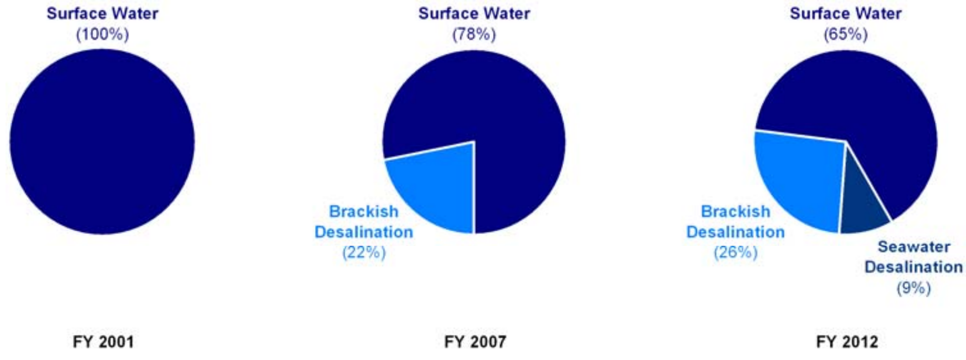

Figure ES-6: BPUB water production by source, current and projected with the proposed Demonstration Project.

Estimated Costs and Required Capital Infusion

The proposed Demonstration Project would cost a total of approximately $67,479,000. Approximately half of the cost of the proposed Demonstration Project ($30.9 million) includes infrastructure developed to provide for future full-scale capacity, especially the intake system, brine discharge pipeline to the Gulf of Mexico, and other site facilities. Implementation will require supplemental funding in the form of a grant from the State of $28.2 million and utilization of $19.3 million from the TWDB's State Participation Fund for a portion of the oversizing of the facility. BPUB proposes to finance $20 million through the TWDB Water Infrastructure Fund toward the implementation of this project (Table ES-2).

Table ES-2: Recommended uses and sources of funds, proposed Demonstration Project.

		Biennium	
	Total	**2010-2011**	**2012-2013**
Use of Funds			
Design Determination Studies	$2,967,000	$2,967,000	-
Environmental Review and Permitting	$1,079,000	$1,079,000	-
Final Design and Specifications	$5,935,000	$5,935,000	-
Construction Support Services	$2,698,000	-	$2,698,000
Startup Support Services	$846,000	-	$846,000
Construction[1]	$53,954,000	$10,791,000	$43,163,000
Total Uses of Funds	**$67,479,000**	**$20,772,000**	**$46,707,000**
Percent of Total	*100%*	*31%*	*69%*
Sources of Funds			
BPUB Loan From WIF	$20,000,000	$8,300,000	$11,700,000
State Grant	$28,200,000	$12,472,000	$15,728,000
State Participation Program	$19,279,000	-	$19,279,000
Total Sources of Funds	**$67,479,000**	**$20,772,000**	**$46,707,000**

[1] A detailed construction cost estimate, including how much is allocated to full-scale infrastructure, is presented in Table 5-7 (Page 5-29) of this report.

From the beginning, it has been understood that seawater desalination would not be the least expensive option to expand treatment capacity. Nevertheless, BPUB has pursued seawater desalination as a means of diversifying its water supply sources by including the only drought resistant supply available. The financial goal of BPUB for the project is to develop a seawater desalination project that is no more costly than one of its other water alternatives. For seawater desalination, this will require a capital infusion from a public source.

Under the proposed funding scenario (see Table ES-2), the cost to BPUB at start up is projected to be $4.06[2] per 1000 gallons (Table ES-3). If grant funding was not provided, the estimated cost would be $7.05[3] per 1000 gallons. However, these values are somewhat misleading considering the amount of the proposed project dedicated to future capacity. As the facility is ultimately expanded and technology improves and is tested, future costs are expected to be much lower due to the initial investment made. With the proposed Demonstration Project, the combined BPUB water cost would increase to $2.43 per 1,000 gallons in 2012, or by approximately 8 percent.

Table ES-3: Current and projected BPUB costs for all water supply sources.

		Current (FY 2007)	Projected (FY 2012)
Water Production			
	Surface Water Plant 1 (Rio Grande)	3,352	2,738
	Surface Water Plant 2 (Rio Grande)	2,970	2,738
	Southmost (Brackish Desalination)	1,763	2,190
	Seawater Desalination	-	803
	Total YTD	**8,085**	**8,468**
Unit Costs of Water Produced ($ per 1,000 gallons)			
Surface Water Treatment	O&M	$1.75	$1.75
	Debt Service	$0.50	$0.50
	Subtotal Surface	$2.25	$2.25
Brackish Groundwater Desalination	O&M	$1.28	$1.28
	Debt Service	$1.02	$1.02
	Subtotal Brackish	$2.30	$2.30
Proposed Demonstration Project	O&M	$0.00	$2.80
	Debt Service[a]	$0.00	$1.26
	Subtotal Seawater	$0.00	$4.06
Total for All BPUB Water Supply Sources	**O&M**	**$1.65**	**$1.73**
	Debt Service	**$0.61**	**$0.71**
	Total Combined BPUB Cost	**$2.26**	**$2.43**

Source: Current data provided by BPUB Public Finance Division, June 2008.
[a] Assumes grant of $28.2 million, debt service of $20 million by BPUP amortized for 25 years at 3%, and $19.3 million financed under the State Participation Program.

[2] Debt service of $20 million (BPUP) amortized for 25 years at 3% utilizing the TWDB Water Infrastructure Fund would be $1.26/1000 gallons plus $2.80/1000 gallons for O&M costs.

[3] Debt service of $67.5 million (BPUP with no grant funding) amortized for 25 years at 3% utilizing the TWDB Water Infrastructure Fund would be $4.25/1000 gallons plus $2.80/1000 gallons for O&M costs.

ADVANTAGES AND CHALLENGES

The proposed Demonstration Project holds several advantages over conventional surface water treatment and brackish desalination facilities. For BPUB, one of the most important advantages is the diversification of its supply. For the State of Texas, the demonstration of the viability of seawater desalination technology in the State is of prime importance. Other key perspectives about the viability of the demonstration project are discussed below:

Advantages

- *Addresses the need for water production for the BPUB* – the 2.5 mgd production capacity of the proposed Demonstration Project will be fully utilized by BPUB. A larger plant at this time would have excess capacity with a much greater investment and risk.
- *Lower near-term investment* – the implementation of the demonstration project has a lower overall initial cost compared to the full-scale plant. A total investment of $67 million compared to $182 million. Nearly 50% of the demonstration cost is for future capacity.
- *Reduction of risk* – A full-scale investment $182 million now incurs some risk in that the Pilot Study yielded good data for a demonstration plant but left some unanswered questions for full production. The Demonstration Project is expected to further refine data in efforts to reduce the overall cost of the full-scale facility.
- *Potential for cost savings in full-scale* – the Pilot Study yielded the need for a higher level of pretreatment and associated costs. The Demonstration Project will be equipped to modify operations to optimize the design data and solicit competition from vendors for the full-scale facility.
- *Development of operational flexibility in demonstration* – the demonstration facility will allow for the testing of a wide variety of conditions such as primary treatment ahead of membrane pretreatment for a portion of the flow to measure cost savings/increases as a result of this flexibility.
- *Provides an opportunity to conditionally permit full-scale facility based on actual demonstration-scale operational data* – the proposed Demonstration Project would provide the opportunity to evaluate the effects of concentrate disposal in the Gulf of Mexico on a smaller scale over a period of years, reducing the environmental risk of full-scale permitting conditions developed solely on artificial modeling results.
- *Operate over a longer term to assure all water qualities* – the Pilot Study operated for a period of 18 months with some short-term successes. The development of the demonstration plant will provide an opportunity for the plant to experience varying conditions over multiple seasons. One potentially complicating phenomenon that did not occur during piloting was the presence of a red tide event.
- *Improvement of intake and its effects on operation and future design parameters* – the pilot was unable to maximize the intake efficiency therefore yielding a highly variable water quality with extreme peaks of turbid water. On the positive side, the pilot yielded good results for poor water conditions. It is anticipated

that an improved intake will yield a reduction in cost and improve the reliability of the demonstration and full-scale plants.

- *Demonstrate to the State the effectiveness of seawater desalination along the Texas coast* – the establishment of an inland desalination facility will give confidence to other areas of the state to evaluate this water supply alternative.
- *Developing excess capacity in certain facility components makes full-scale facility more cost effective to build* – major components of the Demonstration Project, such as intake canals and concentrate discharge lines, would be designed and constructed for full-scale (25 mgd) conditions. These capital costs, sunk in present-day dollars, would reduce the expense of future expansion.

As with any project, there are disadvantages to the implementation of a demonstration plant. The following describes disadvantages to the demonstration plant.

Challenges

- *Higher unit cost of water produced* – economies of scale play a large part in the development of a desalination facility. The demonstration plant includes almost 50 percent in extra cost that cannot be fully utilized until future expansion. For the plant to be cost effective, grants and low interest loans must be utilized to complete the Demonstration Project.
- *Less capacity for future needs* – the initial (smaller) desalination plant would provide less capacity for future needs and regional supply possibilities.
- *Perception of not being "big enough"* – the demonstration plant does not have the "big" or large-scale tag and may be perceived as too small.