Proposal ID 9316

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Project Overview

Today's Date	November 10, 2009 at 9:30:53 AM UTC
Title	Strategies for Treating Variable Source Water
Principal Investigator	Michelle Chapman, mchapman@usbr.gov
Project Type	Conducting
Requested First Fiscal Year	2010
Requested Final Fiscal Year	2012
Intellectual Property	This project does not contain Intellectual Property
Research Topic	Advancing Water Supply Technologies (WS) » Desalination and Water Treatment (WS2)

Research Question

Desalination of locally available saline waters offers the possibility of increased water supply from otherwise unusable sources. A number of places exist in the United States where both brackish water and seawater are available. A water supply developer will normally choose to desalt brackish water over seawater because the unit cost of product water will be substantially lower, typically about half that of desalted seawater. For a brackish water plant, the construction and energy cost is lower, and the fraction of water recovered from a given feed source is higher. Therefore seawater desalting plants are a more expensive water source.

However, the reliability of the water source must be considered. Situations exist particularly along the Gulf Coast of Texas and the Pacific Coast of California where the brackish water source may be available only for part of the year. For such a location, a brackish water desalting plant would prove to be an unreliable water source and would need to be supplemented by seawater, a reliable source of water.

Current treatment processes are typically designed for a specific character of water. A plant designed for brackish water cannot be used to desalt sea water and vice versa.

The question is: “Can a process be devised to adapt a desalting facility to highly variable sources of water that would combine the economy of a brackish water plant with the reliability of a seawater plant?”

Research Strategy

At the request of the Texas Water Development Board, a study was made of the flexibility of a reverse osmosis (RO) plant using conventional equipment connected, possibly, in an unconventional manner. This study used the Integrated Membrane Solutions Design program, V.2008, from Hydranautics. Calculations from this program showed that it was feasible, at least on paper, for an RO plant to treat two very disparate feed waters. [Reference: Bureau of Reclamation, Design Concept for Flexible Desalination Plant, April 30, 2009.]

The calculated plant, operated with brackish water feed, consists of two stages with 26 vessels in the first stage and 14 vessels in the second, each vessel containing 6 membrane elements. The feed pressure is 122 psi and the product TDS is 137 mg/L. The product flow is 1 MGD. Using sea water, the configuration consists of a first pass with 26 vessels and a two stage second passes, each stage containing 7 vessels. The feed pressure is 596 psi in the first pass and 130 psi in the second pass. The product TDS is 158 mg/L. The product flow is 0.42 MGD. It appears that the piping could be arranged so that conversion from one mode to the other could be done with only a moderate amount of operator effort.

The strategy for the project is to develop process features that would allow flexibility in source water composition while maintaining energy efficiency. An economic evaluation will be performed as a reality check to be sure that the new process would not add excessively to the life cycle cost of a system. Then the optimum process strategy will be finalized and a system built, or an existing system will be adapted. Finally the system will be tested with a wide range of source waters. There are four phases of research:

Phase 1. Work with the partner water supply entities, Texas Water Development Board (TWDB), Brownsville Public Utilities Board (BPUB), and San Patricio Municipal Water District (SPMWD), to identify the composition of potential source waters which would serve as feed waters for the test system. One of the partners will host the pilot study of the flexible unit and operate the equipment.

Identify system features that will allow flexibility of operations as source water composition changes with a minimal of operator input. The strategy must keep water production at an optimum level while maintaining energy efficiency as water source shifts from seawater to municipal wastewater to storm water drainage. Such a system will require robust pretreatment, instrumentation, automated valves, flexible staging, a variable frequency drive, and “smart” controls. One possible arrangement for the flexible unit is shown in the study referenced above.

Life cycle cost of the modified process compared to a traditional process will be evaluated. The process modification and cost evaluation are iterative studies to reach the most economically attractive alternative.

Phase 2. Develop a pilot plant by constructing a new unit or modifying existing equipment to match the process alternative determined in Phase 1. An attractive possibility is to modify the Expeditionary Unit Water Purifier (EUWP) owned by Reclamation. The EUWP was built for seawater desalination with a second pass in case of especially dangerous chemical contamination, or a critical need for ultra pure water. The EUWP can operate at a maximum of 60% recovery. It appears that this unit could be re-plumbed at reasonable cost to serve as a pilot plant to demonstrate the flexible plant concept.

Phase 3. Test the process at the site or sites identified above with seawater, storm water, and municipal waste water or brackish groundwater. Partners will provide housing for the test unit, source water, power, and operational support.

Phase 4. Write final report and generate conclusions and recommendations for further possible use of this process.

Need and Benefit

The Texas 2007 State Water plan has identified a shortage of 8 million acre feet annually by 2060. The State water plan also states that 800,000 acre feet of this short fall will be provided by desalination and another 1.6 million acres feet provided by water reuse. As the variability in the climate increases, it is critical that treatment of new sources of water be developed.

Variable source water occurs in the following situations:

- Locations where brackish ground or surface water can be obtained during much of the year but where only seawater is available during dry periods.

- Communities that could use water from a variety of sources – either multiple wells of different composition, or combinations of surface water, storm water drainage, municipal wastewater, and seawater.

- Coastal communities that could treat estuarial water where salinity varies widely with the tides. This occurs frequently in the gulf coast region.

Building a desalination unit to treat brackish water and seawater alternatively presents several challenges.

1) A typical seawater system contains only one stage because only 40-50% recovery is practical. It may also contain a full or second pass to further reduce concentrations of certain components to meet product water standards. By contrast, a typical brackish water unit contains two or possibly three stages depending on scaling limitations, discussed below. This comparison indicates that the flexible plant will differ from conventional seawater or brackish water plants.

2) Operationally there is a great benefit from having the plant use all of the membrane elements regardless of whether the plant is in seawater or brackish water mode. This avoids the work involved in element removal and storage.

3) The pumping system for the plant will be more complex than that for either a seawater or a brackish water plant. Typically seawater plants use an inlet pressure of 600 to 900 psi while brackish plant use 150 to 300 psi. Details of this will be worked out during Phase I.

4) Most conventional seawater plants are now built with energy recovery devices. The energy

recovery device for any system is designed for a certain flow at a certain pressure, the energy from which is used to lift the feed water to high pressure. For the flexible unit, selection of equipment and operating conditions may not be optimal for either mode but should be optimized for overall plant operation.

5) Seawater is generally not of a scaling nature. The salt is predominantly sodium chloride, which is exceptionally soluble. When ionic strength is as high as in seawater concentrate, the most stable form for ions is in solution, not as solids. Brackish sources that are not derived from seawater however tend to be high in calcium, carbonates and sulfates that do form scale. The system would include an anti-scalant feed system that would be used when scaling brackish water is treated.

The study referenced above includes a diagram showing how a two-stage, high recovery system for desalting brackish feed water can be converted to a two-pass, medium recovery system for desalting a seawater feed. Although not shown in the diagram, the same energy recovery device can be used in both operating modes to provide energy conservation benefits. The best pumps for this unit would probably be variable speed drive pumps. Alternatives may be pumps with variable staging so that their optimum efficiency point can be changed from high pressure, low capacity for seawater to lower pressure, higher capacity for brackish sources.

Water savings are obtained by operating the system in seawater mode at a recovery of 40-50% and using a recovery of 75-90% for brackish water.

Mission Responsibility The American Water Works Association stated in its “Summary on Future of Desalination in the United States” (Feb 2007):

“As the nation’s population and industrial development grows, so does fresh water use. Along with this increase in water use, the availability of traditional water supplies is declining while the costs of these supplies are on the rise.”

Reclamation’s historical mission, to manage water resources in an economical and environmentally sensitive manner, is intimately involved with the extension of these traditional water supplies. Desalination is a tool Reclamation is using to extend our traditional supplies of water. Research to increase efficiency of treatment systems contributes to the production of more water for less energy.

It is true that energy and recovery efficiencies for systems designed for one particular water type are close to their theoretical limits, however, there are still efficiencies to gain for systems treating variable sources. The National Research Council 2008 Report states that “cost is no longer a barrier to desalination implementation” - also true. Recent costs have been driven more by commodity prices than by technology. However, Reclamation can still make a big difference in desalination cost by facilitating unique applications such as treatment strategies for multiple sources of water which conserve energy and water resources. Availability of fresh water will be the primary issue of this century. Here is a quote from the 2007 Texas State Water Plan:

“If Texas does not implement the state water plan, water shortages during drought could cost businesses and workers in the state about $9.1 billion per year by 2010 and $98.4 billion per year by 2060”

Comments Details of 2011-2012 partner contributions will be finalized during the first year.

Proposed Technical Reviewers

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Desalination
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People Involved

Team Members

Collins Balcombe,
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Planning
Research Role: Area Office Support

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Research Role: Team Coordination

Mr. Andrew Tiffenbach,
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Mechanical Engineer

Research Role: Insturmentation and Programming Support

Contractors None

Funding

Fiscal Year 2010 Planned $50,000.00 Request

Fiscal Year 2011 Planned $130,000.00 Request

Fiscal Year 2012 Planned $60,000.00 Request

Tasks

Fiscal Year	Task	Type	Completion Date	Funding Request	Comments
2010	Phase 1a. Work with the partner water supply entities, Texas Water Development Board (TWDB), Brownsville Public Utilities Board (BPUB), and San Patricio Municipal Water District (SPMWD), to identify the composition of potential source waters which would serve as feed waters for the test system. One of the partners will host the pilot study of the flexible unit and operate the equipment.	Labor	09-30-2010	$20,000.00	
2010	Phase 1b: Identify system features that will allow flexibility of operations as source water composition changes with a minimal of operator input. The strategy must keep water production at an optimum level while maintaining energy efficiency as water source shifts from seawater to municipal wastewater to storm water drainage. Such a system will require robust pretreatment, instrumentation, automated valves, flexible staging, a variable frequency drive, and “smart” controls. One	Labor	09-30-2010	$30,000.00	

	possible arrangement for the flexible unit is shown in the study referenced above. Life cycle cost of the modified process compared to a traditional process will be evaluated. The process modification and cost evaluation are iterative studies to reach the most economically attractive alternative.				
2011	Phase 2. Develop a pilot plant by constructing a new unit or modifying existing equipment to match the process alternative determined in Phase 1. An attractive possibility is to modify the Expeditionary Unit Water Purifier (EUWP) owned by Reclamation. The EUWP was built for seawater desalination with a second pass in case of especially dangerous chemical contamination, or a critical need for ultra pure water. The EUWP can operate at a maximum of 60% recovery. It appears that this unit could be re-plumbed at reasonable cost to serve as a pilot plant to demonstrate the flexible plant concept.	Labor	04-30-2011	$80,000.00	If the EUWP is used for the pilot it will require control programming, an additional pump, and possibly new RO membranes. A better cost estimate will be developed in the first year.
2011	Phase 3. Test the process at the site or sites identified above with seawater, storm water, and municipal waste water or brackish groundwater. Partners will provide housing for the test unit, source water, power, Lab services, and operational support.	Labor	09-30-2011	$50,000.00	Pilot testing may continue into the third year.

2012	Phase 3 (continued): Complete pilot testing.	Labor	01-01-2012	$30,000.00	
2012	Phase 4. Write final report and generate conclusions and recommendations for further possible use of this process. Present findings in a national and international conference.	Labor	09-30-2012	$30,000.00	Includes review, registration for two conferences and travel to present findings.

Locations

Benefiting Regions Mid-Pacific, Lower Colorado, Upper Colorado, Great Plains

Field-Based Research Contacts

Field Office	Field Contact	Field Contact Email	NEPA Compliance Information
Oklahoma-Texas	Collins Balcombe	cbalcombe@usbr.gov	Not Needed

Research Products and Research Product Documents

Due 09-28-2012 Conference Presentation
Research Product DocumentType: Conference proceedings
Comments: An abstract will be submitted to American Membrane Technology Association, the AWWA Membrane Technology Conference, and International Desalination Association meetings once the equipment is ready for piloting. All of these organizations require a year lead time for abstracts. The document would then be available to the public in their proceedings when the project is completed.

Due 09-28-2012 Journal Publication
Research Product DocumentType: Publication
Comments: A peer reviewed journal article will be developed from the material in the final report.

Due 09-30-2012 Final report in Reclamation format
Research Product DocumentType: Publication
Comments: Final report will be produced to meet Reclamation visual identity requirement in pdf for for the S&T and Advanced Water Treatment web sites.

Partnerships

Estimated Contributions $60,000.00

Contributions

Partner	Contribution Year	Commitment	Type	Description	Amount
Collins Balcombe	2009	Firm	Cash	Funding for proposal development and scoping study performed by Frank Leitz.	$25,000.00
Mr. Jorge Arroyo	2010	Not Firm	In-Kind Services	TWDB is currently implementing the seawater and brackish groundwater desalination initiatives, which include	$10,000.00

				$3.5 million, grant funding for desalination technology demonstration projects. In May 2009, the 81st Texas Legislature appropriated an additional $600,000 for additional grants for demonstration projects. TWDB staff will assist with the scoping of the variable salinity project and provide d source water data and modeling as needed.	
Collins Balcombe	2010	Firm	In-Kind Services	Labor and travel for OTAO to attend meetings in Denver, San Patricio, and/or Brownsville.	$10,000.00
Mr. John S Bruciak	2010	Firm	In-Kind Services	Brownsville PUB will provide water quality data and participate in meetings to determine a pilot location.	$5,000.00
Mr. Don Roach	2010	Firm	In-Kind Services	San Patricio MWD will provide data and participate in meetings to determine a pilot study location.	$5,000.00
Dr. Harry Seah	2010	Firm	Cash	Singapore Public Water Utilities Board will provide data from their work in optimizing equipment operations for variable sources of water and will review test plans for piloting in year 2.	$5,000.00