Desalination:
Silver Bullet or Pipe Dream?

In-Depth Perspective Panel:

Environmental Impacts

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Michael Jensen - Amigos Bravos, *Friends of the Wild Rivers*

"Uncertainties about desalination's environmental impacts are currently a significant barrier to its wider use, and research on these effects -- and ways to lessen them -- should be the top priority." --- Amy K. Zander

Desalination: A National Perspective

Chair, Committee on Advancing Desalination Technology
National Research Council

"Substantial uncertainties remain about the environmental impacts of desalination ... Limited studies suggest that desalination MAY be less environmentally harmful than many other ways to supplement water -- such as diverting freshwater from sensitive ecosystems -- but definitive conclusions cannot be made without further research."

-- ***Desalination: A National Perspective***

Overview

- Water Treatment Process
- Concentrate Disposal
- Energy Use
- Deep Aquifers as Non-Renewable Resources

- Water Treatment Process

Water Treatment Process

- Lots of experience with seawater desalination
- Limited understanding of differences with inland desalination
- Important differences include:
  - Feed water recovery
  - Water chemistry
  - Fouling
  - Concentrate disposal options

Water Treatment Process

- Risk of polluting groundwater from the drilling process when installing feedwater pumps

- Leakage from pipes that carry feedwater into the desalination plant and highly concentrated brine out of the plant may percolate underground and contaminate groundwater aquifers

Water Treatment Process

- Pretreatment
  - Chlorination
  - Polymer additives used for scale control
  - Acid sometimes used in addition to additives
  - Corrosion inhibitors (in thermal processes)
  - Dechlorination

Water Treatment Process

- Cleaning Chemicals (Fouling and Scaling)
  - Enzymes to break down bacterial slimes
  - Detergents and surfactants to resuspend particulate material and dissolve organic material
  - Biocides to kill bacteria
  - Chelators to remove scale
  - Acids to dissolve inorganics
  - Caustics to dissolve organic substances and silica

Water Treatment Process

Health issues

- Desalinated water can be soft and corrosive
- Hard water can lower incidence of cardiovascular disease
- Corrosive water can leach metals like lead and copper from household plumbing
- Important to reestablish proper mineral content and stability of water

- Concentrate Disposal

Concentrate Disposal

"Except for a few short-term lethality studies that do not give insight into long-term effects, little research has been done on the impacts of concentrate discharges on organisms in receiving waters."

"Adequate site-specific studies on potential biological or ecological effects are necessary prior to the development of desalination facilities …"

-- *Desalination: A National Perspective*

Concentrate Disposal

"Where low-cost concentrate management alternatives are not available, the financial costs of desalination can be prohibitive."
-- *Desalination: A National Perspective*

- Inland plants have few or no cost-effective and environmentally sustainable disposal methods

Concentrate Disposal

- Current concentrate disposal practices
  - Discharge to surface water
  - Discharge to sanitary sewer
  - Deep well injection
  - Land application/irrigation
  - Evaporation ponds (landfill of solid wastes)

Concentrate Disposal

Disposal Option	Environmental Concern	Mitigation Method
Surface Water	Contamination of receiving water	
Sewer System Blending	Contamination of eventual receiving water	Reduce recovery; membrane type selection
Land Application	Contamination of underlying groundwater and of soil	Reduce recovery; blending membrane type selection
Deep Well Injection	Contamination of overlying drinking water aquifers due to well leakage	Move disposal location or change means of disposal
Evaporation Ponds	Contamination of underlying higher quality aquifers due to pond leakage	Double lining with leachate collection system
Zero Liquid Discharge	Contamination of underlying higher quality aquifers due to landfill leakage	Double lining with leachate collection system

Concentrate Disposal

- Waste production by desalination
  - A 5 mgd facility removing 2,000 mg/L TDS from water will generate 83,000 lbs of dry solids per day
  - A 60 mgd facility removing 10,000 mg/L TDS from water will generate 5,000,000 lbs of dry solids per day

Concentrate Disposal

- Study of disposal options for 20 mgd concentrate stream (Phoenix)

  - **Evaporation ponds**
  - 10 square miles in area
  - Total capital cost = $410,000,000

  - **Pipeline to Gulf of California**
  - 184 miles of 30-60 inch pipeline, additional distance through existing canal
  - Total capital cost = $456,000,000 (includes Tucson)

Concentrate Disposal

- Excessive ion buildup in concentrate can cause desalination facilities to fail NPDES Whole Effluent Toxicity (WET) standards
  - Experience from nine Florida desalination plants
  - Cause shown to be excessive calcium and flouride in the groundwater feed water

Concentrate Disposal

NAS Study Recommendations

- More comprehensive studies are needed to adequately identify all contaminants in desalination brines and to mitigate the impacts of brine discharge

- Federal or state regulators should evaluate whether new water-quality regulations are needed to protect local environments or human health

- Disposal of brine in underground aquifers should be prohibited unless comprehensive and competent groundwater surveys are done and there is no reasonable risk of brine plumes appearing in freshwater wells

- Energy Use

Energy Use

- A 5 mgd facility treating 2,000 mg/L TDS water to 85% recovery
  - Power requirement for the feed pumps (85% efficiency) will be 12,600 kWh/day
  - Using Albuquerque's electricity profile, CO_2 emissions will be 15,800 lbs CO_2/day
- A 60 mgd facility treating 10,000 mg/L TDS water to 75% recovery
  - 340,000 kWh/day
  - 430,000 lbs CO_2/day

Energy Use

“The future cost of desalinated water will be more sensitive to changes in energy prices than will other sources of water.”

--Pacific Institute

Energy Use

- Even with improved technologies, the energy used by reverse osmosis probably cannot be reduced more than 15 percent below current levels

- Larger reductions in energy costs may be possible using other methods, such as co-generation (using low-grade heat left over from other industrial processes) – e.g. thermal desalination

Energy Use

- Design should be based on water demand (i.e. water delivered to houses) not consumptive use

- Can design for consumptive use if wastewater is recycled back to RO plant for reuse

Energy Use

- Desalination offers both advantages and disadvantages in the face of climate changes
  - Desalination facilities may help reduce the dependence of local water agencies on climate sensitive sources of supply
  - Extensive development of desalination can lead to greater dependence on fossil fuels, an increase in greenhouse gas emissions, and a worsening of climate change

Energy Use

Carlsbad Desalination Facility (California)

- First major California infrastructure project to eliminate its carbon footprint

ON-SITE & PROJECT-RELATED REDUCTION OF GHG EMISSIONS

- Increased Energy Efficiency
- GHG Emission Reduction by Green Building Design
- On-Site Solar Power Generation
- Recovery of CO2
- Avoided Emissions from Reducing Energy Needs for Water Reclamation
- Avoided Emissions from Displaced Imported Water
- Avoided Emissions through Coastal Wetlands

ADDITIONAL OFF-SITE REDUCTIONS OF GHG EMISISONS

- Carbon Offset Projects
- Sequestration through Reforestation
- Renewable Energy Partnerships

- Deep Aquifers as a Non-Renewable Resource

Deep Aquifers as a Non-Renewable Resource

“Groundwater resources are never strictly non-renewable. But in certain cases the period needed for replenishment (100s or 1000s of years) is very long in relation to the normal time-frame of human activity in general and of water resources planning in particular. In such cases it makes practical good sense to talk in terms of ‘**non-renewable groundwater resources**’”

-- UNESCO, *Non-Renewable Groundwater Resources*

Deep Aquifers as a Non-Renewable Resource

"Sustainable water resources systems … contribute to objectives of society now and in the future while maintaining ecological, environmental, & hydrological integrity."

-- ASCE Committee on Sustainability

Deep Aquifers as a Non-Renewable Resource

- Introducing new water from desalination may not actually reduce the amount of water taken from other sources

“The problem is, well, maybe people are going to want to do both. That's the whole issue of growth.”

-- Jeffrey Graham

Marine Biologist, Scripps Institution of Oceanography

Commenting on San Diego seawater desalination plant

Deep Aquifers as a Non-Renewable Resource

"In many parts of the world, alternatives can provide the same freshwater benefits of ocean desalination at far lower economic and environmental costs. These alternatives include treating low-quality local water sources, encouraging regional water transfers, improving conservation and efficiency, accelerating wastewater recycling and reuse, and implementing smart land-use planning."
-- Pacific Institute

Deep Aquifers as a Non-Renewable Resource

"Conservation and transfers from low- to high-valued uses will usually be less costly than supply augmentation schemes, including desalination."

- Methods of demand management can make significant additional quantities of water available at less cost than desalination
- Market-like transfers of water can also offer relatively low-cost ways of acquiring additional supplies of water
- Conservation and efficiency improvements that reduce the total demand for water often come with associated benefits, such as reduced energy costs

Deep Aquifers as a Non-Renewable Resource

- Suggestions that desalinated deep brackish water should be “part of the mix”
  - Source of water during periods of drought
  - Source of minerals such as gypsum for wallboard, salt for industrial or food applications, or trace minerals such as uranium or vanadium for energy or material uses

- Would we really invest in desalination only to use it as a reserve?

Conclusions

"… as with most resource questions, the theoretical potential and the practical potential are far different. All water management and planning takes place in the context of economic, social, environmental, and political factors, and these factors are far more important than technological desalination process constraints in limiting the potential for desalination to help meet anticipated water supply needs."

-- *Desalination: A National Perspective*

Conclusions

"The report also recommends that environmental research be emphasized up front when implementing the research agenda, because this research has the greatest potential for enabling desalination to help meet future U.S. water needs."

-- *Desalination: A National Perspective*

Conclusions

"All components of the water use cycle should be considered, including source water impacts, the likely greenhouse gas emissions from the energy requirements of the desalination process, potential impacts from concentrate management approaches, and environmental health considerations in the product water. Ideally, these considerations should be compared against equally rigorous environmental impact analyses of water supply alternatives, so that decisions can be made based on comparisons of the full economic costs and benefits, including environmental and social costs and benefits, among the various water supply alternatives."

-- Pacific Institute

Deep Aquifers as a Non-Renewable Resource

"We urge regulators to develop comprehensive, consistent, and clear rules for desalination proposals, so that inappropriate proposals can be swiftly rejected and appropriate ones identified and facilitated. And we urge private companies, local communities, and public water districts that push for desalination facilities to do so in an open and transparent way, encouraging and soliciting public participation and input in decision making."

-- Pacific Institute

Contact Information:

Michael Jensen
Grants & Communication
Amigos Bravos / Albuquerque
mjensen@amigosbravos.org
(505) 362-1063

www.amigosbravos.org