RECLAMATION
Managing Water in the West

Treatment of Impaired Water as an Alternative to Importation of Fresh Water

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Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

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Advanced water treatment technologies are often considered to be costly; however, due to the high cost of moving water from one location to another, traditional water supply approaches may also be costly. For example, a water treatment plant may be capable of treating a local brackish groundwater source at a fraction of the cost of a lengthy pipeline to deliver fresh water from miles away. At what pipeline length will treatment be cost competitive? Clearly the answer to this question is site-specific and depends on a number of factors. This research idea will provide a framework for how to answer such questions.

Case studies using the framework will identify economic drivers that determine the viability of advanced water treatment implementation and can be used to direct future research and establish research goals for the development of new treatment technologies.

Other components, which are relevant to the need and benefit of the proposed project are to develop cost and options for small communities to conduct advanced water treatment. Reclamation has much of the information already from past planning activities, design projects, and VE studies. Synthesizing this information will determine where Reclamation has gaps in technology and knowledge.

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Peer Reviewer: I have reviewed the assigned items/sections(s) noted for the above document and believe them to be in accordance with the project requirements, standards of the profession, and Reclamation policy.

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Executive Summary

When communities are evaluating a new supply of water, often there is a choice between a local supply that is impaired and a fresh source that requires importation. Advanced water treatment technologies are often considered to be costly; however, due to the high cost of moving water from one location to another, traditional water supply approaches may also be costly. For example, a water treatment plant may be capable of treating a local brackish groundwater source at a fraction of the cost of a lengthy pipeline to deliver fresh water from miles away. At what pipeline length will treatment be cost competitive? Clearly the answer to this question is site-specific and depends on a number of factors. However, treating locally available impaired water allows for local control of water supplies and may reduce the cost of increasing water supplies.

Using two previously conducted Reclamation studies: Upper Arkansas River Basin Public Water Supply Alternatives Viability Analysis Water Supply Alternatives for Hamilton, Kearny, and Finney Counties, Kansas and the Colorado River Basin Studies, we compiled a list of key factors used to determine the feasibility of AWT compared to other water supply methods

The case studies identified the primary concern with AWT compared to pipelines was the waste disposal of treatment residuals and brine. However, construction costs for AWT are generally lower than for pipelines; annual operating and maintenance costs are higher for AWT, yet the lifecycle costs are similar or slightly lower for AWT compared to pipelines. Some of the key challenges for pipelines compared to AWT are the permitting requirements, potential for land disturbances and the need for easements and access to land. Additionally, the pipelines were generally considered to be less sustainable.

Case Study No. 1 — Upper Arkansas River Basin Public Water Supply Alternatives Viability Analysis

Introduction

The Upper Arkansas River Basin Public Water Supply Project focused on a viability analysis of water supply alternatives to provide reliable potable water to several small communities along the Arkansas River Valley in Western Kansas. The communities in this analysis included: (1) Coolidge, (2) Syracuse, (3) Hamilton County Rural Water District No. 1 (Hamilton RWD1), (4) Deerfield, and (5) Holcomb, which are located in Hamilton, Kearny, and Finney Counties, west of Garden City. The existing water supplies in these areas consist of bedrock aquifers and the Ogallala Aquifer. Water quality in each of these sources is poor and would require advanced water treatment in order to consistently meet the Environmental Protection Agency's National Primary and Secondary Drinking Water Regulations. As an alternative to advanced water treatment, importation of fresh water sources was also considered.

Alternative Development

For each of the five communities included in the viability analysis, the following key concepts were considered in development of the alternatives:

1. Advanced water treatment for the individual community (nanofiltration or ion exchange, depending on water quality)
2. Development of a regional authority to operate and maintain advanced water treatment facilities for all individual communities
3. Importation of fresh water supply for the individual community
4. Development of a regional authority to operate and maintain importation of fresh water supply for all individual communities
5. Purchase and conveyance of treated water from other public water providers

Evaluation Criteria

In accordance with the *Principles and Guidelines for Water and Related Land Resources Implementation Studies* (Water Resources Council 1983), each alternative was evaluated with respect to four key evaluation criteria: (1) effectiveness, (2) efficiency, (3) acceptability, and (4) completeness. For each evaluation criterion, key factors specific to this project were identified and points were allocated to each factor based on its overall importance to satisfying the key evaluation criterion. The following is a summary of the evaluation criteria and scoring system for this particular project:

1. ***Effectiveness – 18 Points:*** Extent to which the proposed alternative would reliably meet the planning objective by alleviating a specified problem and achieving goals.
   a. ***Quality & Quantity – 8 Points:*** Ability to meet future water demands with sufficient water quality.
   b. ***Constructability – 4 Points:*** Challenges associated with construction of the proposed infrastructure.
   c. ***Operation & Serviceability – 6 Points:*** Challenges associated with operation and serviceability.
2. ***Efficiency – 20 Points:*** Extent to which an alternative is cost effective and is based on preliminary-level capital costs and annual operations and maintenance (O&M) costs.
   a. ***Construction Cost – 12 Points:*** Preliminary capital costs of construction for each alternative.
   b. ***Annualized O&M Cost – 8 Points:*** Preliminary annual O&M costs for each alternative.
3. ***Acceptability – 15 Points:*** Workability and viability of an alternative with respect to how compatible it is with authorities, regulations, policies, and environmental law.
   a. ***Authorities, Regulations & Policies – 5 Points:*** Extent to which the alternative is in conflict with authorities or policies of agencies with statutory jurisdiction.
   b. ***Public Acceptance – N/A (not available at time of report):*** Extent to which construction or operation is accepted by the public.
   c. ***Environmental Considerations – 5 Points:*** Extent to which construction and/or operations would impact the natural environment such as fish and wildlife and culturally sensitive areas.
   d. ***Public Health & Safety – 5 Points:*** Extent of impact to public health and safety.
4. ***Completeness – 15 Points:*** Extent to which an alternative accounts for all necessary investments or other actions to ensure realization of goals.
   a. ***Coordination & Available Water Rights – 5 Points:*** Extent to which multi-organizational coordination would be required for construction and/or operation of proposed facilities.
   b. ***Engineering Uncertainties & Risk – 5 Points:*** Degree of engineering uncertainty and associated risks.
   c. ***Permits, ROW & Easements – 5 Points:*** Extent to which proposed facilities would require permits or clearances which entail risk that could affect the timing or successful completion of the project.

Results

The following provides a summary of the evaluation results for each of the five communities with respect to the previously identified evaluation criteria. “AWT” is noted next to each alternative that involves advanced water treatment of impaired water sources, and "IMP" is noted next to each alternative that involves importation of higher quality raw water, or importation of treated water.

1. **Coolidge**
   a. ***AWT – Shared Regional O&M of Advanced Water Treatment – 59 Points***
   b. IMP – Southwest Kansas Groundwater Management District No. 3 (GMD3) Application in the Paleo Aquifer with Syracuse and Hamilton RWD1 – 57 Points
   c. IMP – GMD3 Application in the Paleo Aquifer with Syracuse – 54 Points
   d. AWT – Advanced Water Treatment of Dakota Aquifer Water – 51 Points
   e. IMP – Individual GMD3 Application in the Paleo Aquifer – 39 Points
2. **Syracuse**
   a. ***IMP – GMD3 Application in the Paleo Aquifer with Coolidge and Hamilton RWD1 – 58 Points***
   b. ***IMP – Administrative Rule Changes in Kansas Water Rights – 58 Points***
   c. IMP – GMD3 Application in the Paleo Aquifer with Coolidge – 52 Points
   d. IMP – GMD3 Application in the Paleo Aquifer with Hamilton RWD1 – 51 Points
   e. IMP – Individual GMD3 Application in the Paleo Aquifer – 42 Points
   f. AWT – Advanced Water Treatment of Dakota Aquifer Water – 35 Points
3. **Hamilton RWD1**
   a. ***AWT – Shared Regional O&M of Advanced Water Treatment – 56 Points***
   b. IMP – GMD3 Application in the Paleo Aquifer with Coolidge and Syracuse – 52 Points
   c. IMP – GMD3 Application in the Paleo Aquifer with Syracuse – 51 Points
   d. AWT – Advanced Water Treatment of Dakota Aquifer Water – 50 Points
   e. IMP – Purchase Treated Water from Lakin – 47 Points
4. **Deerfield**
   a. ***IMP – Wheatland Water Importation from Ogallala Aquifer – 54 Points***
   b. IMP – Purchase Treated Water from Lakin – 53 Points
   c. AWT – Shared Regional O&M of Advanced Water Treatment – 40 Points
   d. AWT – Advanced Water Treatment of Ogallala Aquifer Water – 36 Points
5. **Holcomb**
   a. ***IMP – Wheatland Water Importation from Ogallala Aquifer – 55 Points***
   b. ***IMP – Purchase Treated Water from Wheatland – 55 Points***
   c. AWT – Shared Regional O&M of Advanced Water Treatment – 44 Points
   d. AWT – Advanced Water Treatment of Ogallala Aquifer Water – 42 Points

As shown above, a shared regional authority advanced water treatment solution is recommended for Coolidge and Hamilton RWD1, while various forms of water importation are recommended for Syracuse, Deerfield, and Holcomb. Individual (non-regional) advanced water treatment solutions were not recommended for any of the alternatives.

Key Factors in Advanced Water Treatment vs. Importation

For this particular project, the key factors driving the decision between advanced water treatment versus importation were as follows:

1. ***Annualized O&M Costs*** – In general, the O&M costs associated with an advanced water treatment facility are greater than those for importation of higher quality raw water sources. Advanced water treatment O&M costs are estimated to be reduced by 40 percent where the O&M is regionalized. The O&M costs for importation are significantly influenced by pumping distances and hydraulic gradients.
2. ***Operations and Serviceability*** – Some communities do not have the available resources to operate and maintain an advanced water treatment system. Importation of raw water or treated water can help alleviate the concerns with operability.
3. ***Disposal of Waste Streams*** – The disposal of waste streams (concentrate) from the advanced water treatment facilities creates engineering uncertainties. Contaminants of concern that will require disposal include, but are not limited to, uranium, selenium, and radionuclides.
4. ***Proximity of Alternative Raw Water or Treated Water Sources*** – Construction cost is a key factor in evaluation of advanced water treatment versus importation. Proximity to the nearest viable water source significantly impacts the overall construction costs.

Case Study No. 2 — Colorado River Basin Water Supply and Demand Study

Introduction

The Colorado River Basin Water Supply and Demand Study was conducted to identify current and future water supply and demand imbalances in the Colorado River Basin and surrounding areas that utilize water from the Colorado River. It is recognized that the sustainability of the Colorado River Basin water supply is in question as a result of increasing demands and a diminishing water supply. The purpose of the study was to identify and evaluate alternatives that would aid in mitigation of these water imbalances. The study was completed by the Bureau of Reclamation's Upper and Lower Colorado Regions and agencies representing the Colorado River's seven "Basin States," in collaboration with stakeholders throughout the study area. The study can be found at the following link: http://www.usbr.gov/lc/region/programs/crbstudy.html.

Given the complexities and scale of this project, the final documentation for the study was broken down into an executive summary, a study report, and seven technical reports. The technical reports included the following:

1. Technical Report A – Scenario Development
2. Technical Report B – Water Supply Assessment
3. Technical Report C – Water Demand Assessment
4. Technical Report D – System Reliability Metrics
5. Technical Report E – Approach to Develop and Evaluate Options and Strategies to Balance Supply and Demand
6. Technical Report F – Development of Options and Strategies
7. Technical Report G – System Reliability Analysis and Evaluation of Options and Strategies

This case study summary focuses on water supply options that were developed and analyzed in Technical Report F related to the importation of fresh water versus advanced water treatment of impaired water sources.

Importation and Advanced Water Treatment Options

Importation from freshwater sources and advanced water treatment were both considered in the development of water supply options for the Colorado River Basin Study. The following is a brief summary of the options that were considered related to each of these water supply alternatives:

1. Importation of Freshwater: Fifteen options related to freshwater importation were identified and were categorized into the following three groups:
    a. Importation from the Missouri River or Mississippi River to areas adjacent to the Basin to meet project water shortages and/or reduce water diversions from the Colorado River Basin.
    b. Importation/diversion from the upper headwaters of rivers adjacent to the Green River to the headwaters of the Green River.
    c. Importation from other regions using ocean routes to Southern California coastal areas — includes sub-ocean pipelines from the Columbia River, tanker ships from Alaskan rivers, and tug boat transport of icebergs.
2. Advanced Water Treatment: Fifteen options related to desalination and one option related advanced water treatment of local water supplies were identified. These options were categorized into the following four groups:
    a. Desalination of ocean water along the Southern California coast or near the international border with Mexico, and in the Gulf of California, Mexico.
    b. Regional brackish water desalination of agricultural drainage water diverted upstream of the Salton Sea on the New and Alamo Rivers. The treated water would be discharged to the All American Canal and exchanged for an in-kind amount of reduction in diversions from the Colorado River at Imperial Dam.
    c. Desalination of brackish water in Southern California and Arizona, and refurbishing the Yuma Desalting Plant to allow full-scale production.
    d. Treatment of coal bed methane-produced waters to augment supply in the Colorado River Basin.

Evaluation Criteria

The following is a summary of the evaluation criteria that were used to characterize each of the water supply options:

1. ***Quantity of Yield***: Long-term estimated quantity of water generation characterized by increase in supply or decrease in demand
2. ***Timing***: Estimated timing of availability of the option
3. ***Technical Feasibility***: Feasibility based on the extent of underlying technology or practices
4. ***Cost***: Annualized capital, operating and replacement cost per unit of water yield
5. ***Permitting***: Level of requirements and precedence of similarly permitted projects
6. ***Legal***: Consistency with current legal frameworks and laws or precedence with success in legal cases for similar projects
7. ***Policy Considerations***: Extent of political challenges related to Federal, State, and local policies
8. ***Implementation Risk***: Risk based on funding mechanisms, competing demands for critical resources, challenging operations, or challenging mitigation requirements

9. ***Long-Term Viability***: Reliability to meet objectives over the long-term
10. ***Operational Flexibility***: Flexibility to be idled from year to year with limited financial drawbacks or other impacts
11. ***Energy Needs***: Energy requirements related to treatment, conveyance, and distribution
12. ***Energy Source***: Anticipated energy source to be utilized for operation
13. ***Hydropower***: Anticipated increase or decrease in hydroelectric energy generation with implementation of the option
14. ***Water Quality***: Anticipated improvements or degradation of the water quality associated with implementation of the alternative
15. ***Recreation***: Impacts to in-river and shoreline recreational activities
16. ***Other Environmental Factors***: Impacts to air quality or to aquatic, wetland, riparian, or terrestrial habitats
17. ***Socioeconomics***: Impacts to socioeconomic conditions in regions within or outside the study area

Each water supply option was scored based on a five-point rating system ("A" through "E"). "A" is considered the most favorable rating (5 points), and "E" is the least favorable (1 point).

Results

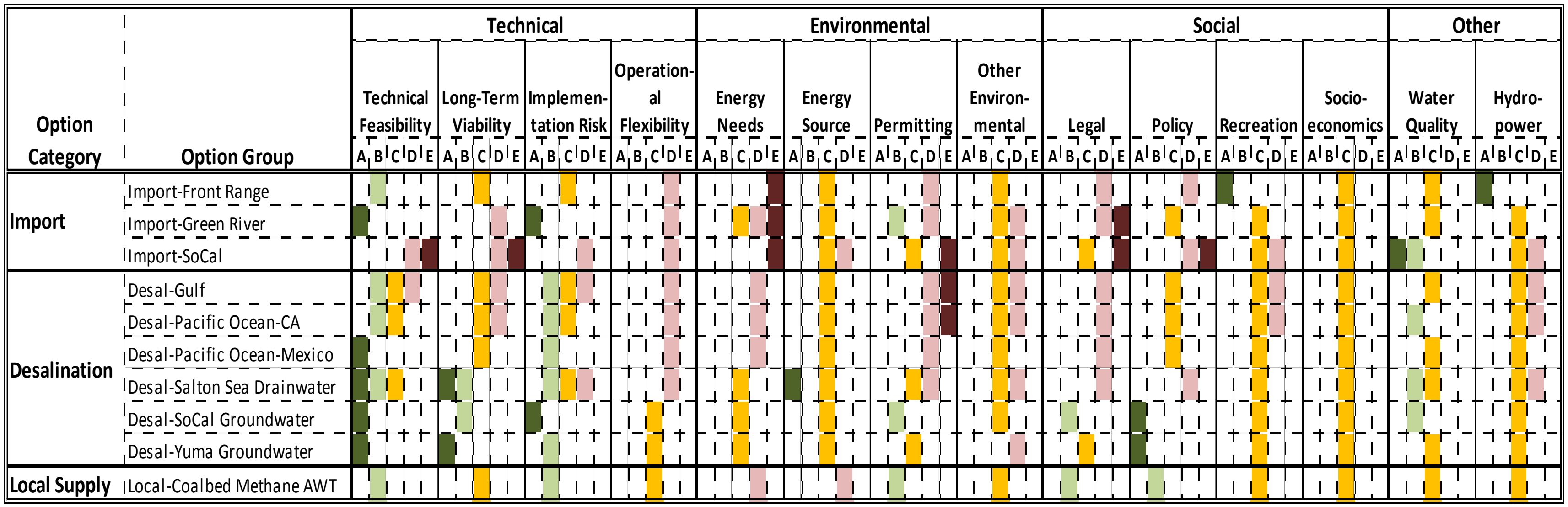
Table 1 provides a summary of the evaluation results based on options characterization ratings, as developed in Technical Report F. This table includes only the key importation and advanced water treatment options that were considered for the Colorado River Basin study.

The quantity of yield, timing and cost evaluation criteria are not included in this table. The following is a summary of ranges for each of these criteria as identified in Technical Report F, Figures F-3, F-4, and F-5.

1. ***Importation***
    a. Front Range: 1,200,000 acre-ft/year (afy), 30-year implementation, $1,700–$2,300/af
    b. Green River: 158,000 afy, 15-year implementation, $720–$1,900/af
    c. Southern California: 2,000,000 afy, 20- to 40-year implementation, $2,700–$3,400/af
2. ***Desalination***
    a. Gulf: 1,200,000 afy, 17- to 20-year implementation, $2,100/af
    b. Pacific Ocean in California: 600,000 afy, 20- to 25-year implementation, $1,850/af
    c. Pacific Ocean in Mexico: 56,000 afy, 15-year implementation, $1,500/af

d. Salton Sea Drainwater: 500,000 afy, 15- to 25-year implementation, $1,000–$1,300/af

Table 1 – Summary of Options Characterization Ratings



Source: Colorado River Basin Water Supply and Demand Study, Study Report, Figure 15, page SR-50.

e. Southern California Groundwater: 20,000 afy, 10-year implementation, $750/af

f. Yuma Groundwater: 100,000 afy, 10-year implementation, $600/af

3. Local Supply

a. Coalbed Methane AWT: 14,000 afy, 10-year implementation, $2,000/af

Given the complexities of this project and the scale of water imbalances, several portfolios were developed that incorporated some or all of these importation and advanced water treatment options. For this particular project, the key parameters of note when comparing these options were: (1) quantity of yield, (2) cost, (3) technical feasibility, (4) long-term viability, (5) implementation risk, (6) policy, and (7) legal considerations. In general, desalination of local groundwater sources in Southern California and Yuma showed favorable characterization ratings at one of the lowest costs per acre-foot. Importation to Southern California from Alaska and the Columbia River was the highest cost option.