Assessing Seawater Intake Systems for Desalination Plants [Project #4080]

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OBJECTIVES:
The goal of this project was to take a detailed, integrated view of the seawater intake planning and implementation process through (1) the presentation of an overview of the process, and (2) the provision of a methodology that walks the user through the decision-making process.

BACKGROUND:
As coastal populations grow, traditional drinking water sources are struggling to keep up with new demands. Tapping the ocean for potable water via seawater desalination is gaining popularity as a potential water supply source. However, it can only be used where the associated regulatory, ecological, and public relations challenges can be overcome. Of the three components of seawater desalination (intake, treatment, and concentrate discharge), intake location and design is often the most challenging aspect of the system in terms of technical strategy, regulatory challenges, and public perception.

APPROACH:
The research goal, to develop a detailed presentation of the seawater intake planning and implementation process, was met through four primary objectives:

1. Development of a user-friendly technical report summarizing the state-of-the-science on seawater desalination intake structures and methods and the costs and benefits associated with different intake approaches (Chapter 2).
2. Characterization of utility experience with the ocean intake planning, design, and implementation process (Chapter 3).
3. Creation of an ocean intake planning and decision-making tool that takes the information in the report and makes sense of the planning process for the user (Chapters 4 and 5 and a Microsoft Access-based tool, DesalIntakeTool.mdb, included on the attached CD-ROM and through the WaterRF Website).
4. Illustration of the desalination intake planning and implementation process (and use of the tool) through two case studies (Chapter 6 and example data input to the DesalIntakeTool.mdb file).
RESULTS/CONCLUSIONS:

The Current State-of-the-Science in Seawater Intake Design and Implementation

Ocean intake alternatives include the following surface and subsurface options:

- **Open intakes** are located above the seafloor and are the most common type of intake for large (>10 mgd, or >38,000 m³/d, production) plants.
- **Subsurface intakes** are buried pipes and/or wells dug beneath the shoreline or ocean floor. Seawater is drawn through the subsurface into the intake pipe. The subsurface geology typically limits capacity and performance (as compared to open intakes). These can be either wells or infiltration galleries.
- **Co-location with an existing intake** makes use of an existing intake system for a new (desalination) application. Seawater is withdrawn from an existing intake or outfall for another facility system (almost always a power plant).

Each option is best-suited to different types of subsurface geology and has associated positive and negative impacts on the environment and aesthetic values. To date, wells are the most common types of intake in use. This may change as the number of seawater desalination plants grows; new locations under consideration are much more diverse than in the past.

The applicability of different intake types depends upon the project-specific siting options, site geology, local ecology, cost, regulations, and stakeholder considerations. Environmental impacts (and associated permitting), especially impingement and entrainment concerns, are typically the most challenging (and costly) influence on the intake design selected and the manner in which it is constructed and operated. Seawater intake wells have proven to be quite economical for desalination plants with production capacities smaller than 10 mgd (38,000 m³/d), while open ocean intakes have found wider application for large seawater desalination plants. In general, U.S. regulatory agencies have indicated a preference for subsurface intake technologies (where feasible) as opposed to direct, open-water intakes due to the reduced environmental impacts associated with these systems. Sometimes this preference can curtail the development of a seawater source or treatment site. Generally, it will greatly increase the unit cost for producing water. Clearly, the consideration of multiple engineering, cost, and stakeholder issues are an integrated part of the planning and design process.

Facilitating Navigation of the Decision-Making Process

The essential planning elements, technical limitations, and controlling parameters identified in the state-of-the science work was used to guide the development of a decision framework for assessing the relative feasibility and merits of different intake design options for a given intake scenario (as defined by the user). The structure of the decision process is as follows:
Part 1. Define the Options

Step 1. Define the Scenario. Describe the capacity, potential location(s), and cost factors for the scenario under consideration.

Step 2. Do Preliminary Assessment of Technical Feasibility. The range of technical options is identified for each location type selected (e.g., a cliff installation precludes the option of a vertical well). Some of the data will likely need to be collected before the full analysis can be done (e.g., geologic surveying). In the interim, the user can assume the option(s) are viable if preferred, finish the preliminary analysis, and then come back and update the scenario with the needed information when it’s available. This step is intended, in part, to help users identify data gaps.

Step 3. Capture Constraints and Concerns with Stakeholders (optional). Users are encouraged to identify the stakeholders and their respective concerns that will influence the decision-making process. The user is encouraged to consider meeting with stakeholder groups to (1) educate them about the technical limitations and pros and cons of the possible options; and (2) capture their comments, concerns, and preferences about the various options.

Part 2. Evaluate the Options

Step 4. Complete Feasibility Analysis. Evaluate technical, permitting, and stakeholder issues. Prompt the user, in part, to collect needed data. This four-step process (technical, permitting, costs, and stakeholders) is recommended, although the last step is not strictly needed and so is optional (though strongly recommended by the project team).

Step 5. Estimate Cost. Identify and quantify cost elements. Each technology will have “studies,” “permitting,” and “construction” cost lists. Calculations and default data will be provided as feasible (this is an ongoing effort).

Part 3. Compare the Options

Step 6. Grade and Rank Options. Assign grading criteria with weighting values and rank the options.

Step 7. Next Steps. The user is then prompted to consider a range of options to pursue next.

Please note: This tool is intended to facilitate the planning process, but is not intended to replace a detailed Pre-Design and/or Master Plan. It is assumed that if the user were to pursue development of a seawater intake and desalting plant following use of this tool, (s)he would commission a detailed process design before any firm, concrete decisions were made.

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APPLICATIONS/RECOMMENDATIONS:
As seawater desalination becomes an increasingly attractive tool in the world’s struggle to provide water for a growing population, it is the responsibility of those with the right expertise to help make desalination a realistic option for public agencies and their customers. This project delivers a user-friendly resource and decision methodology to help water utility managers navigate the ocean intake selection process.

Public agencies, particularly those who are relatively unfamiliar with seawater desalination, can use this report to

1. learn about the state-of-the-science in seawater intake technology and implementation issues,
2. learn what other utilities considering and using seawater intakes for desalination are doing, and
3. use the Desalination Intake Decision Tool to analyze potential scenarios for their own situation, compare it with similar efforts, and weigh the benefits of desalination versus the effort of implementation with respect to ocean intakes.

MULTIMEDIA:
This decision process was turned into the Desalination Intake Decision Tool, available on the CD-ROM and WaterRF Website (Microsoft Access program DesalIntakeTool.mdb). This software walks the reader step-by-step (tab-by-tab) through the evaluation process. The user is prompted to answer a series of questions. Most queries have “Note” sections where the user can add additional documentation related to the questions as desired. As the decision tool is targeted at developing an intake development plan, it is assumed that the user has already determined the desalting process scenario to the extent that he/she knows the volume of feed water the process will need.

If intake design options are deemed unfeasible at any point in the process, they are eliminated from further consideration. This process delivers technically defensible options that help a user evaluate and select which options are best for the application.

RESEARCH PARTNERS:
- WateReuse Research Foundation
- U.S. Bureau of Reclamation
- California Department of Water Resources

PARTICIPANTS:
Nine utilities from throughout the United States participated in this project.