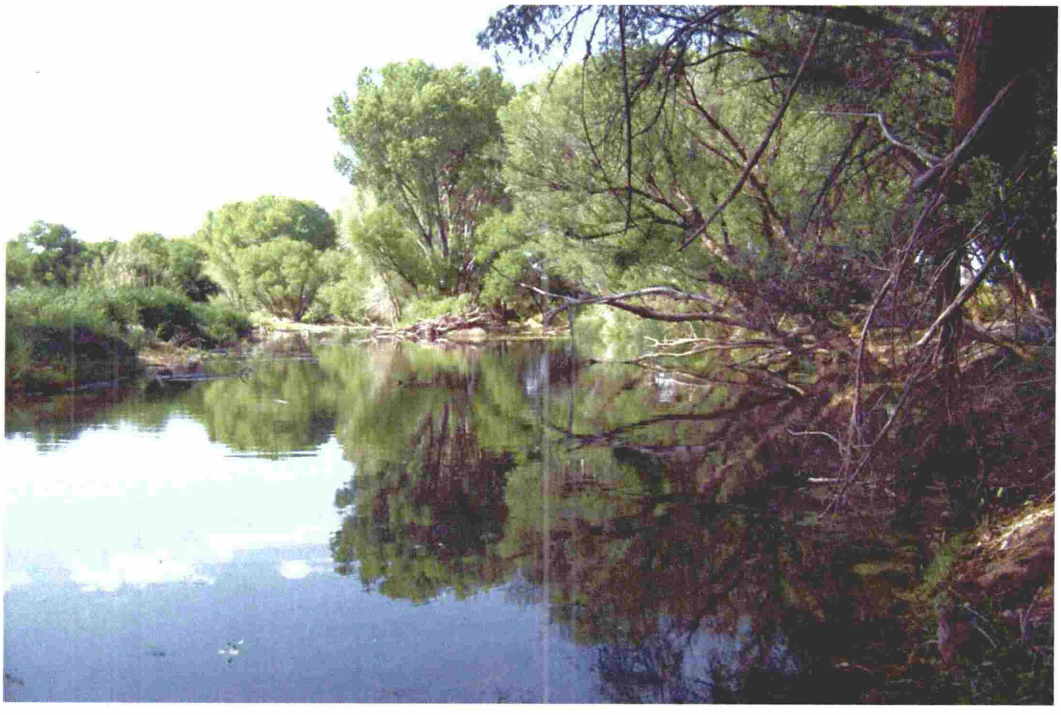
# RECLAMATION

*Managing Water in the West*

Appraisal Report

# Augmentation Alternatives for the Sierra Vista Sub-watershed, Arizona

Lower Colorado Region



U.S. Department of the Interior
Bureau of Reclamation

June 2007

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## Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

*Cover photo*: Courtesy of Dr. Holly Richter, The Nature Conservancy.

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**BUREAU OF RECLAMATION**
**Lower Colorado Region**
**Phoenix Area Office and**
**Technical Service Center, Denver, Colorado**
**Client Support and Technical Presentations Group,**
**86-8010**

# Augmentation Alternatives for the Sierra Vista Sub-watershed, Arizona

## Acknowledgements

This report summarizes the appraisal process undertaken by Reclamation with the assistance of the Upper San Pedro Partnership to evaluate water augmentation alternatives for the Sierra Vista Sub-watershed.

We want to acknowledge individuals from agencies that contributed to the report: Tom Runyon, Gretchen Kent, and Mike Shaughnessy - Fort Huachuca; Pat Call, Jody Klein, Carl Robie, Mark Apel, and Allon Owen - Cochise County; Bill Childress and Dan Moore - BLM, Bob Strain, Chuck Potucek, George Michael, and Mike Hemesath - city of Sierra Vista; Maynard Kreps and Ted White - city of Bisbee; Robert Reames – city of Tombstone; Jim Leenhouts – USGS; Dave Goodrich, Lanie Levick, and Russ Scott - USDA-ARS; Sherry Barrett and Jason Douglas – USFWS; Holly Richter and Jean Marie Haney - The Nature Conservancy; Trisha Gerrodette and Bill Brannan - Audubon Arizona; Tom Whitmer and Rich Burtell – ADWR; Judy Gignac - Bella Vista Ranches, Mary Ann Black, Arizona Association of Conservation Districts; Lynn Slagle, Rencie Woolsey, and Lanna Hendrickson – USPP. I want to especially thank Carol Sanger, USPP Executive Director, who has made very positive changes in USPP operations, which in turn have helped with the augmentation planning process.

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*Eric Holler, P.E.*
*Program Manager*

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# Acronyms and Abbreviations

| | |
|---|---|
| ACC | Arizona Corporation Commission |
| ADEQ | Arizona Department of Environmental Quality |
| ADWR | Arizona Department of Water Resources |
| afy | acre-feet per year |
| AHI | Area of Hydrologic Impact |
| AMA | Active Management Area |
| APP | Aquifer Protection Permit |
| A.R.S. | Arizona Revised Statutes |
| ASR | aquifer storage and recovery |
| AWBA | Arizona Water Banking Authority |
| AZPDES | Arizona Pollutant Discharge Elimination System (see NPDES) |
| BLM | Bureau of Land Management |
| BO | Biological Opinion |
| CAGRD | Central Arizona Groundwater Replenishment District |
| CAP | Central Arizona Project |
| CAWCD | Central Arizona Water Conservation District |
| CQM | Copper Queen Mine |
| CT | Conventional Treatment |
| DOI | U.S. Department of the Interior |
| ESA | Endangered Species Act |
| ExCom | Executive Committee |
| Fort | U.S. Army's Fort Huachuca |
| GAC | USPP Government Affairs Committee |
| GPCD | gallons per capita per day |
| IGA | intergovernmental agreement |
| INA | Irrigation Non-expansion Area |
| MF | microfiltration |
| mg/L | milligrams per liter |

| | |
|---|---|
| NEPA | National Environmental Policy Act |
| NPDES | National Pollutant Discharge Elimination System (see AZPDES) |
| NPS | National Park Service |
| NTU | Nephelometric Turbidity Unit |
| O&M | operation and maintenance |
| PAC | USPP Partnership Advisory Commission |
| ppm | parts per million |
| Reclamation | Bureau of Reclamation |
| RO | reverse osmosis |
| SDI | Silt Density Index |
| SDWA | Safe Drinking Water Act |
| Section 321 | Section 321, 1994 National Defense Authorization Act |
| SPRNCA | San Pedro Riparian National Conservation Area |
| SSF | slowsand filtration |
| SV WRF | Sierra Vista Water Reclamation Facility |
| SWG | USPP Staff Working Group |
| TDS | total dissolved solids |
| Tech | USPP Technical Committee |
| UF | ultrafiltration |
| USDA | U.S. Department of Agriculture |
| USF | Underground Storage Facility |
| USFS | U.S. Forest Service |
| USFWS | U.S. Fish and Wildlife Service |
| USPP | Upper San Pedro Partnership |
| WIFA | Water Infrastructure Financing Authority |
| WWTP | wastewater treatment plant |

# Executive Summary

## Need for the Study

The Upper San Pedro Basin stretches from the United States-Mexico border to about 11 miles north of the town of Benson, Arizona. The San Pedro River (SPR), the main surface-water feature, flows north out of Mexico through the center of the valley. The Sierra Vista Sub-watershed makes up the southern portion of the Upper San Pedro Basin, beginning at the border and extending to the watershed divide which intersects the SPR near Tombstone, Arizona.

A section of the SPR was protected by Congress in 1988 as the San Pedro Riparian National Conservation Area (SPRNCA). Adjacent to the SPRNCA is the U.S. Army's Fort Huachuca, the largest employer in the area, which greatly benefits not only southeast Arizona but the entire State's economy. Preserving these two important Federal assets requires augmenting the local water supply.

Development near Sierra Vista has resulted in a substantial groundwater overdraft that negatively impacts the San Pedro River. Groundwater is the primary water source for the approximately 76,000 residents of the Sierra Vista Sub-watershed. It is also essential in sustaining the base flow of the SPR and its riparian ecosystem. Outflow from the regional aquifer, including water withdrawn by pumping, exceeds natural inflow. As a result, groundwater levels are declining and groundwater storage is being depleted in specific areas in the Sierra Vista Sub-watershed (Section 321 Annual Report for 2004).

Aquifer storage depletion was estimated to have been about 3,500 acre feet in 2004. As the population in the Sierra Vista Sub-watershed grows, so will pumping, from about 19,000 acre-feet per year (afy) in 2005 to an estimated 38,500 afy by 2050.

## Upper San Pedro Partnership

The Upper San Pedro Partnership (USPP), a consortium of 21 Federal, State, local and private agencies and organizations, was established in 1998. Its mission is to

meet the long-term water needs of the Sierra Vista Sub-watershed by achieving sustainable yield[1] of the regional aquifer by 2011 and beyond to:

(1) Preserve the San Pedro Riparian National Conservation Area
(2) Ensure the long-term viability of Fort Huachuca

## Section 321

In 2004, Section 321 of the National Defense Authorization Act (Section 321) formally recognized the USPP and directed it to prepare annual reports on progress toward the goal of "sustainable yield" by September 30, 2011. Section 321 also requires the USPP to monitor and verify the overdraft reduction each year and to identify the contribution of USPP members in reducing the overdraft. The USPP has identified projects that, if implemented, will augment, recharge, and conserve water to yield an estimated 11,000 acre feet by the year 2011.

## Augmentation Appraisal Study

To meet long-term water needs and achieve sustainable yield, the USPP realized that augmentation would be a necessary component of an overall water resource management plan. The purpose of this appraisal study is to identify structural ways to augment the water supply in the Sierra Vista Sub-watershed, to help the USPP achieve sustainable yield.

As part of the appraisal study process, the USPP worked closely with Reclamation to develop a detailed problem statement, which identified the goal of water augmentation as a part of the larger USPP water management strategy.

**Problem Statement:**

> *Water levels in parts of the regional aquifer of the Sierra Vista Sub-watershed are declining, with the potential to impact the hydrologic conditions of the San Pedro Riparian National Conservation Area. A set of water augmentation solutions is needed that would add approximately 10,000 acre-feet a year (afy) by 2011 and 26,000 afy by 2050, to negate a portion of the 38,500 afy total demand projected by 2050. Water augmentation would supplement existing and future recharge, reuse, conservation and other water resource management solutions implemented in the Sub-watershed.*

[1] "Sustainable yield" is defined as the management of groundwater in a way that it can be maintained for an indefinite period of time, without causing unacceptable environmental, economic, or social consequences.

Several types of water supply augmentation alternatives were analyzed. End uses include serving municipal and industrial demand, as well as recharge at an area or areas of maximum benefit for the SPRNCA. Some alternatives involved importing water; others consisted of treating and using poor quality water within the Sub-watershed. The possibility of capturing and using stormwater was also examined. The designs provided use existing data, and developed new data, in order to generate conceptual plans. The analyses provide enough detail to make informed policy and management decisions. Augmentation alternatives analyzed by Reclamation during the appraisal process are listed below:

*Intra-basin Transfer Alternatives:*

A1. **Tombstone Mine Workings to Fort Huachuca WWTP:** Recover and convey mine water to the Fort Huachuca Wastewater Treatment Plant, for use in the Fort's reclaimed water system.

A2. **Tombstone Mine Workings to SPRNCA Recharge:** Recover, treat, and convey mine water to the SPRNCA for recharge.

B. **Retire Agriculture North of Benson to Fort Huachuca/Sierra Vista:**

Retire agricultural pumping north of Benson, Arizona and convey a portion to Fort Huachuca and/or the Sierra Vista area for municipal use.

C1. **Copper Queen Mine to Fort Huachuca/Sierra Vista:** Recover, treat and deliver water from Bisbee's Copper Queen Mine to Fort Huachuca and/or Sierra Vista for municipal use.

C2. **Copper Queen Mine to Bisbee and Naco:** Recover, treat and deliver water from Bisbee's Copper Queen Mine to Naco and Bisbee for municipal use, with recharge of excess into Greenbush Draw.

C3. **Copper Queen Mine to SPRNCA Recharge:** Recover and treat water from Bisbee's Copper Queen Mine, convey to the SPRNCA for recharge.

*Inter-basin Transfer Alternatives:*

D1. **Extend Central Arizona Project to Sierra Vista, Recharge and Recovery of Municipal Supplies, with San Pedro River Recharge:** Recharge and recover CAP water in the Area of Hydrologic Impact for municipal use, as well as recharge near the SPR to sustain flows.

D2. **Extend Central Arizona Project to Sierra Vista, Direct Delivery of Municipal Supplies, with San Pedro River Recharge**: Treat and directly deliver CAP water for municipal use, as well as recharge near the SPR to sustain flows.

E1. **Relocate Bisbee Municipal Wells to Douglas Basin:** Develop new wells in Douglas Basin, convey water to Bisbee for municipal use.

E2. **Relocate Fort Huachuca and/or Sierra Vista Municipal Wells to Douglas Basin:** Develop new wells in Douglas Basin, convey water to Fort Huachuca and/or Sierra Vista for municipal use.

*Local Alternatives:*

F1. **Capture and Reuse of Residential Stormwater:** Capture, treat and non-potable indoor reuse of stormwater from roofs and patios of a new subdivision.

F2. **Capture and Reuse of Commercial Stormwater:** Capture, treat and non-potable reuse of stormwater from roofs of a new commercial or industrial building.

G1. **Recharge Urban Runoff near the SPRNCA:** Collect runoff in urbanized areas of SierraVista, treat and recharge close to the SPRNCA.

G2. **Recharge Urban Runoff to the AHI:** Collect runoff in urbanized areas of SierraVista, treat and recharge between the city of Sierra Vista, where pumping is taking place, and the San Pedro River.

H. **No Action Alternative:** No Federal actions associated with augmenting groundwater use or recharging the aquifer within the Sierra Vista Sub-watershed would be implemented.

## The Screening Process

The screening process was designed to compare and contrast the augmentation projects and to recommend which ones should be explored in more detail. Alternatives were evaluated for three key factors:

- Effectiveness (meeting objectives, solving the problem)
- Implementability (identifying technical and administrative constraints and determining that the alternative could be accomplished)
- Cost (capital and O&M)

This screening process evaluated alternatives with respect to specific criteria developed by the USPP for effectiveness, implementability, and cost. After rating the alternatives, the workgroup made recommendations to the USPP's governing Partnership Advisory Commission, which officially selected the alternatives to pursue.

The appraisal level information in this report may be used as a starting point for future feasibility studies. A feasibility study is a detailed investigation and must be authorized by an Act of Congress. It determines whether congressional authorization should be sought to implement a project. Feasibility studies contain a detailed environmental analysis pursuant to the National Environmental Policy Act (NEPA).

## USPP Partnership Advisory Commission Recommendations

### Alternatives Recommended for Feasibility Report

**Short term:** Alternatives had yields and a proposed recharge location that offered good benefits to the river in both the short and long term. In addition, there seemed to be no significant legal or regulatory impediments to implementation.

- **G1. Recharge Urban Runoff near SPRNCA**
- **C3. Copper Queen Mine to SPRNCA Recharge**

**Long term**: Alternatives would take longer to implement, but offer substantial benefit, if feasible. These were the only augmentation alternatives that met the 2050 requirements in a single project, or a combination of projects.

- **D1. Extend CAP to Sierra Vista – Recharge and Recovery of Municipal Supplies with San Pedro River Recharge**
- **D2. Extend CAP to Sierra Vista – Direct Delivery of Municipal Supplies with San Pedro River Recharge**

### Alternatives to Pursue without Further Study

Alternatives are easy to implement, using existing technology with no significant regulatory impediments. Though the yields are relatively low, these options offer other advantages, such as public awareness, support and participation, as well as a sustaining flood flows and water quality for the river.

- **F1. Capture and Reuse of Residential Stormwater**
- **F2. Capture and Reuse of Commercial Stormwater**

Alternatives that were held for consideration at a later date, if the primary alternatives cannot be implemented, and alternatives for which no further action is recommended, can be found in the chapter 4 of the report.

## Recommendations for Implementation

In order to proceed with conclusions made by the study, two parallel activities—a decisionmaking process and a legal/institutional process—are recommended.

The decisionmaking activity involves elected officials, water managers, and the public in the next round of the augmentation alternative selection process. This consists of public education, community input, and a feasibility level process for selecting alternative(s). The legal/ institutional activity entails discussions of ownership, operation, financing, and repayment factors. The two activities move forward in parallel: interaction between them is essential for a successful outcome.

### The Decisionmaking Process

An initial step in the decisionmaking process is to use the material from the appraisal study to educate policymakers and the public. Both groups need to fully understand, and then to discuss, the information presented in the study. Subsequently, using information provide by the feasibility study, a procedure should be developed for the final selection of an alternative(s). Reclamation recommends that this procedure include the following elements:

- Develop informational materials and data.
- Identify the most common issues and concerns
- Education, public information, and public involvement

## Legal and Institutional Process

Concurrent with the education and public involvement activities, the legal/institution process will address issues of facility ownership, O&M, financing, and repayment. The following steps are recommended:

- Create organizational structure
- Investigate and develop financing strategies (Federal, State, local)
- Develop repayment strategies
- Determine facility ownership
- Apportion operations and water costs

## USPP Actions

To begin implementing selected alternatives, the following actions are being pursued:

- Pursue the authorization and funding necessary for a Feasibility Study.

- Determine the viability of pursuing the CQM to SPRNCA Recharge alternative.

- Stormwater capture for residential and commercial construction alternatives will be included for implementation in the Partnership's Strategic Plan

- Continue investigating the acquisition of rights to Colorado River or CAP water

This appraisal report documents the development of water augmentation alternatives for the Upper San Pedro Basin's Sierra Vista Sub-watershed, in southeastern Arizona. Chapter 1 introduces the study area, chapter 2 discusses the appraisal planning process used by Reclamation, and chapter 3 describes the alternatives Reclamation investigated. Chapter 4 details the evaluation of the alternatives, and chapter 5 describes future actions recommended for implementation. The appendices provide the complete reports on the alternatives, their ratings, and supporting documentation.

# Chapter I: Introduction

## Needs

The Sierra Vista Sub-watershed is located within the Upper San Pedro Basin in southeast Arizona (Figure 1). The San Pedro River, the main surface-water feature, originates in Mexico and flows north about 145 miles before joining the Gila River. While Sierra Vista is the largest city, the sub-watershed includes the communities of Fort Huachuca, Huachuca City, Tombstone, and Bisbee, as well as rural residents (Figure 2).

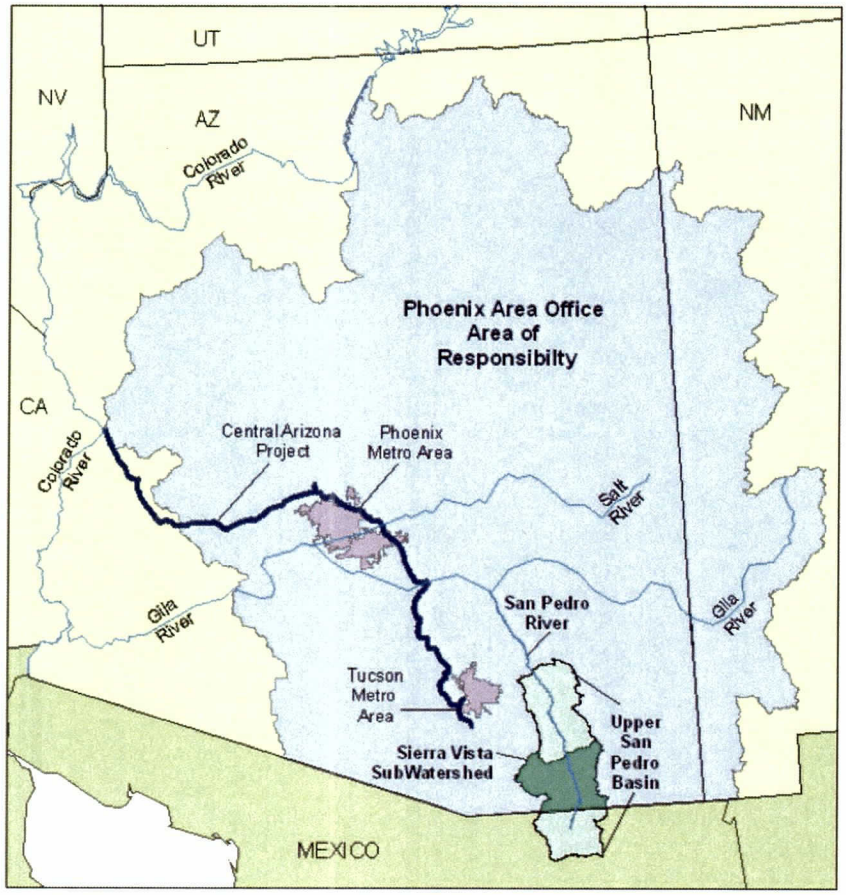



**Figure 1: Study overview map.**

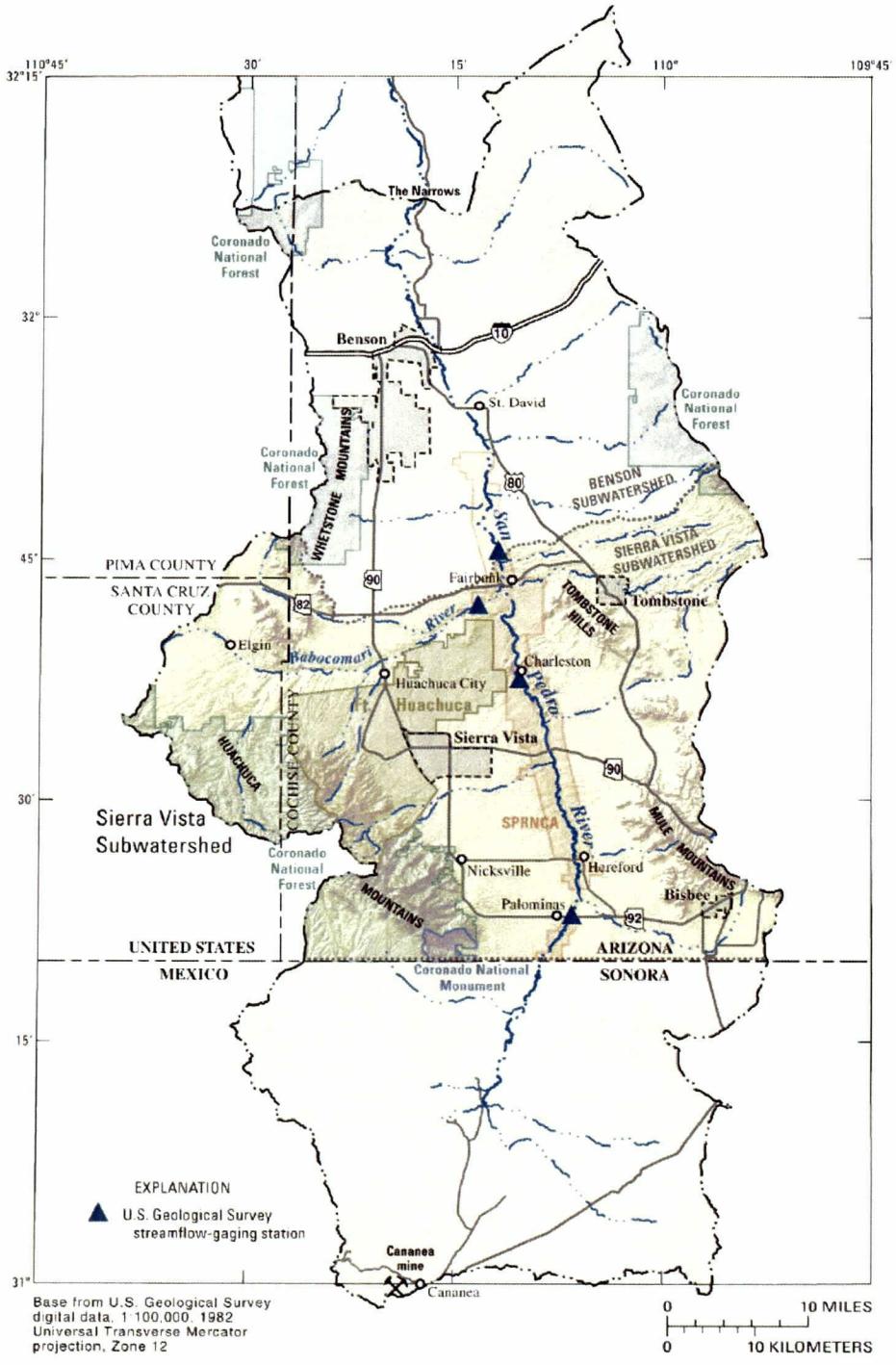



**Figure 2: Location of the Sierra Vista Sub-watershed, Arizona (Source: Section 321 Annual Report for 2004).**

A section of the San Pedro River, one of the most significant perennial desert river reaches in the United States, was protected by Congress in 1988 as the San Pedro Riparian National Conservation Area (SPRNCA). Adjacent to the SPRNCA is the U.S. Army's Fort Huachuca (Fort), the largest employer in the area, which greatly benefits not only southeast Arizona but the entire State's economy. Preserving these two important Federal assets requires augmenting the local water supply.

Development near Sierra Vista has resulted in a substantial groundwater overdraft that negatively impacts the San Pedro River. Groundwater is the primary water source for the approximately 76,000 residents of the Sierra Vista Sub-watershed. It is also essential in sustaining the base flow of the San Pedro River and its riparian ecosystem. Outflow from the regional aquifer, including water withdrawn by pumping, exceeds natural inflow. As a result, groundwater levels are declining and groundwater storage is being depleted in specific areas in the Sierra Vista Sub-watershed (U.S. Department of the Interior [DOI], 2005 [Also referred to as the Section 321 Annual Report for 2004]).

Aquifer storage depletion was estimated to have been about 3,500 acre feet in 2004 (Section 321 Annual Report for 2005, page 31, Table 3). As the population in the Sierra Vista Sub-watershed grows, so will groundwater pumping, from about 19,000 acre-feet per year (afy) in 2005 to an estimated 38,500 afy by 2050.

Water augmentation is not only necessary to protect the SPRNCA, but also to protect the Fort, since the Fort's groundwater use could indirectly impact endangered species that depend on the San Pedro River.

## Facilities

**Fort Huachuca:** The Fort plays a critical role in national defense through its military intelligence and testing missions, and it is integral to the economic vitality of Cochise County and the State of Arizona. As of 2007, 9,119 people work at the Fort, making it one of the largest employers in southern Arizona (Arizona Daily Star 2007). A 2002 economic impact study estimated that an additional 13,040 local jobs were generated by the Fort-related expenditures. The same study estimated the Fort's local economic impact to be almost $1.5 billion.

The Fort is spread over 73,272 acres directly west of the San Pedro River, and it borders the city of Sierra Vista. The Fort's northern border parallels the Babocomari River, a tributary to the San Pedro River.

- **SPRNCA:** The SPRNCA is a section of the San Pedro River and the bordering riparian area that was formally protected through Public Law 100-696 in 1988. The SPRNCA extends about 43 miles north from the international boundary with Mexico to St. David, Arizona, and is up to 5 miles wide in some areas. The Bureau of Land Management (BLM) manages the SPRNCA's 58,000 acres to conserve, protect, and enhance the natural resources of this ecologically diverse riparian system.

  The SPRNCA is considered one of the most significant perennial desert river reaches in the United States. It provides an important natural asset for residents and the tens of thousands of tourists who visit each year (Orr and Colby 2002). The SPRNCA serves as a primary corridor for the migration of approximately 4 million birds, representing 250 species. It also provides vital habitat for an additional 100 species of resident birds, 81 species of mammals, 43 species of reptiles and amphibians, and 2 threatened species of native fish (the spikedace and loach minnow). The SPRNCA is recognized as "One of the Last Great Places in the World" by The Nature Conservancy and is designated as a "Globally Important Birding Area" by the American Bird Conservancy.

## Groundwater Deficit

As a result of groundwater overdraft, a cone (or cones) of depression in the regional aquifer has formed along the boundary between the Fort and Sierra Vista. Pumping has lead to the formation of a cone of depression, which captures groundwater that would otherwise flow to the river (Arizona Department of Water Resources [ADWR] 1991, 1994; ASL 1995; Fenske 1998; Fort 2002). Modeling suggests that the declining water levels will eventually diminish groundwater subflow and surface flow to the river. For example, reaches of the San Pedro River near Palominas, where perennial surface flows used to occur, have become intermittent (personal communication, Dr. Holly Richter, Nature Conservancy, 4/9/2007). A cone of depression has also affected flow patterns in the nearby Babocomari River, where base flow is severely depleted or absent during the dry season (Schwartzman 1990).

The Fort continues to implement water conservation and recharge measures as part of its responsibilities under the Endangered Species Act (ESA). Since 1995, the Fort has reduced its groundwater pumping by more than 50 percent.

Still, the Fort's actions will not eliminate the groundwater deficit in the Sierra Vista Sub-watershed. Without a concerted effort to reverse these trends, the most likely future scenario is continued groundwater mining, enlargement of the cone of depression, and dewatering of more portions of the San Pedro River.

Dewatering the San Pedro River will degrade wetland and riparian vegetation and cause changes in species composition (ADWR 1994, Stromberg et al. 1996, U.S. Fish and Wildlife Service [USFWS] 2002).

## Upper San Pedro Partnership

The Upper San Pedro Partnership (USPP), a consortium of 21 Federal, State, local, and private agencies and organizations, was established in 1998. Table 1 lists the USPP members. Its mission is to meet the long-term water needs of the Sierra Vista Sub-watershed by achieving sustainable yield[2] of the regional aquifer by 2011 and beyond to:

(1) Preserve the SPRNCA
(2) Ensure the long-term viability of the Fort

**Table 1: USPP members**

| Federal | Local |
|---|---|
| Fort Huachuca<br>Bureau of Land Management (BLM)<br>U.S. Forest Service (USFS)<br>National Park Service (NPS)<br>Reclamation<br>U.S. Geological Survey (USGS)<br>U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS)<br>U.S. Fish and Wildlife Service (USFWS) | Cochise County<br>City of Sierra Vista<br>Huachuca City<br>City of Bisbee<br>City of Tombstone |
| **State** | **Private and non-governmental** |
| State Land Department<br>Arizona Department of Environmental Quality (ADEQ)<br>Arizona Department of Water Resources (ADWR)<br>Hereford Natural Resource Conservation District | The Nature Conservancy<br>Audubon Arizona<br>Bella Vista Ranches<br>Arizona Association of Conservation Districts |

## Section 321

In 2004, Section 321 of the National Defense Authorization Act (Section 321) formally recognized the USPP and its efforts to establish a collaborative water use

[2] "Sustainable yield" is defined as the management of groundwater in a way that it can be maintained for an indefinite period of time, without causing unacceptable environmental, economic, or social consequences.

management program in the Sierra Vista Sub-watershed. Section 321 directed the USPP to prepare annual reports on progress toward the goal of sustainable yield by September 30, 2011. This goal, at least initially, is measured by eliminating annual deficits from the regional aquifer and then by accreting storage, with the intent of replenishing some of the depletion. Section 321 of the 2004 National Defense Authorization Act is reprinted in Appendix D.

Section 321 also requires the USPP to monitor and verify the overdraft reduction for each fiscal year and to identify the contribution of each USPP member in reducing the overdraft. An interagency science plan has been designed to complete this task. The BLM, USGS, and the USDA-ARS monitor the regional hydrologic system and verify the yields of USPP member projects, to track the overdraft reduction.

## Concept of Sustainable Yield

The USPP has begun to define needs for sustainable yield as shown in Table 2.

**Table 2: Initial criteria for sustainability**

| Social and economic needs | Environmental needs |
|---|---|
| Sufficient water quantity for human needs | Groundwater levels in aquifer within the San Pedro Riparian NCA are maintained |
| Fort remains operational unless for reasons unrelated to water | Stream base flow and flood flows in the river are maintained |
| Cost of living, insomuch as controlled by water, remains within the means of a diverse population | Aquifer storage is increased |
| Local participation in water management | Riparian habitat and ecologic diversity are maintained |
| Water quality is maintained | Water quality is sustained in river |
| | Overall riparian condition is maintained |
| | Springs in the SPRNCA continue to flow |

Although a simple water-budget approach is easily applied and readily understood, it does not consider aspects of sustainability such as spatial water-use management. To reach sustainable yield, the USPP is aiming to balance the water budget and to effectively manage where water is pumped and recharged back into the aquifer.

As a result, an aquifer response approach will be developed to evaluate progress toward sustainable yield. A monitoring program has been initiated to measure the responses of the regional aquifer system to water-use management actions. The USPP will continue to track estimated yields from projects and to consider the yields relative to a sub-watershed water budget.

## USPP Committees

The USPP committees listed below participated in developing this appraisal report. As the USPP adapts its organizational structure, committees are created and dissolved to respond to changing needs. Therefore, some of the committees listed below were later dissolved in an effort to streamline the USPP's administration.

- *Executive Committee (ExCom)*
  The ExCom carries out day-to-day USPP activities, including project implementation, identifying funding sources, and addressing legislative impediments to achieving sustainable yield. It also coordinates the other committees.

- *Partnership Advisory Commission (PAC)*
  PAC establishes overall policy and direction for the USPP and acts in the role of a "Board of Directors" to approve strategic plans, make policy, establish legislative agendas, and maintain overall cognizance of Partnership activities.

- *Staff Working Group (SWG)*
  SWG recommends Partnership plans and prepares planning and reporting documents. It prioritizes and tracks projects and actions of the USPP member agencies, and establishes criteria for award of partnership grants.

- *Government Affairs Committee (GAC)*
  GAC recommends the legislative agenda for the USPP and pursues the agenda with the appropriate government bodies at the State and Federal levels. It maintains USPP relationship with lobbyists and tracks legislative developments of concern to the USPP.

- *Technical Committee (Tech)*
  Tech performs the scientific and engineering functions of the USPP. It commissions and reviews studies and makes technical recommendations to other USPP committees and PAC regarding proposed projects. It also ensures the technical sufficiency of USPP products.

## USPP Actions

The USPP has invested significant resources towards identifying, evaluating and documenting water-management measures to attain sustainable yield. It has initiated and funded studies to improve understanding of the regional hydrologic system, the riparian ecosystem, and the process of groundwater recharge. The USPP has implemented a strategy of adaptive management so that management measures may be added, eliminated, or modified as necessary, to meet the goal of sustainability.

Prior to the enactment of Section 321, residents and policymakers in the Sierra Vista Sub-watershed were actively seeking solutions to water issues. Earlier conservation efforts resulted in substantial reductions in net water use. Thus, to determine the effect of the USPP adaptive management program, estimates of yield under Section 321 used 2002 as the baseline year.

The USPP has identified projects that, if implemented, will augment, recharge, and conserve water to yield an estimated 11,000 acre feet by the year 2011 (Figure 3).

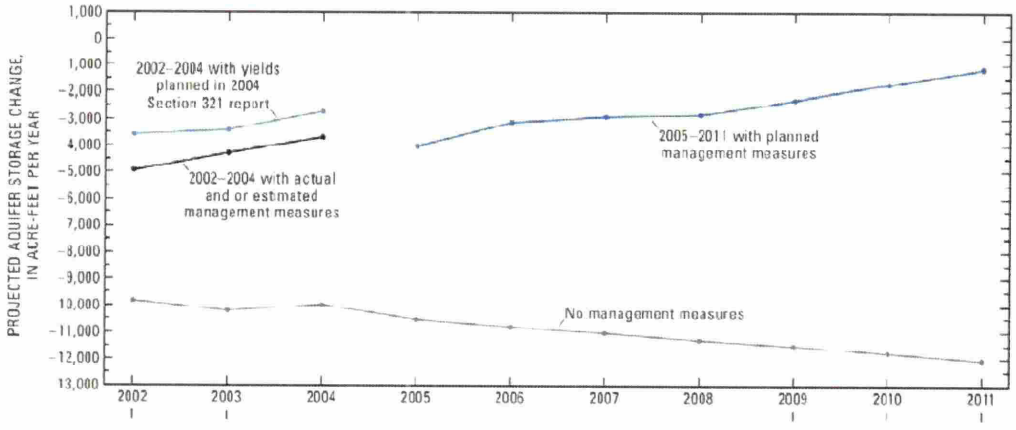



**Figure 3: Projected aquifer storage change in acre-feet per year (Source: Section 321 Annual Report for 2005).**

## Augmentation Appraisal Study

### Purpose

To meet long-term needs and achieve sustainable yield, the USPP realized that a comprehensive water resource management plan would be necessary, and that augmentation would be an important component of the plan. This purpose of this appraisal study is to identify structural ways to augment the water supply in the Sierra Vista Sub-watershed to help the USPP achieve sustainable yield.

### Reclamation's Involvement

Reclamation's direct involvement with water resource issues in the Sierra Vista Sub-watershed began in 1996, with a project to recharge treated effluent. Reclamation provided $1.5 million in funding under a cooperative agreement with the city of Sierra Vista, towards construction of the Sierra Vista Water Reclamation Facility. The recharged effluent was to create a groundwater mound to act as a hydrologic barrier between the cone of depression and the San Pedro River, thereby slowing the progression of the cone of depression towards the river

and sustaining the base flow. The facility was completed and brought into operation in 2002. Reclamation is currently evaluating the effectiveness of the facility.

The USPP commissioned a study examining alternatives for water conservation, reclamation, and augmentation, using consultants (BBC/Fluid Solutions Report 2003). The USPP's intent was to compare the augmentation alternatives and implement one or more of them to offset the groundwater pumping taking place in the Sierra Vista Sub-watershed. However, the number of alternatives, their complexity, and the lack of concrete information presented in the study prompted the USPP to seek long-term assistance. At USPP's request, Reclamation agreed to assist with the augmentation portions of an overall water management plan.

Reclamation signed an Intergovernmental Agreement (IGA) with the city of Sierra Vista, fiscal agent for the USPP, which formalized the assistance in November 2003. The IGA identified tasks, including facilitating development of a water management plan and the analysis of additional augmentation alternatives. Reclamation was admitted as the 21st member of the USPP on February 11, 2004.

In April 2004, Reclamation suggested a planning process to help the USPP make sound decisions. Reclamation's planning process includes identifying the problem, developing a long list of alternatives, analyzing alternatives, and screening the long list into a short list. At the same time, the USPP requested that Reclamation re-examine particular augmentation alternatives found in the BBC/Fluid Solutions Report (2003). Reclamation agreed to review the information and identify any data gaps needed to undertake the screening process. A "write-in" to the fiscal year 2005 budget officially authorized a Sierra Vista/Upper San Pedro Study under Reclamation's South/Central Arizona Investigations Program.

## Background

### Study Location

The Upper San Pedro Basin[3] is a groundwater management unit which stretches from the United States-Mexico border to a bedrock constriction, the "Narrows," about 11 miles north of Benson, Arizona (see Figure 2). The basin is bounded on

[3] The Upper San Pedro Basin is formally defined by statute in the Arizona Groundwater Management Act of 1980. The hydrologic boundaries of the Upper San Pedro Basin (a groundwater unit) and the San Pedro surface water drainage do not coincide, although the differences are minor. This report makes no attempt to resolve these differences in terminology.

the west by the Huachuca Mountains and on the east by the Mule Mountains and Tombstone Hills. The San Pedro River flows north out of Mexico through the center of the valley.

The Sierra Vista Sub-watershed makes up the southern portion of the Upper San Pedro Basin, starting at the United States-Mexico border and extending to the watershed divide, which intersects the San Pedro River at the gauging station near Tombstone, Arizona. The area within these bounds is an alluvium-filled valley with surfaces that slope gradually down from the base of the mountains to the San Pedro River. These alluvial sediments constitute the Sierra Vista Sub-watershed's regional aquifer.

## Climate

The climate of the Sierra Vista Sub-watershed is semiarid. A basin-wide annual average rainfall of 16.1 inches was calculated using records from 1956 to 1997, from four precipitation stations (Pool and Coes 1999). Precipitation is typically greater on the basin-bounding mountain ranges than on the valley floor. About 65 percent of the annual precipitation comes in late summer thunderstorms, with the remainder generally arriving in winter storms (Goodrich et al. 2000).

## Population

The Sierra Vista Sub-watershed supports a population of about 76,000 (Arizona Department of Economic Security, 2005) that is distributed among the municipalities of Bisbee, Sierra Vista, Huachuca City, and Tombstone, as well as unincorporated rural areas. Sierra Vista, the sub-watershed's largest city, had a population of about 44,870 in 2006 (Arizona Department of Economic Security, 2007), which includes the permanent residents of the Fort.

# Chapter II: Appraisal Process

## General Appraisal Study Approach and Description

The appraisal study process provides brief investigations of alternatives to solve a perceived problem. Appraisal-level designs provide enough detail to make informed policy and management decisions. These analyses provide conceptual solutions to help:

- Determine if there is a potentially workable alternative
- Look for fatal flaws in the alternatives
- Determine the need for continued Reclamation involvement
- Provide a basis for requesting feasibility authority from Congress

The appraisal process Reclamation followed involves several steps, including problem identification and development of evaluation criteria. Figure 4 illustrates this process. It begins with the creation of a long list of alternatives and an analysis of each one. After the analyses, the long list of alternatives is screened, using evaluation criteria. The result is a short list of the most viable alternatives.

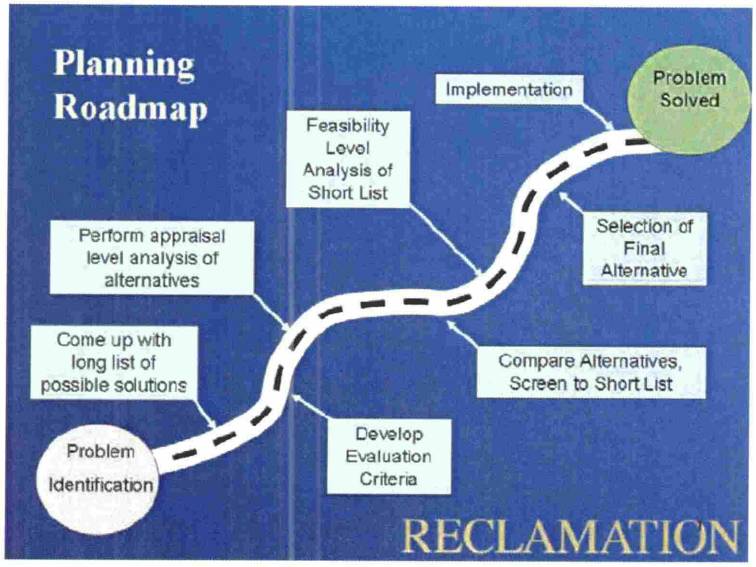



**Figure 4: Planning roadmap for augmentation alternatives.**

## Determining the Problem

To meet long-term water needs and achieve sustainable yield of the regional aquifer by 2011, the USPP realized that augmentation would be a necessary component of an overall water resource management plan.

As part of the appraisal study process, the USPP worked closely with Reclamation to develop a detailed problem statement that would be instrumental in identifying alternatives. The problem statement explicitly identified the goal of augmentation as a part of the larger USPP water management strategy.

**Problem Statement:**

> *Water levels in parts of the regional aquifer of the Sierra Vista Sub-watershed are declining, with the potential to impact the hydrologic conditions of the San Pedro Riparian National Conservation Area. A set of water augmentation solutions is needed that would add approximately 10,000 afy by 2011 and 26,000 afy by 2050 to negate a portion of the 38,500 afy total demand projected by 2050. Water augmentation would supplement existing and future recharge, reuse, conservation, and other water resource management solutions implemented in the Sub-watershed.*

*Calculation assumptions include:*

- *2050 sub-watershed population of 170,000 people—based on the projections of the Section 321 2005 Annual Report extrapolated out to 2050.*
- *Actual GPCD for 2004, which includes all water uses—population, recreation, industrial, and agricultural.*
- *All figures are estimates based on current available information for planning purposes only. They will need to be refined over time as new information becomes available.*

## Developing and Evaluating Alternatives

### Identifying Alternatives

The initial goal of the Reclamation – USPP IGA was to evaluate three new augmentation alternatives:

- Removing, treating, and delivering water from the Tombstone mine workings to the Sierra Vista area
- Retiring agricultural land north of Benson and relocating the Sierra Vista area well fields to this location
- Extracting, treating, and delivering water from the Copper Queen Mine (CQM) in Bisbee to the Sierra Vista area

These studies were designed to allow comparison with alternatives assessed in the 2003 BBC/Fluid Solutions Report. The new alternatives would be added to the original BBC/Fluid Solutions alternatives to create a long list of potential solutions. Reclamation would then facilitate the USPP's selection of viable alternatives, using the appraisal process.

## Adding Alternatives

In late 2004, the USPP requested two additional evaluations. The first was an update to a 1993 scoping report on the extension of the Central Arizona Project (CAP) to the Sierra Vista area, emphasizing a current cost estimate. After reviewing the 1993 report, Reclamation recommended a more detailed analysis of this alternative. The USPP concurred and requested that Reclamation proceed.

The second request was a study of stormwater harvesting alternatives. This included the capture and reuse of rainwater on both commercial and residential properties and the collection and recharge of urban runoff. These alternatives were developed using information from many sources, including a new Cochise County Flood Control / Urban Runoff Recharge Plan.

## Analyzing Alternatives to a Special Study Level of Detail

A more in-depth level of investigation was necessary given the cost and resource impacts of the augmentation alternatives. For this reason, the analyses were performed at a "Special Study"[4] level.

## Developing an Appraisal Process Work Plan

In January 2005, Reclamation provided the USPP with a work plan outlining activities required for the appraisal process. Per the work plan, Reclamation committed to reviewing selected alternatives in the BBC/Fluid Solutions report and identifying data gaps that would need to be filled to make the alternatives comparable with the "Special Study" level analyses. After reviewing the

[4] Special studies, unlike appraisal reports, use both existing and new information. Similar to appraisal level studies, they are investigations that evaluate solutions that may lead to resource management decisions but are not intended to lead to Federal actions requiring congressional authorization.

BBC/Fluid Solutions report, Reclamation provided a summary of the appropriateness of its information and detailed the data gaps that would need to be addressed.

## Reviewing and Finalizing Alternatives with the USPP

In general, the analysis of each alternative was reviewed in several iterations by the Technical Committee. Progress and results of the analysis of each alternative were relayed to the Staff Working Group, Government Affairs Committee and the USPP Partnership Advisory Commission.

Once technical aspects of alternatives had been evaluated with input from GAC, SWG and Tech, the PAC finalized the alternatives, especially with respect to policy and political issues.

## Evaluating Alternatives

A special USPP group, consisting of members of the SWG, Tech and GAC committees, was formed to evaluate and screen the augmentation alternatives.

Alternatives were evaluated for three key factors:

- Effectiveness (meeting objectives, solving the problem)
- Implementability (identifying technical and administrative constraints and determining that the alternative could be accomplished)
- Cost (capital and operation and maintenance [O&M])

Some alternatives were eliminated from consideration during this phase, with supporting documentation showing why they were discarded. The end result of this process was a short list of potential solutions.

# Chapter III: Augmentation Alternatives

This chapter briefly describes the appraisal level augmentation alternatives investigated by Reclamation on behalf of the USPP. The designs in this section are preliminary—existing data have been used to generate conceptual plans. The analyses provide enough detail to initiate a dialogue with interested parties and permit informed policy and management decisions.

After completing the appraisal level studies, a screening process is used to evaluate whether a given alternative merits further consideration. This process involves rating each alternative on how well it meets each of the evaluation criteria. This allows technical experts, policymakers, managers, and the public to make informed decisions about whether the alternative is viable.

The appraisal level information may be used as a starting point for future feasibility studies. A feasibility study is a detailed investigation that must be authorized by an Act of Congress. It determines whether congressional authorization should be sought to implement a project. All feasibility studies contain a detailed environmental analysis pursuant to the National Environmental Policy Act (NEPA) and other related statutes.

Several types of water supply augmentation alternatives were analyzed for this study. End uses include serving municipal and industrial demand, as well as recharge at an area or areas of maximum benefit for the SPRNCA. Some alternatives involved importing water for use in the Sierra Vista Sub-watershed, with sources located both inside and outside the Upper San Pedro Basin. Others consisted of treating and using poor quality groundwater within the Sub-watershed that otherwise would go unused. Finally, the possibility of capturing and using stormwater that would otherwise become runoff was examined. Several "hybrid" variations on the original alternatives were developed during the screening process. Augmentation alternatives analyzed by Reclamation during the appraisal process are listed below.

***Intra-basin Transfer Alternatives:***

A. Water Development Potential of Underground Mine Workings in the Tombstone District

   A1. **Tombstone Mine Workings to the Fort Huachuca Wastewater Treatment Plant (WWTP)**: Recover and convey mine water to the Fort Huachuca Wastewater Treatment Plant, for use in the Fort's reclaimed water system.

A2. **Tombstone Mine Workings to the SPRNCA Recharge:** Recover, treat, and convey mine water to the SPRNCA for recharge.

**B. Retire Agriculture North of Benson to Fort Huachuca/Sierra Vista**

Retire agricultural pumping north of Benson, Arizona, and convey a portion to Fort Huachuca and/or the Sierra Vista area for municipal use.

C. Water Development Potential of the Copper Queen Mine (CQM) in the Bisbee District

C1. **CQM to Fort Huachuca/Sierra Vista:** Recover, treat and deliver water to Fort Huachuca and/or Sierra Vista for municipal use.

C2. **CQM to Bisbee and Naco:** Recover, treat and deliver water to Naco and Bisbee for municipal use, with recharge of excess into Greenbush Draw.

C3. **CQM to SPRNCA Recharge** (hybrid alternative): Recover, treat and recharge water in the SPRNCA

***Inter-basin Transfer Alternatives:***

D. Extend Central Arizona Project to Sierra Vista

D1. **Recharge and Recovery of Municipal Supplies, with San Pedro River Recharge** (hybrid alternative): Recharge and recover CAP water in the Area of Hydrologic Impact (AHI) for municipal use, as well as recharge near the SPR to sustain flows.

D2. **Direct Delivery of Municipal Supplies, with San Pedro River Recharge** (hybrid alternative): Treat and directly deliver CAP water for municipal use, as well as recharge near the SPR to sustain flows.

E. Relocate Sierra Vista Sub-watershed Municipal Wells in Douglas Basin (primary analysis by BBC/Fluid Solutions, 2003)

E1. **Douglas Basin to Bisbee** (WIE 1a in BBC/Fluid Solutions): Develop new wells in Douglas Basin, convey water to Bisbee for municipal use.

E2. **Douglas Basin to the Fort/Sierra Vista** (WIE 1c in BBC/Fluid Solutions): Develop new wells in Douglas Basin, convey water to Fort Huachuca and/or Sierra Vista for municipal use.

*Local Alternatives:*

F. Stormwater Harvesting: Water Development Potential of Rainwater Collection for New Residential Communities and New Commercial/ Industrial Businesses

F1 **Capture and Reuse of Residential Stormwater**: Stormwater captured from the roofs and patios of a new subdivision would be treated in a central facility and put to non-potable indoor use.

F2. **Capture and Reuse of Commercial Stormwater**: Stormwater captured from the roofs of a new commercial or industrial building would be put to non-potable use.

G. Stormwater Harvesting: Water Recharge Potential of Collected Urban Runoff in the Sierra Vista Area

G1. **Recharge Urban Runoff Near the SPRNCA:** Collect runoff in urbanized areas of Sierra Vista, treat and recharge close to the SPRNCA.

G2. **Recharge Urban Runoff to the AHI:** Collect runoff in urbanized areas of Sierra Vista, treat and recharge between the city of Sierra Vista, where pumping is taking place, and the San Pedro River. (This alternative was not evaluated, since alternative G1 was judged to better reflect the USPP's priority on addressing flows in the San Pedro River).

H. **No Action Alternative:** No Federal actions associated with augmenting groundwater use or recharging the aquifer within the Sierra Vista Sub-watershed would be implemented.

An additional hybrid alternative, the Linear Park Recharge project, developed by the Hereford Natural Resource Conservation District, was introduced late in the screening process and is not described in this report.

## Common Issues for Action Alternatives

The following issues would need to be addressed for most of the alternatives.

## Financial

- Where the money funding for construction comes from, how it is paid back, and who pays, must be determined.

- Where the funding for O&M comes from must be determined.

## Environmental and Cultural

- NEPA compliance (either an environmental assessment or an environmental impact statement) is required if the project is partly or wholly funded by the Federal Government.

- Surveys and appropriate consultation under the ESA, Section 7, should be conducted where necessary. Federally listed species may include:

    - Chiricahua Leopard Frog (*Rana chiricahuensis*)
    - Gila Chub (*Gila intermedia*)
    - Jaguar *(Panthera onca)*
    - Lesser Long-nosed Bat (*Leptonycteris curasoae verbabuenae*)
    - Mexican Spotted Owl *(Strix occidentalis lucida)*
    - Northern Aplomado Falcon (*Falco femoralis septentrionalis*)
    - Pima Pineapple Cactus (*Coryphantha scheeri* var. *robustispina*)
    - Loach Minnow (*Rhinichthys cobitis*)
    - Spikedace (*Meda fulgida*)
    - Sonora Tiger Salamander (*Ambystoma tigrinum stebbinsi*)
    - Southwestern Willow Flycatcher (*Empidonax traillii extimus*)
    - Huachuca Water Umbel (*Lilaeopsis schaffneriana* spp *recurva*)
    - Yellow billed cuckoo (*Coccyzus americanus*)
    - Cochise pincushion cactus (*Coryphantha robbinsorum*)

- Other environmental and cultural analyses may include:

    - Addressing potential effects to endangered species in the NEPA document.

    - Walking and surveying pipeline routes for endangered species and cultural resources.

    - Transplanting sensitive plants in right-of-way.

    - Surveying and consulting with Tribes on cultural resource issues.

    - Assessing potential effects to cultural resources by conducting Section 106 consultation with the State Historic Preservation Office.

- Performing cultural resource surveys for the area of potential effect. A Class I survey should be conducted first to determine what areas may have been surveyed recently.

### Permitting and Regulatory Issues

- Section 402 of the Clean Water Act requires a National Pollutant Discharge Elimination System (NPDES) permit if recharge takes place along the stream channel. Consultation with the Arizona Department of Environmental Quality would also be necessary. A NPDES stormwater permit would be needed for certain industrial and construction alternatives that discharge stormwater.

- Permits under Section 404 of the Clean Water Act would be needed for fills associated with pipeline crossings of washes and streams.

- Recharge projects would most likely be implemented under the A.R.S. Title 45 regulations. Under Title 45, ADWR requires recharge facilities within Active Management Areas (AMA) to obtain up to three permits. An Underground Storage Facility (USF) permit allows the permit holder to operate a facility that stores water in the aquifer. A Water Storage Permit allows the permit holder to store water at a USF. A Recovery Well Permit allows the permit holder to recover long-term storage credits or to recover stored water annually. Although these are not required in the Sierra Vista Sub-watershed, because it is outside of an AMA, it is recommended that the USPP comply with State permit guidelines. The guidelines ensure that recharge is effective and does not cause harm to other entities. The required studies can also be used to implement a maintenance, monitoring, and operational regime that ensures optimum recharge efficiency. State regulations regarding the recharge of CAP water are described in Appendix C: Regulatory and Institutional factors.

- Arizona Corporation Commission (ACC) regulations would need to be changed to allow private water companies to charge customers for water that is more expensive than native groundwater. Currently, the ACC typically does not allow the companies to buy more expensive water and pass the cost on to the consumer.

## Intra-basin Transfer Alternatives

### A. Water Development Potential of Underground Mine Workings in the Tombstone District

Poor quality groundwater, from abandoned mine workings in and around the city of Tombstone, would be recovered and combined with effluent discharged from

the Tombstone WWTP. The combined flows would be conveyed to the point of end use (see Figure 5 for a map and Table 3 for cost summaries).

**Appraisal Level Locations of Tombstone Mine Workings Pipelines**

Option A1: Deliver to Ft. Huachuca Reclaimed Water System
Option A2: Recharge South of Highway 92

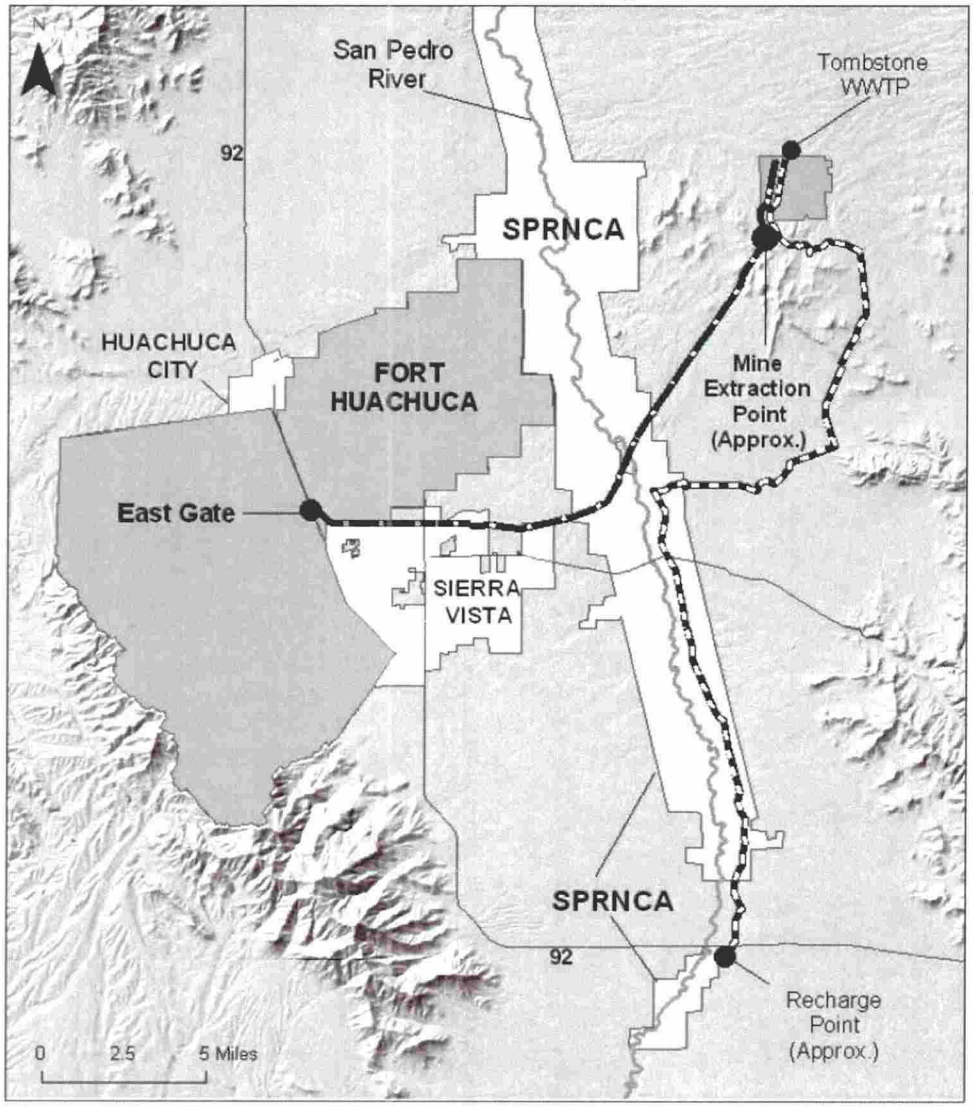



**Figure 5: Schematic of pipelines for A) Water Development Potential of Underground Mine Workings in the Tombstone District alternatives.**

**Table 3: Cost estimates and delivery volumes for Alternative A: Water Development Potential of Underground Mine Workings in the Tombstone District**

| Volume (afy) | Capital cost ($millions) | Annualized capital cost ($millions) | O&M cost ($millions) | Total annual cost ($millions) | Cost per acre-foot | Cost per 1,000 gallons |
|---|---|---|---|---|---|---|
| **Tombstone Mine Workings to Fort Huachuca WWTP** | | | | | | |
| 500 | 6.35 | .47 | .26 | .72 | $1,449 | $4.45 |
| 1,322 | 9.19 | .68 | .66 | 1.34 | $1,013 | $3.11 |
| **Tombstone Mine Workings to SPRNCA Recharge** | | | | | | |
| 500 | 8.09 | .60 | .14 | .73 | $1,466 | $4.50 |
| 1,322 | 10.91 | .80 | .27 | 1.07 | $809 | $2.28 |

ADWR estimates the natural recharge rate of the Tombstone mine workings to be less than 500 afy, and 1,210 afy as the amount that could be withdrawn continuously for a 20-year period. The Tombstone WWTP produces 112 afy of effluent, which is now discharged into Walnut Gulch. Together, an estimated 1,322 afy could be produced for 20 years, or about 500 afy could be withdrawn on a permanent basis. Options were developed using each of these water volumes:

- **A1. Tombstone Mine Workings to the Fort WWTP.** Recovered mine water and effluent would be conveyed to Fort Huachuca's WWTP, treated and used in the Fort's reclaimed water system.

- **A2. Tombstone Mine Workings to the SPRNCA Recharge.** The recovered Tombstone mine water and effluent would be combined and piped to a recharge site of greatest benefit to the SPRNCA. Most likely this would be an area upstream of the San Pedro River, south of Highway 92. To address water quality concerns, the water would be treated with slowsand filtration (SSF). A NPDES permit would be required to discharge the water. Specific issues to be determined under this option include:

    - Before proceeding with the recharge option, the quality of the mine water would have to be investigated. If more extensive treatment than slow sand filtration is indicated, recharge of the recovered water would be significantly more expensive.

    - The location for recharge would have to be identified and evaluated based on benefits to the riparian ecosystem, recharge capacity, water quality impacts (i.e., a NPDES permit), effects on drainage (e.g., flooding) and wildlife.

### *Effectiveness*

The water to be transferred from the Tombstone mine workings would likely reach the San Pedro River eventually, and thus the project does not bring "new" water into the Sub-watershed. However, it allows mine water to be treated and used beneficially on a shorter time scale than it would otherwise.

### *Issues and Further Investigations*

- The quantity of water that can be removed on a sustainable basis would need further analysis.

- Dropping water levels resulting from this alternative may affect the aging mine works, causing settlement and subsidence.

- Withdrawal of Tombstone mine workings water may impact other wells in the Tombstone area. The complex geology of the area makes the effects very difficult to predict. However, over the long term, the withdrawal of the low quality water from the mine area may improve overall groundwater quality for Tombstone.

- Issues of water rights and ownership must be addressed. Three out of four of the abandoned mine shafts are on BLM land. BLM's policy is that withdrawal of water should not conflict with existing mineral claims. These claims date back to the late 1800s and are poorly documented.

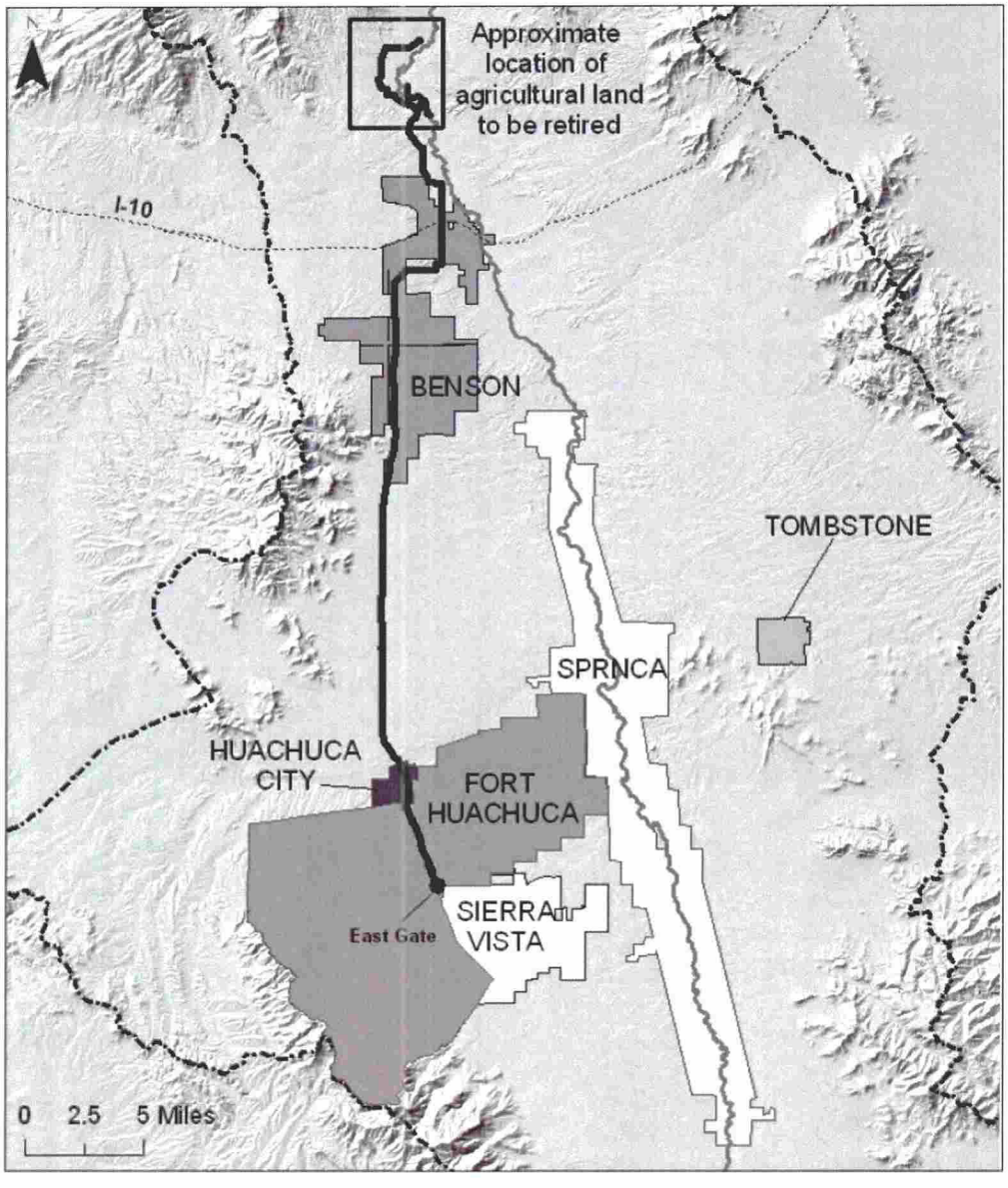
## B. Retire Agricultural Pumping North of Benson to Fort Huachuca/Sierra Vista

Agricultural lands north of Benson would be purchased to retire existing agricultural pumping. A portion of the retired water would be pumped from existing wells on the properties and piped to the Fort and/or the Sierra Vista area to serve municipal demand. The rest would augment groundwater levels in the Benson area. (See Figure 6 for a map, Figure 7 for a cost curve, and Table 4 for cost estimates.)

### *Effectiveness*

This alternative transfers groundwater from one sub-watershed of the Upper San Pedro Basin to another. Coordinated watershed-scale groundwater management would be required to ensure that the water demands placed on the Benson area aquifer did not result in negative consequences.

**Appraisal Level Location of Pipeline from Agricultural Properties North of Benson**




Yield: 500 AFY - 7500 AFY, depending on number of properties purchased.

Cost in $/AF = 1596 - (0.095 * Yield in Acre-Feet)

Example: $1282/AFY for yield of 3375 Acre-Feet

**Figure 6: Pipeline location for B) Retire Agriculture North of Benson to Fort Huachuca/Sierra Vista alternative.**

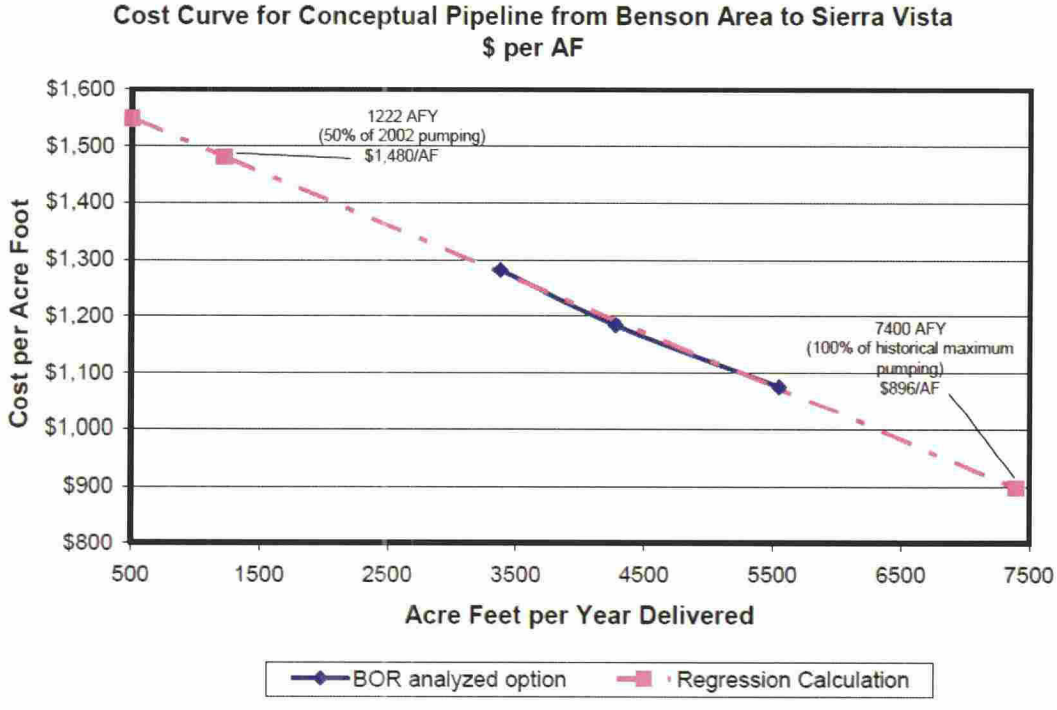



**Figure 7: Cost curve for conceptual pipeline from north of the Benson Area to Sierra Vista.**

**Table 4: Cost Estimates for Alternative B: Retire Agricultural Pumping North of Benson to Fort Huachuca/Sierra Vista**

| Volume (afy) | Capital cost ($millions) | Annualized capital cost ($millions) | O&M cost ($millions) | Total annual cost ($millions) | Cost per acre-foot | Cost per 1,000 gallons |
|---|---|---|---|---|---|---|
| 3375 | 31.64 | 2.33 | 2.0 | 4.3 | $1,282 | $3.93 |

The yield of this alternative depends on the number of properties purchased and how much water would be conveyed from them. ADWR estimated that three sample properties used a total of 7,399 afy in 1991 and 2,444 afy in 2002. The appraisal study developed detailed costs for a volume of 3,375 afy, an amount midway between 50 percent of the estimated current pumping (1222 afy) and the historical maximum (7,399 afy). To give a better idea of how cost would vary with the volume transported, a curve was developed using three mid-range cost estimates (Figure 7).

### *Issues and Further Investigations*

- The quality and treatment of recovered water will need to be addressed. Benson area groundwater has the potential for naturally occurring arsenic and fluoride slightly above drinking water standards. To resolve this issue, treatment with activated alumina is recommended.

- No legal determination has been made as to whether the wells on these properties are pumping groundwater or surface water "subflow" [5]. ADWR expects that this determination will take at least several years (personal communication, Rich Burtell, Arizona Department of Water Resources, 6/22/2004).

- Should it be determined that these wells are pumping subflow, they would be subject to surface water regulations. The legal water rights claims associated with surface water can only be determined through an adjudication process.

- Benson residents indicated substantial opposition to this alternative, and this would need to be addressed before proceeding further.

## C. Water Development Potential of the Copper Queen Mine in the Bisbee District

Groundwater currently inundating the workings of the CQM near Bisbee, Arizona, would be recovered, treated, and conveyed to the point of end use. A report by Southwest Groundwater Consultants, Inc. (2004) estimated that 4,000 afy of mine water can be recovered over 21–25 years. (See Figure 8 for a map and Table 5 for cost estimates.) There are three options:

- **C1. CQM to Fort Huachuca and/or Sierra Vista.** Mine water treated with reverse osmosis would be piped to existing water systems on the Fort and/or in the Sierra Vista area for municipal use.

- **C2. CQM to Bisbee and Naco.** Mine water treated with reverse osmosis would be piped to existing water systems in Naco and Bisbee for municipal use. Any excess would be recharged (possibly via injection using an existing well) into Greenbush Draw, a tributary of the San Pedro.

[5] Those waters which first slowly find their way through the sand and gravel constituting the bed of the stream, or the lands under or immediately adjacent to the stream, and are themselves a part of the surface stream. (Source: ADWR Rural Arizona Watershed Alliance Web site: http://www.azwater.gov/dwr/Content/Find_by_Program/Rural_Programs/content/faq/definitions.htm#S, accessed 6/15/2007.

Appraisal Level Location of CQM to Ft. Huachuca/Sierra Vista and CQM to Bisbee/Naco Pipelines

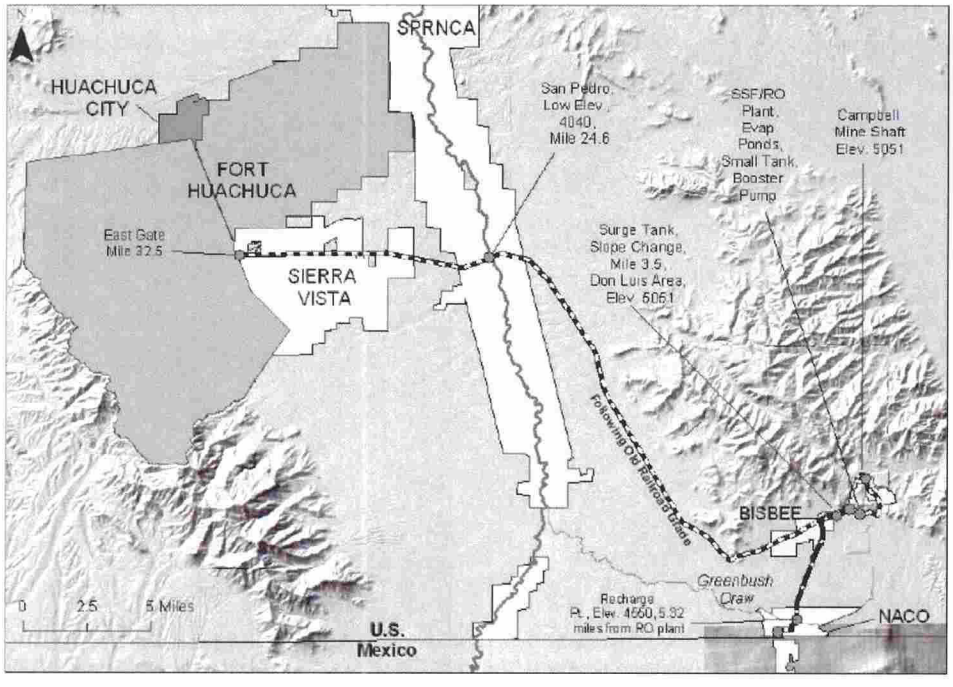



**Figure 8: Pipelines for C) Water Development Potential of the CQM in the Bisbee District alternatives.**

**Table 5: Cost estimates for Alternative C: Water Development Potential of the Copper Queen Mine in the Bisbee District**

| Volume (afy) | Capital cost ($millions) | Annualized capital cost ($millions) | O&M cost ($millions) | Total annual cost ($millions) | Cost per acre-foot | Cost per 1,000 gallons |
|---|---|---|---|---|---|---|
| **To Fort Huachuca/Sierra Vista** | | | | | | |
| 1800 | $51.85 | $3.82 | $1.33 | $5.15 | $2,860 | $8.78 |
| 2600 | $54.02 | $3.98 | $1.39 | $5.36 | $2,062 | $6.33 |
| **To Naco/Bisbee/Recharge** | | | | | | |
| 1800 | $41.61 | $3.06 | $1.25 | $4.32 | $2,397 | $7.36 |
| 2600 | $40.46 | $2.98 | $1.27 | $4.25 | $1,635 | $5.02 |

**C3. CQM to SPRNCA Recharge** (hybrid alternative). Treated mine water would be conveyed to a recharge site of greatest benefit to the SPRNCA. Most likely, this would be an area upstream of the San Pedro River and south of Highway 92. Due to the late introduction of this alternative, it was not possible to develop a separate cost estimate or pipeline alignment. It is anticipated that this alternative would cost more than C2) delivery to Bisbee/Naco but less than C1) delivery to Fort Huachuca/Sierra Vista.

### *Effectiveness*

The Southwest Groundwater Consultants study indicated that most likely only a very small amount of the water in the CQM reaches the San Pedro River, due to the geology of the area. The CQM is surrounded by faults to the east, west and south that function as aquitards. Therefore, this alternative actually would likely augment the amount of water in the Sierra Vista Sub-watershed.

### *Issues and Further Investigations*

**Water Quality**

The CQM water has relatively high concentrations of total dissolved solids (TDS) (300 parts per million [ppm] to higher than 8,000 ppm), sulfate (above 1,000 ppm), iron, manganese, and suspended solids. The proposed treatment train would consist of oxidation and greensand filtration to remove the iron and manganese, followed either by SSF, microfiltration (MF), or ultrafiltration (UF) to remove suspended solids. This pretreatment would be followed by reverse osmosis.

In addition, the reported water quality varies greatly. A more robust water quality characterization will be required. Due to the very poor water quality and the large amount of variability, the amount of water recoverable through reverse osmosis cannot be determined with certainty. Reclamation estimates that 1,800-2,600 afy of the 4,000 afy withdrawn could be recovered. The remainder, or "concentrate," would be disposed of using evaporation ponds.

It will be necessary to perform long-term pilot testing using RO to evaluate effectiveness, cost, permeate compositions, and RO concentrate compositions. Reclamation can provide mobile treatment equipment for pilot testing from the Water Quality Improvement Center, located in Yuma, Arizona.

**Legal and Regulatory**

- Before this alternative is formally moved forward to feasibility study, the USPP would have to contact the mine owners to determine their level of interest.

- The USPP will need to negotiate water costs and long-term contracts for the CQM with the mine owners.

# Inter-basin Transfer Alternatives

## D. Extend Central Arizona Project to Sierra Vista

These alternatives would acquire and convey 20,000; 30,000; or 40,000 afy from a Colorado River water entitlement to the Sierra Vista area. An extension to the CAP system, including several pumping plants, would be constructed from the CAP terminus in Tucson. The water could be used for municipal, industrial, and turf demand, as well as for environmental mitigation/restoration. (See Figure 9 for a map and Table 7 for cost estimates.) There are two main options for using the CAP water:

- **D1. Recharge and Recovery of Municipal Supplies with San Pedro River Recharge.** Under this option, the CAP pipeline would be extended from Tucson to several sites suitable for recharge in the Sierra Vista area. At least part of the water would be recharged into the cone of depression and would later be recovered using existing wells. The water would also be recharged to sustain flows in the San Pedro River. This would involve recharging into constructed basins, into the natural channels downstream from the basins and potentially into the recent alluvium adjacent to the San Pedro River.

- **D2. Direct Delivery of Municipal Supplies with San Pedro River Recharge.** Under this option, water delivered from the CAP pipeline would be treated at a facility operated by a local entity. In addition, some water would be recharged into constructed basins and/or natural channels, to store water in the recent alluvium adjacent to the San Pedro River.

  The type of treatment would need to be determined by the subcontractor. Treatment of CAP water is the responsibility of the subcontractor, not Reclamation's. Treated water would be conveyed through a main distribution pipeline and connected to existing distribution systems in the Sierra Vista area. Water providers would propose turnouts for deliveries into their private water systems. Cooperation among the water providers would be necessary to maximize the use of existing infrastructure.

### *Effectiveness*

With reuse, these alternatives could offset the entire 38,500 afy of municipal, industrial, and agricultural demand that is projected in the Sierra Vista Sub-watershed by the year 2050. Some of this water could also be used to preserve groundwater levels at key locations in the SPRNCA.

**Appraisal Level Routes for Extension of CAP to Sierra Vista Area**

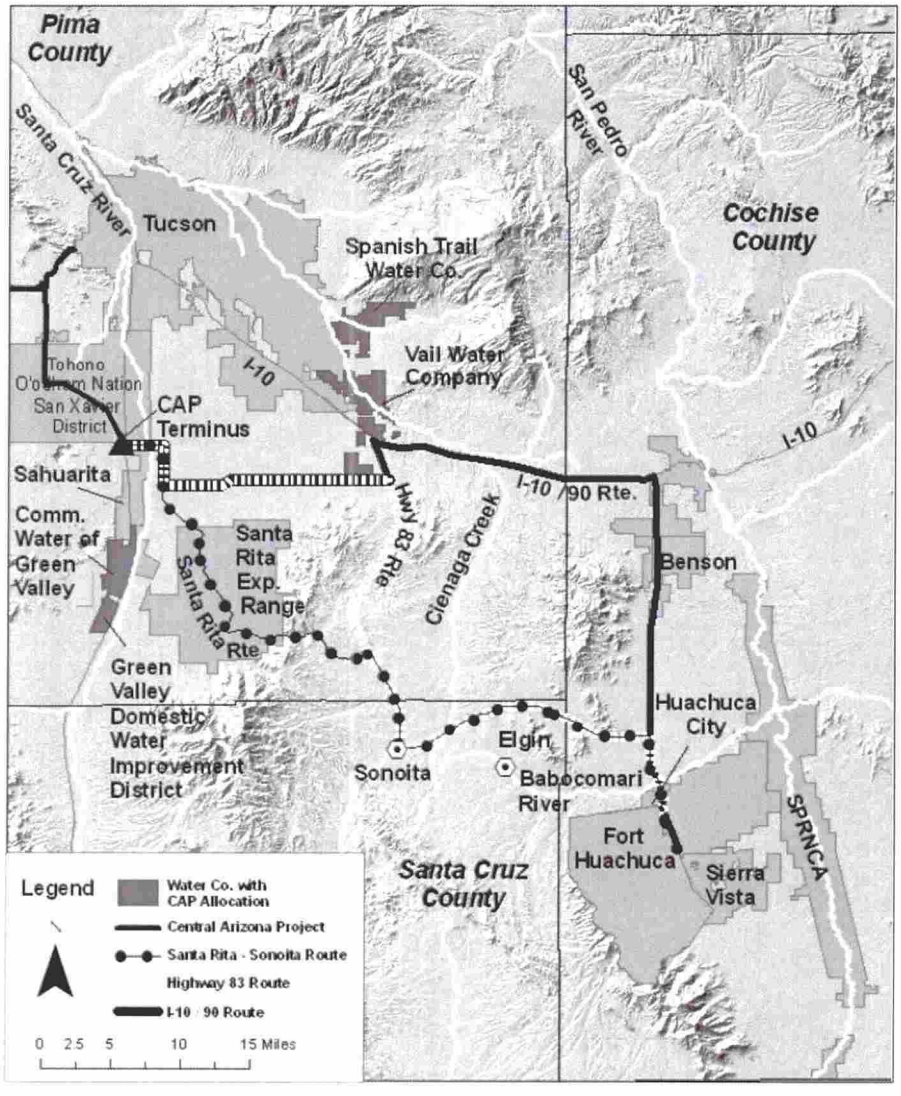



**Figure 9: Three alignments for D) Conveying CAP Water to Sierra Vista – Direct Delivery or Recharge Alternatives.**

The cost evaluation includes construction and right-of-way costs for the pressurized pipeline, reservoir tanks, power lines, and booster pump stations. Detailed appraisal level designs and corresponding costs were developed for three alignments, shown in Figure 9. The preferred alignment option runs along I-10 and Highway 90 and uses existing underground utilities and easements.

- **D1. Recharge and Recovery of Municipal Supplies with San Pedro River Recharge.** Replenishing the aquifer and maintaining higher groundwater levels, instead of mining the groundwater, provides important benefits. It keeps pumping energy costs down, mitigates the need to deepen wells and helps assure the reliability of groundwater supplies. Basic water quality standards would likely be met through "soil-aquifer treatment" which occurs during the recharge process. However, soil-aquifer treatment does not remove dissolved solids from the recharged water.

- **D2. Direct Delivery of Municipal Supplies with San Pedro River Recharge**. This option allows the quality of water to be tailored to the needs of the residents of the Sierra Vista Sub-watershed. However, CAP system reliability is a significant concern under a direct delivery option, and will be influenced by the type of entitlement that is acquired. Reliability and redundancy for the treated water distribution system downstream from the CAP system remains a CAP subcontractor responsibility.

### *Issues and Further Investigations*

**Supply Acquisition**
Currently, there are no allocations of Colorado River water for the Sierra Vista area. Potential sources of supplies include Indian Tribes, non-Indian Colorado River contractors, non-Indian CAP subcontractors, or the future reallocation of CAP entitlements. The risk of shortage to a Colorado River entitlement depends on its seniority and priority within the CAP system.

**Water Quality**
CAP water has a higher TDS level (about 700 milligrams per liter [mg/L]) than that of native groundwater (about 265 mg/L). Although the level of TDS or salinity, is not a health hazard, water high in TDS can be aesthetically unpleasing and have undesirable impacts. These include taste and color problems, hardness, scaling, and sedimentation. Reverse osmosis, discussed under the D2 (direct delivery) option, can reduce the levels of total dissolved solids.

**Potential for Cooperation**
Depending on the route, several entities that possess CAP allocations may be interested in cooperating in constructing the pipeline. CAP subcontractors that have not had access to "wet" water from the CAP system include: the Vail Water Company, Community Water Company of Green Valley, the Green Valley Domestic Water Improvement District and the Spanish Trails Water Company. If the I-10 route is selected, access to CAP water on the east side of the Tucson area may provide options for Tucson Water, another CAP subcontractor.

**Legal and Regulatory**

- At the present time, Indian CAP entitlements cannot be leased for exportation and use outside of the Central Arizona Water Conservation District (CAWCD) service area, which includes Maricopa, Pinal, and Pima counties, except by exchange. Provisions for lease and export of Indian entitlements out of the CAWCD service area would require modification of existing Indian water contracts as well as State law and the CAP Master Repayment Contract. Tucson area CAP subcontractors have a first right of refusal to any Tucson area Indian water being leased.

- Regardless of how an allocation of CAP water might be obtained, it will likely come with strings attached. There might be a parallel in the history—Arizona was required to pass the 1980 Groundwater Management Act, which mandated the State to take measures to control groundwater use, before the Federal Government constructed the CAP system.

**Environmental and Cultural**

- Importing water with quality different from the existing groundwater may have an effect on soil geochemistry, wastewater quality, surface water and groundwater quality. These issues have been accepted by the existing users of CAP water.

- Environmental issues associated with transportation of non-native fish into the San Pedro River basin will be greater if CAP water is recharged, ponded, or put into an open conveyance system. If CAP water is delivered directly to the end user (pipe to pipe), the effects can be mitigated.

- *D1. Recharge and Recovery of Municipal Supplies with San Pedro River Recharge.*

  An evaluation of geomorphology, hydrogeology, water quality, and geochemistry will be necessary in order to determine the technical feasibility of recharge and recovery.

  The CAP system has the potential to import non-native fish into the Upper San Pedro Basin. Endangered Species Act Section 7 consultation and subsequent mitigation may be required to offset these impacts. See Appendix A, CAP Alternative, for details.

- *D2. Direct Delivery of Municipal Supplies with San Pedro River Recharge.*

  This option must address water treatment, which is the responsibility of the water contractor. Aside from meeting Safe Drinking Water Act standards, the treatment method and finished water quality are at the discretion of the contractor.

  Methods for treating CAP water vary in cost and quality of the treated water. See Appendix A, CAP Alternative, for details.

  Several primary treatment methods can meet Safe Drinking Water Act (SDWA) standards. However, basic water treatment methods do not remove TDS (also known as mineral content or salinity). Reverse osmosis (RO) is commonly used to reduce salinity due to its relatively low cost. To be cost effective, RO requires a quality of water that exceeds the SDWA standards. Therefore, a very effective type of primary treatment is required as a pretreatment to RO.

  RO treatment systems must dispose or manage the rejected concentrate. Since the Sierra Vista Sub-watershed isn't near any saline bodies of water, the recommended disposal method is the use of evaporation ponds. It is estimated that 900 acres of evaporation ponds will be required to dispose of the concentrate generated from the desalting of 30,000 afy of CAP water at an 85 percent recovery rate. Table 6 displays the water treatment options for direct delivery of CAP water and Table 7 summarizes costs for treating water under these options, as well as for the recharge and recovery option.

**Table 6: Water treatment options for Alternative D1: Direct Delivery of CAP Water**

| No desalting with variable-production plants | Desalting with constant-production plants and aquifer storage and recovery (ASR) |
|---|---|
| CAP water with Conventional Treatment (CT) | CAP water with CT and RO |
| CAP water with SSF | CAP water with SSF and RO |
| CAP water with MF or UF | CAP water with MF/UF and RO |

Table 7: Cost estimates for D) CAP Alternatives, Using the I-10 Alignment

| Volume | Recharge and recovery | SSF | CT | MF-UF | SSF-RO | CT-RO | MF-UF/RO |
|---|---|---|---|---|---|---|---|
| $ per acre foot | | | | | | | |
| 20,000 afy | $1,725 | $1,411 | $1,550 | $1,549 | $1,747 | $1,847 | $1,831 |
| 30,000 afy | $1,594 | $1,281 | $1,420 | $1,418 | $1,617 | $1,717 | $1,700 |
| 40,000 afy | $1,570 | $1,257 | $1,396 | $1,394 | $1,593 | $1,693 | $1,677 |
| $/1,000 gallons | | | | | | | |
| 20,000 afy | $5.29 | $4.33 | $4.76 | $4.75 | $5.36 | $5.67 | $5.62 |
| 30,000 afy | $4.89 | $3.93 | $4.36 | $4.35 | $4.96 | $5.27 | $5.22 |
| 40,000 afy | $4.82 | $3.86 | $4.28 | $4.28 | $4.89 | $5.20 | $5.15 |

## E. Relocate Sierra Vista Sub-watershed Municipal Wells in Douglas Basin (Primary Analysis by BBC/Fluid Solutions)

New municipal wells for the Sierra Vista Sub-watershed would be drilled on property purchased or leased in the Douglas Basin, the groundwater management unit directly east of the Upper San Pedro Basin. Water would be piped from the new wells to existing distribution systems. The new wells would need to be located so that their drawdown would not impact existing users in the Douglas Basin. (See Figure 10 for a map and Table 8 for costs.) There are two options under this alternative:

- **Douglas Basin to Bisbee (WIE 1a in BBC/Fluid Solutions Report).** A pipeline would be constructed from the new wells in the Douglas Basin to the Bisbee area. Existing water distribution systems would connect to this pipeline to serve their customers. Because the Bisbee water service area includes both the Upper San Pedro and Douglas Basins, this alternative would not violate Arizona Revised Statutes (A.R.S.) § 45-544.

- **Douglas Basin to Fort Huachuca and/or Sierra Vista (WIE 1c in BBC/Fluid Solutions Report)**. A pipeline would be constructed from the new wells in the Douglas Basin to the Sierra Vista area. Existing water distribution systems would connect to this pipeline to serve their customers. This option transfers water between the Douglas and the Upper San Pedro groundwater basins. A.R.S. § 45-544 does not allow for the transportation of water between groundwater basins, except in specific identified cases. Therefore, implementing this alternative would require a change in Arizona law.

Appraisal Level Location Map for
BBC/FS Douglas Basin to Sierra Vista and Bisbee Augmentation Alternatives

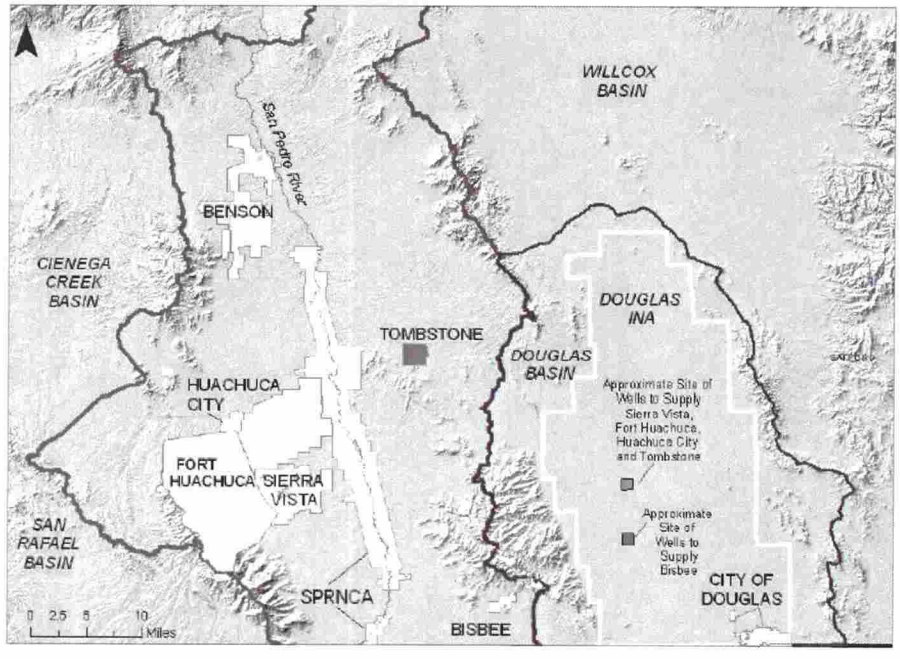



**Figure 10: Relocation of E) Sierra Vista Sub-watershed Municipal Wells to Douglas Basin alternatives (BBC/Fluid Solutions).**

**Table 8: Cost estimates for Alternative E) Relocate Sierra Vista Sub-watershed Municipal Wells in Douglas Basin (without reuse) in $/afy**

| End use | Yield (afy) | BBC/fluid solutions estimated cost ($/afy) |
|---|---|---|
| Bisbee municipal use | 1,010 | $689 |
| Ft. Huachuca /Sierra Vista municipal use | 8,880 | $1016 |

### *Effectiveness*

These alternatives would introduce a new source of supply to the Sierra Vista Sub-watershed and reduce or eliminate pumping in the major population centers. Yields of these alternatives were estimated by BBC/Fluid Solutions by estimating the groundwater use of each community in 2010. These volumes are 1,010 afy for Bisbee and 8,880 afy for Sierra Vista. However, more or less water could be transferred under these alternatives.

### *Issues and Further Investigations*

Reclamation's cursory review of groundwater pumping in the Douglas Basin indicates a history of significant demand and corresponding drops in water levels. Identifying a productive pumping site where drawdown would not interfere with groundwater flow patterns is essential, and will greatly influence the costs of this option.

This alternative does not attempt to make up for exporting water by retiring an equal or greater amount of agricultural demand in the Douglas Basin. It is likely that this will be necessary to make this alternative politically acceptable to the Basin's residents.

*Reclamation review of BBC/Fluid Solutions cost estimates* (in Table 8) *concluded that these costs were seriously underestimated.* No pipeline alignments have been identified. In addition, the pipeline size does not account for peak flows, there is no emergency storage, and increases in construction material prices need to be accounted for. Finally, funds will be required to mitigate environmental impacts. The BBC/Fluid Solutions Report does not discuss the biological or cultural resources that would be impacted by the project or the costs of investigating and mitigating them.

## Local Alternatives

### Stormwater Harvesting Investigation

The USPP requested a thorough, real-world, implementable analysis of stormwater harvesting. Stormwater has several advantages as a resource for augmentation: it is not considered surface water until it enters a stream channel and there are no issues associated with removing water from another political jurisdiction. As Reclamation began the investigation, it became clear that although there was a great amount of information available—methods, techniques, water saving estimates, etc.—but the information lacked the required scientific and engineering detail needed for project design. Reclamation decided to divide the investigation into two phases. The first phase would collect information on the latest techniques in stormwater harvesting in the developed world. The second phase would develop stormwater harvesting designs customized for the Sierra Vista Sub-watershed using the information collected in phase I.

To efficiently complete phase I, Reclamation hired the highly regarded consulting firm, ARCADIS, to perform a survey of stormwater harvesting projects throughout the world, with an emphasis on developed, semiarid areas. The projects included innovative rooftop capture and reuse systems, as well as larger systems that collected and reused runoff from urbanized catchments. The survey emphasized projects that harvested urban runoff for water supply augmentation.

The most notable of these were found in the arid regions of Australia, particularly near the city of Adelaide. The concept of "Water Sensitive Urban Design," which seeks to maximize on-site stormwater reuse and minimize off-site runoff, was identified as a concept that would be useful for the Sierra Vista Sub-watershed. The results of Phase I were presented to the USPP for general information. Phase I allowed Reclamation to recommend two concepts for stormwater harvesting that would be analyzed as augmentation alternatives: (1) stormwater capture and reuse for new residential and commercial construction and (2) the collection and recharge of urban runoff. Phase I documentation and results were published as a separate report on a CD, which is not included here.

## F. Stormwater Harvesting: Water Development Potential of Rainwater Collection for New Residential Communities and New Commercial/Industrial Businesses

Rainwater would be collected off of rooftops and reused. This would involve typical building components such as gutters and downspouts, as well as collection pipes, pumps, filters, common water storage areas, and return water delivery pipes. There are two options:

- **F1. Capture and Reuse of Residential Stormwater.** A design was developed to capture and reuse runoff from roofs and patios in a fifty home residential subdivision. The runoff would be stored and treated in a central location to eliminate the need for maintenance by the individual homeowner. Our analysis found that enough rainwater could be captured to provide an alternate water supply for toilet flushing within the subdivision. For the residential analysis, annual average yield over a 45-year period was projected to be 1,095 afy, assuming an 80 percent adoption rate by new households.

- **F2. Capture and Reuse of Commercial Stormwater.** A rooftop of 400,000 square feet was selected for the new commercial development analysis. Approximately 10 afy of rainwater could be collected for non-potable use using a 1.5-million-gallon tank. A projection of new commercial construction through 2050 led to an estimate of an average annual yield (over the 45-year period) of 331 afy, given an 80 percent adoption rate.

### *Effectiveness*

The water collected in the rooftop capture alternatives would otherwise run off and either evaporate or infiltrate into the ground. Therefore, it may reduce the amount of enhanced stormwater recharge taking place in the sub-watershed. However, the amount of aquifer recharge that would be lost from this alternative is negligible compared to the gain in high quality supplies. Because this alternative uses rainfall, it would not be reliable during a period of drought.

### *Costs*

Table 9 displays costs for this alternative.

**Table 9: Cost estimates for Alternative F) Stormwater Harvesting: Water Development Potential of Rainwater Collection**

| End use | Individual project yield (afy) | Average annual yield through 2050 (afy) | Cost ($/afy) |
|---|---|---|---|
| Residential capture and reuse (50 home subdivision) | 3.7 | 1,095 afy | $23,780 |
| Commercial/industrial capture and reuse (400,000 sq. ft. roof) | 9.6 | 331 afy | $7,778 |

## G. Stormwater Harvesting: Water Recharge Potential of Collected Urban Runoff in the Sierra Vista Area

This alternative would collect stormwater from streets, parking lots, and other impervious surfaces from a highly urbanized, 8-square-mile area in Sierra Vista. The water would be conveyed to a storm sewer system and transported to a centralized facility for treatment, storage and distribution to recharge facility. The appropriate location and method of recharge would need to be resolved as part of the feasibility study (see Figure 11 for a map and Table 10 for costs). The estimated yield for this alternative is 1,800 afy. There are two options:

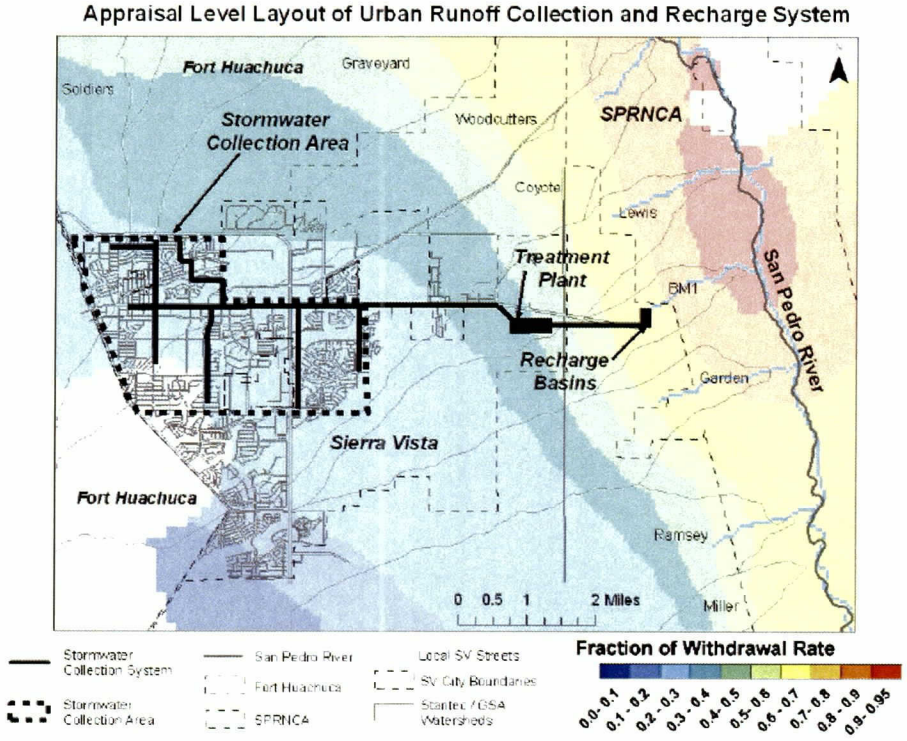



**Figure 11: Appraisal level layout of G) Stormwater Harvesting: Water Recharge Potential of Collected Urban Runoff in the Sierra Vista Area.**

**Table 10: Cost estimates for G) Stormwater Harvesting: Water Recharge Potential of Collected Urban Runoff in the Sierra Vista Area**

| Alternative | Capital cost ($M) | Annualized capital cost ($M) | O&M cost ($M) | Total annual cost ($M) | Cost per acre-foot | Cost per 1,000 gallons |
|---|---|---|---|---|---|---|
| Recharge near San Pedro River | $61.16 | $4.50 | $0.31 | $4.81 | $2,675 | $8.21 |
| Recharge at AHI | $51.73 | $3.81 | $0.28 | $4.09 | $2,271 | $6.97 |

- **G1. Recharge Urban Runoff Near the SPRNCA.** Recharging water near the river is intended to create a groundwater mound to sustain surface water flow in the San Pedro River and supplement alluvial groundwater levels during low flow periods. By providing storage in the recharge area and down-gradient, the project would provide river base flow during non-storm periods.

- **G2. Recharge Urban Runoff to the AHI.** This area is located between the city of Sierra Vista and the San Pedro River, where major pumping is taking place. Under this option, the recharge location would be sited to have a direct hydrologic effect on areas where pumping demand is high. The effects on the San Pedro River from the recharge would not be immediate as in option G1; however, the overall cost is less. An exact recharge location has not been identified.

### *Effectiveness*

Runoff has increased due to urbanization within the Sierra Vista Sub-watershed, creating additional stormwater flow. Under these alternatives, approximately 70 percent of the difference between pre and post-development runoff within the study area would be captured. This stormwater might otherwise evaporate or recharge far away from the San Pedro River. Instead, it would be transported to a site where it would either fill in the cone of depression or sustain flow in the river. Pipelines are also readily expanded to new development as the area grows and could be financed incrementally with developer participation.

Collecting stormwater in a storm sewer system before it flows into natural channels avoids the issue of acquiring surface water rights. Stormwater flow to the San Pedro River would remain at or above pre-development levels, since only 70 percent of the additional runoff would be captured.

The estimated yield for this alternative is 1,800 afy, based on average rainfall patterns. However, this alternative would not be as effective during a long-term drought.

### *Issues and Further Investigations*

Groundwater recharge is required to comply with Federal and State water quality standards. Special care must be taken that treatment produces water quality acceptable for recharge.

Appraisal-level cost estimates (Table 10) do not include the indirect cost of losses to businesses that are affected by the installation of the storm sewer system. Such an estimate is beyond the scope of this study, but is likely to be substantial.

## H. No Federal Action Alternative

The no action alternative is associated with augmenting groundwater supplies or recharging the aquifer within the Sierra Vista Sub-watershed.

### Description

The USPP has developed a strategy with alternatives to reduce groundwater dependence, or to recharge the groundwater supply. The no action alternative is described as:

> *The no action alternative would not take any Federal action to construct some or any of the augmentation projects under consideration. The no action alternative would also involve other factors associated with the regional environment, for example, continued estimated population growth. The annual regional groundwater pumping deficit is anticipated to be approximately 38,500 afy by the year 2050.*

No slate of potential replacement projects have been identified for study if none of the present list projects are implemented.

### Impacts

The no action alternative would result in a continued decline in groundwater levels that would jeopardize the goal of sustainable yield of the regional aquifer by 2011 and beyond. Federal augmentation projects would not be implemented to either augment or replace existing groundwater. This would potentially result in failure to meet the goals of Section 321. Not constructing some or all of the projects would result in:

- Fewer disturbances of soil and geology
- No short term impacts to air and water quality
- No short term increases in wages associated with construction

### *Regional Aquifer and the San Pedro River*

Failure to offset current groundwater pumping could result in diminished flows to the river, potentially impacting the Huachuca water umbel, an endangered species. These are unacceptable consequences under both Section 321 and the ESA.

### *SPRNCA*

The no action alternative would impact the BLM's ability to meet the requirements to protect, conserve, and enhance the SPRNCA as directed under P.L. 100-696. Continued decline of groundwater levels would impact the hydrologic conditions necessary to support a diversity of riparian species (including threatened and endangered species). The loss of this riparian ecosystem would have negative consequences transcending international borders.

### *Fort Huachuca*

Failure to offset non-sustainable groundwater use could also impact the missions of the Fort, which must be conducted so as not to jeopardize endangered species. The cost of moving these missions, in those cases where it is even possible to find suitable relocation, will greatly exceed the cost of the actions.

### *Economic Impacts*

The no action alternative has the potential to result in up to $1 billion in economic reduction within Cochise County due to loss of income from Fort Huachuca. Additional losses from nature-based tourism reductions attributed to both the Fort and the SPRNCA would lead to an overall loss of a $2 billion annually to the State of Arizona.

# Chapter IV: Screening Process and Recommendations

## The Screening Process

The USPP used the screening process to compare and rate the alternatives to:

- Document why alternatives should move forward or not, with supporting facts and explanations.
- Allow the organization to focus its limited resources on pursuing the most promising alternatives.

The goal at this stage in the appraisal process was to identify one or more alternatives that should be investigated in greater detail. Just as important, some alternatives were eliminated from consideration. This chapter provides supporting documentation for these decisions. This documentation curbs the tendency to revisit solutions once considered promising. It also promotes continuity by providing a record of the decision process, since implementing an alternative typically takes many years.

The screening process was designed to compare and contrast the augmentation projects and to recommend which ones should be explored in more detail. The USPP screening process evaluated alternatives against specific effectiveness, implementability, and cost criteria it developed. The PAC selected the alternatives to pursue.

### Alternative Review

Before screening the alternatives, the USPP provided input and feedback on Reclamation's analyses of augmentation alternatives. Three USPP committees worked together to review augmentation alternatives.

- The Technical Committee (Tech) reviewed the technical and scientific aspects of the reports, which were revised per the committee's requests.
- The Staff Working Group (SWG) reviewed the planning implications.
- The Governmental Affairs Committee (GAC) reviewed the political and/or legal ramifications.

SWG, Tech, and GAC provided their recommendations for final acceptance of appraisal studies to PAC. PAC accepted the revised studies and authorized Reclamation to advance to the screening process.

A workgroup consisting of members of the SWG, Tech and GAC was formed to screen the alternatives and develop recommendations for the PAC to consider. Consensus decisionmaking was used throughout the screening process, in accordance with USPP policy. Consensus is an agreement made without voting. Agreement is reached by gathering information and points of view, discussing, analyzing and persuading. The goal of a consensus decision is to reach a decision everyone can accept. Not everyone will necessarily like the solution equally, or will have an equal commitment to it.

## Alternative Screening

The USPP Screening Process steps are detailed below:

1 Two joint SWG/Tech/GAC meetings were held to develop a problem statement and screening criteria. Twenty-six individual criteria were developed in the categories of effectiveness, implementability, and cost. These documents were refined as the screening process evolved.

2 A workgroup of SWG, Tech and GAC members was created to carry out the screening process. "Straw man" draft summary sheets were developed for 15 augmentation alternatives. Each alternative was scored as good, fair or poor with respect to each of the criteria by each member of the workgroup.

3 The draft summary sheets were e-mailed to the SWG/Tech/GAC workgroup members for review and comment with the following instructions:

   i. Review the Reclamation appraisal report for each alternative

   ii. Review the draft summary sheets for each alternative

   iii. Mark any rating disagreed with and add suggested rating and explanation.

   iv. Put comments in the box provided for them.

   Agencies were asked to come to agreement within their organization and to submit only one response per agency.

4 Member agency comments were compiled to be used as a starting point for discussion at a joint SWG/Tech/GAC workgroup meeting.

5 Joint SWG/Tech/GAC workgroup meetings were held to:

- Resolve draft summary sheet concerns
- Review ratings
- Finalize summary sheet ratings

The final versions of the summary sheets are reproduced in Appendix B.

6 Results of the summary sheet ratings were compiled in a matrix for review and reconciliation by the Joint SWG/Tech/GAC workgroup. Meetings were held to review ratings and resolve outstanding concerns. Ratings were adjusted at this point to ensure consistency of evaluation.

7 The individual criteria ratings were used as input to formulate an "Overall" rating for effectiveness, implementability, and cost. The workgroup decided to evaluate the alternatives with respect to their effectiveness in sustaining base flows in the San Pedro River over multiple time frames. Thus, effectiveness was evaluated over the short-term (<50 years) and the long term (>50 years). The Joint SWG/Tech/GAC workgroup then came up with draft overall ratings and explanations. These draft overall ratings were e-mailed to workgroup representatives for comment and review.

8 "Overall" short-term and long-term effectiveness ratings, as well as overall implementability and cost ratings, were agreed on for each alternative. The "overall" ratings also included a short explanation of the group's reasons for the rating. The Joint SWG/Tech/GAC workgroup resolved outstanding concerns and developed recommendations for PAC's selection of alternatives. Summary sheets and rating sheets are reprinted in Appendix B.

This screening process took place over 14 months, with 9 half-day joint SWG/Tech/GAC meetings and "homework" in between.

## Alternative Modifications

During the screening process, several modifications were made to the problem statement, the criteria and the alternatives. The joint SWG/Tech/GAC workgroup agreed to make the following modifications to the long list of alternatives:

- The Tombstone Mine alternatives (A) would only be evaluated for the yield which would be sustainable on a permanent basis (500 afy).

- Alternative B, Retire Agriculture North of Benson to Fort Huachuca/Sierra Vista, would be evaluated at a quantity of 3,375 afy, an amount midway between 50 percent of the estimated current pumping (1,222 afy) and the historical maximum (7,399 afy)

- Alternative G2, Recharge Urban Runoff to the AHI, was dropped from future consideration in favor of G1, Recharge Urban Runoff Near the SPRNCA. This is consistent with the workgroup's emphasis on improving base flows in the SPRNCA.

- Hybrid alternatives were added to the "long list," including the following:

  - Both CAP alternatives (D1 and D2) were modified to include a recharge component near the San Pedro River, to help preserve river base flows. Several recharge locations would be identified to address the San Pedro River's short and long term needs in future studies. Revisions were made to the CAP to Sierra Vista report to reflect these changes in the alternatives.

  - Treating CQM water and conveying it to an area near the San Pedro River for recharge (option C3).

  - A "Linear Park" recharge concept developed by the Hereford Natural Resources Conservation District.

## Evaluation Criteria

Evaluation criteria were used to help the USPP compare and contrast water augmentation options, to determine which ones should receive further scrutiny and which ones could be eliminated from further consideration. Evaluation criteria fall into three categories:

- **Effectiveness** measures how well each alternative meets the defined objectives. Factors considered in the evaluation include the alternative's technical effectiveness, reliability, and the geographic distribution of benefits and impacts, including human health and the environment.

- **Implementability** includes both the technical and administrative feasibility of the alternative. It considers characteristics of the proposed site, such as hydrology, geology and land use. Regulatory and permitting requirements also have an impact on an alternative's implementability. Implementability criteria include an alternative's political constraints, including the social equity of benefits and impacts and public support or opposition.

- **Costs** at this point in the screening process are relative. Capital and O&M costs, rather than detailed estimates, were used to generate ratings. Total annual cost divided by expected annual yield (in acre-feet) was used in the screening. However, other cost information was calculated and presented. (See individual analyses for details.) Total annual cost is the sum of total amortized capital cost and annual operations and maintenance cost. All estimates assumed a 4 percent interest rate and 20-year payback period, to allow comparability with the BBC/Fluid Solutions Report. An alternative which is comparable to another in effectiveness and implementability, but is significantly more expensive, will probably be eliminated from further consideration.

## Effectiveness

How effective the alternative would be to alleviate the identified problem, including:

- Yield in terms of acre-feet.
- Likelihood that project magnitude and location of yields will benefit the regional aquifer or the river.
- Ability to help sustain natural range of alluvial groundwater levels in their current spatial distribution. ("Natural range of alluvial groundwater levels" is defined as the groundwater levels and gradients within the Sierra Vista Sub-watershed that existed at or about the time of the establishment of the SPRNCA.)
- Ability to help sustain natural base flows within their general spatial distribution. ("Natural base flows" is defined as the range of base flows experienced in the river between 1954 and 1988.)
- Ability to help sustain flood flows within their natural range of variability in terms of timing, frequency, and magnitude. ("Natural range of flood flows" is defined as the range of flood flows experienced in the river between 1954 and 1988.)
- Ability to help maintain existing (or better) water quality within the river.
- Ability of strategy to continue addressing problem during periods of extended drought and over long periods of time (50 years+).
- Estimated yields are adequate to meet future projected population and SPRNCA needs.

- The project's ability to reliably produce water every year or the project's dependence on rainfall.
- Complements current or planned USPP projects.
- Timing of benefits (how quickly the SPRNCA would benefit).
- Length of time to work through the regulatory requirements.
- The ability of the project to replace or reduce groundwater demand.
- The potential for unintended environmental consequences at the source location of the water or within the Sierra Vista Sub-watershed.

## Implementability

The ease with which the alternative can be implemented, including:

- Spatial, geologic and hydrologic constraints
- Environmental impact issues
- State of technology (i.e., proven method or pilot)
- Legal and regulatory issues at the local, State (e.g., ACC, ADWR, ADEQ, Arizona State Land Department) and Federal levels
- Current land ownership, right of way, water rights, etc.
- Current ownership of water utility
- Current land use and zoning
- Compatibility of project with adjacent uses
- Complexity of crossing jurisdictional boundaries
- Likely community support or opposition
- Impacts on area where water is being transferred from—political, environmental, economic, etc.

### Cost

The overall cost of the alternative, including:

- Capital requirements
- Operating and maintenance expenses
- Total annual cost (sum of capital cost amortized over life of project plus O&M
- Cost/yield ratio
- Timing of when dollars would be needed
- Availability of State or Federal funding

## Evaluation Summary

Tables 11 through 14 and Figures 12 and 13 show alternative comparisons.

***Note:*** The committee had basically concluded that recharge at the SPRNCA was superior to recharge at the AHI, so alternative G2) Urban Runoff at the AHI was never formally evaluated.

## Table 11: Alternative volumes and cost

| | Alternative | Volume | Capital Cost (millions) | Annualized Capital Cost (millions) | O&M costs (millions) | Total Annual Cost (millions) | Cost per Acre-Foot | Cost per 1000 gallons |
|---|---|---|---|---|---|---|---|---|
| *Intra-basin Alternatives:* | A1. Tombstone mine workings to Fort Huachuca WWTP | 500 AFY | $6.35 | $0.47 | $0.26 | $0.72 | $1,449 | $4.45 |
| | | 1322 AFY | $9.19 | $0.68 | $0.66 | $1.34 | $1,013 | $3.11 |
| | A2. Tombstone mine workings to SPRNCA Recharge | 500 AFY | $8.09 | $0.60 | $0.14 | $0.73 | $1,466 | $4.50 |
| | | 1322 AFY | $10.91 | $0.80 | $0.27 | $1.07 | $809 | $2.48 |
| | B. Retire ag N of Benson to Fort Huachuca and/or Sierra Vista | *3375 AFY | $31.64 | $2.33 | $2.00 | $4.33 | $1,282 | $3.93 |
| | C1. CQM to Fort Huachuca and/or Sierra Vista | 1800 AFY | $51.85 | $3.82 | $1.33 | $5.15 | $2,860 | $8.78 |
| | | 2600 AFY | $54.02 | $3.98 | $1.39 | $5.36 | $2,062 | $6.33 |
| | C2. CQM to Bisbee and Naco | 1800 AFY | $41.61 | $3.06 | $1.25 | $4.32 | $2,397 | $7.36 |
| | | 2600 AFY | $40.46 | $2.98 | $1.27 | $4.25 | $1,635 | $5.02 |
| | C3. CQM to SPRNCA Recharge (hybrid) | 1800 AFY | less than CQ Mine to Ft. and/or S.V, more than CQ Mine to Bisbee & Naco (due to late introduction of alternative, detailed costs were not calculated.) | | | | | |
| | | 2600 AFY | less than CQ Mine to Ft. and/or S.V, more than CQ Mine to Bisbee & Naco (due to late introduction of alternative, detailed costs were not calculated.) | | | | | |
| *Inter-basin Alternatives* | D1. CAP to Sierra Vista - Recharge and Recovery, with SPR Recharge (hybrid) | 20,000 AFY | $162.51 | $11.96 | $18.43 | $30.39 | $1,520 | $4.66 |
| | | 30,000 AFY | $212.73 | $15.66 | $27.57 | $43.23 | $1,441 | $4.42 |
| | | 40,000 AFY | $277.18 | $20.40 | $37.33 | $57.73 | $1,443 | $4.43 |
| | D2a. CAP to Sierra Vista, Direct Delivery w/ SPR Recharge (hybrid), I-10 Rt., Slow Sand Filtration (least cost treatment) | 20,000 AFY | $158.17 | $11.64 | $16.21 | $27.85 | $1,393 | $4.27 |
| | | 30,000 AFY | $201.30 | $14.82 | $22.95 | $37.77 | $1,259 | $3.86 |
| | | 40,000 AFY | $258.68 | $19.04 | $30.49 | $49.53 | $1,238 | $3.80 |
| | D2b. CAP to Sierra Vista, Direct Delivery w/ SPR Recharge (hybrid), I-10 Route - CT&RO (most expensive treatment) | 20,000 AFY | $232.87 | $17.14 | $18.29 | $35.43 | $1,772 | $5.44 |
| | | 30,000 AFY | $313.36 | $23.06 | $26.17 | $49.23 | $1,641 | $5.04 |
| | | 40,000 AFY | $408.08 | $30.03 | $34.66 | $64.69 | $1,617 | $4.96 |
| | E1. Douglas Basin to Bisbee | **1010 AFY | $6.47 | $0.48 | $0.22 | $0.70 | $689 | $2.12 |
| | E2. Douglas Basin to Fort Huachuca and/or Sierra Vista | **8430 AFY | $89.58 | $6.59 | $1.97 | $8.56 | $1,016 | $3.12 |
| *Local Alternatives* | F1. Capture and Reuse of Residential Stormwater | 1095 AFY | $344.62 | $25.36 | $1.40 | $26.76 | $23,780 | $72.98 |
| | F2. Capture and Reuse of Commercial Stormwater | 331 AFY | $33.14 | $2.44 | $0.15 | $2.59 | $7,778 | $23.87 |
| | G1. Recharge of Urban Runoff near the SPRNCA | 1800 AFY | $61.16 | $4.50 | $0.31 | $4.81 | $2,675 | $8.21 |
| | G2. Recharge of Urban Runoff at the Area of Hydrologic Impact | 1800 AFY | $51.73 | $3.81 | $0.28 | $4.09 | $2,271 | $6.97 |
| | H. No Action Alternative | 0 AFY | $0.00 | $0.00 | $0.00 | $0.00 | $0 | $0.00 |

* Volume and resulting cost may vary
** Cost estimated by BBC/FS, seriously underestimated in Reclamation's view

Table 12: Joint consensus ratings

USPP Joint SWG/Tech/GAC Consensus Ratings on Augmentation Alternatives with respect to Effectiveness Criteria

| | Criteria | Intra-basin Transfer | | | | | | Inter-Basin Transfer | | | | Local | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | * Estimated w/r/t estimated 2010 water balance deficit estimated by BBC/FS<br>** Annualized Yield to 2050, assuming population increase of 2055/year, 80% implementation rate, yield as estimated in Rooftop Capture Appraisal Studies | A1. Tombstone mine workings to Fort Huachuca WWTP | A2. Tombstone mine workings to SPRNCA Recharge | B. Below Ag N of Bisbee to Fort/SV | C1. CQM to Fort/SV | C2. CQM to Bisbee and Naco | C3. CQM to SPRNCA (Hybrid) | D1. CAP - Recharge & Recovery, w/ SPR recharge (hybrid) | D2. CAP - Direct Delivery w/ SPR recharge (hybrid) | E1. Douglas Basin to Bisbee (BBC/FS) | E2. Douglas Basin to Fort/ SV (BBC/FS) | F1. Capture and Reuse of Residential Stormwater | F2. Capture and Reuse of Commercial Stormwater | G1. Recharge of Urban Runoff near the SPRNCA | H. No Action Alternative | Linear Park Recharge (Hybrid) |
| Effectiveness | Yield (AFY) at which alternative is rated | 500 | 500 | 3375 | 1800-2600 | 1800-2600 | 1800-2600 | 20,000 - 40,000 | 20,000 - 40,000 | 1010* | 8430* | 1095** | 331** | 1800 | 0 | 216 |
| | Expected Time Limit of Yield (years) | N/A | N/A | N/A | 20 | 20 | 20 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | 1) Yield Rating | POOR | POOR | FAIR | FAIR | FAIR | FAIR | GOOD | GOOD | POOR | FAIR | POOR | POOR | GOOD | POOR | POOR |
| | 2a) Benefits regional aquifer | POOR | POOR | FAIR | FAIR | FAIR | POOR | GOOD | GOOD | FAIR | GOOD | POOR | POOR | POOR | POOR | POOR |
| | 2b) Benefits river ( < 50 years) | POOR | GOOD | POOR | POOR | POOR | GOOD | GOOD | POOR | POOR | POOR | POOR | POOR | GOOD | POOR | POOR |
| | 2c) Benefits river ( > 50 years) | FAIR | POOR | FAIR | POOR | GOOD | GOOD | GOOD | GOOD | FAIR | GOOD | POOR | POOR | GOOD | POOR | POOR |
| | 3a) Sustains SPRNCA alluvial gw levels ( < 50 yrs ) | POOR | GOOD | POOR | POOR | POOR | GOOD | GOOD | POOR | POOR | POOR | POOR | POOR | GOOD | POOR | POOR |
| | 3b) Sustains SPRNCA alluvial gw levels ( > 50 yrs ) | FAIR | POOR | FAIR | FAIR | GOOD | FAIR | GOOD | GOOD | FAIR | GOOD | POOR | POOR | GOOD | POOR | POOR |
| | 4a) Sustains SPRNCA base flows ( < 50 years ) | POOR | GOOD | POOR | POOR | POOR | GOOD | GOOD | POOR | POOR | POOR | POOR | POOR | GOOD | POOR | POOR |
| | 4b) Sustains SPRNCA base flows ( > 50 years ) | FAIR | FAIR | GOOD | FAIR | FAIR | FAIR | GOOD | FAIR | FAIR | FAIR | POOR | POOR | GOOD | POOR | POOR |
| | 5) Sustains flood flows | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | FAIR | FAIR | FAIR* | POOR | FAIR |
| | 6) Maintains or improves river water quality | N/A | FAIR | N/A | N/A | N/A | FAIR | FAIR | FAIR | N/A | N/A | N/A | N/A | GOOD | N/A | GOOD |
| | 7) Reliable through long-term drought | FAIR | FAIR | FAIR | GOOD | GOOD | GOOD | GOOD | GOOD | GOOD | GOOD | POOR | POOR | FAIR | N/A | FAIR |
| | 8) Meets future population and SPRNCA needs | POOR | POOR | POOR | POOR | POOR | FAIR | GOOD | GOOD | POOR | POOR | POOR | POOR | POOR | POOR | POOR |
| | 9) (Local) Rainfall independent | GOOD | GOOD | FAIR | GOOD | GOOD | GOOD | GOOD | GOOD | GOOD | GOOD | POOR | POOR | FAIR | POOR | FAIR |
| | 10) Complementary w/ other USPP projects | FAIR | GOOD | FAIR | FAIR | GOOD | GOOD | GOOD | GOOD | FAIR | FAIR | FAIR | FAIR | FAIR | N/A | FAIR |
| | 11) Short lead time for benefits to river | POOR | GOOD | POOR | POOR | POOR | GOOD | GOOD | POOR | POOR | POOR | POOR | POOR | GOOD | POOR | POOR |
| | 12) Length of regulatory timeline | FAIR | FAIR | FAIR | FAIR | FAIR | FAIR | POOR | POOR | POOR | POOR | GOOD | GOOD | FAIR | N/A | GOOD |
| | 13) Replace / reduce gw demand | POOR | POOR | GOOD | GOOD | GOOD | POOR | GOOD | GOOD | FAIR | GOOD | FAIR | FAIR | POOR | POOR | POOR |
| | 14) Low potential for unintended environmental consequences | POOR | POOR | FAIR | FAIR | FAIR | GOOD | POOR | FAIR | FAIR | POOR | GOOD | GOOD | GOOD | N/A | GOOD |
| | General Effectiveness Rating < 50 YRS | POOR | GOOD | POOR | POOR | POOR | GOOD | GOOD | GOOD | POOR | POOR | POOR | POOR | GOOD | POOR | POOR |
| | General Effectiveness Rating > 50 YRS | POOR | FAIR | FAIR | FAIR | FAIR | GOOD | GOOD | GOOD | FAIR | FAIR | POOR | POOR | GOOD | POOR | POOR |

Table 12: Joint consensus ratings (continued)

USPP Joint SWG/Tech/GAC Consensus Ratings on Augmentation Alternatives with respect to Implementability and Cost Criteria

| Criteria | | Intra-basin Transfer | | | | | | Inter-Basin Transfer | | | | Local | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | * Cost estimated in Year 2000 dollars by BBC/Fluid Solutions, not updated for current construction costs. | A1. Tombstone mine workings to Fort Huachuca WWTP | A2. Tombstone mine workings to SPRNCA Recharge | B. Retire Ag W of Benson to Fort/SV | C1. CGM to Fort Huachuca / Sierra Vista | C2. CGM to Bisbee and Naco | C3. CGM to SPRNCA (hybrid) | D1. CAP - Recharge & Recovery w/ SPR recharge (hybrid) | D2. CAP - Direct Delivery w/ SPR recharge (hybrid) | E1. Douglas Basin to Bisbee (BBC/FS) | E2. Douglas Basin to Fort/ SV (BBC/FS) | F1. Capture and Reuse of Residential Stormwater | F2. Capture and Reuse of Commercial Stormwater | G1. Recharge of Urban Runoff near the SPRNCA | H. No Action Alternative | Linear Part. Recharge (Hybrid) |
| Implementability | 16) Spatial, Geologic, Hydrologic Constraints | FAIR | FAIR | FAIR | FAIR | FAIR | FAIR | FAIR | FAIR | FAIR | FAIR | GOOD | GOOD | GOOD | N/A | GOOD |
| | 16) Environmental Impact Issues | FAIR | FAIR | FAIR | FAIR | FAIR | FAIR | POOR | FAIR | UNKNOWN | UNKNOWN | GOOD | GOOD | GOOD | N/A | GOOD |
| | 17) Uses well-developed technology | GOOD | FAIR | GOOD | POOR | POOR | POOR | GOOD | GOOD | GOOD | GOOD | GOOD | GOOD | GOOD | N/A | GOOD |
| | 18) Legal and Regulatory Issues (Fed. State, local) | FAIR | FAIR | FAIR | POOR | POOR | FAIR | POOR | POOR | FAIR | POOR | GOOD | GOOD | FAIR | N/A | GOOD |
| | 19) Land ownership, ROW & surface water rights | POOR | POOR | FAIR | POOR | FAIR | POOR | POOR | POOR | UNKNOWN | UNKNOWN | GOOD | GOOD | GOOD | N/A | GOOD |
| | 20) Issues with water utility ownership | GOOD | GOOD | POOR | POOR | POOR | N/A | POOR | POOR | POOR | POOR | GOOD | GOOD | GOOD | N/A | GOOD |
| | 21) Land use & zoning | GOOD | GOOD | GOOD | GOOD | GOOD | GOOD | FAIR | FAIR | GOOD | GOOD | GOOD | GOOD | GOOD | N/A | GOOD |
| | 22) Compatibility w/ Adjacent Uses | POOR | POOR | FAIR | GOOD | GOOD | GOOD | GOOD | GOOD | FAIR | POOR | GOOD | GOOD | GOOD | N/A | GOOD |
| | 23) Complexity of crossing jurisdictional boundaries | POOR | FAIR | POOR | POOR | FAIR | FAIR | POOR | POOR | FAIR | POOR | GOOD | GOOD | GOOD | N/A | GOOD |
| | 24) Likely Community Support | POOR | POOR | POOR | FAIR/POOR | FAIR | GOOD | POOR | POOR | POOR | POOR | GOOD | GOOD | GOOD | N/A | GOOD |
| | 25) Impacts on water source area (political, env., economic) | POOR | POOR | POOR | FAIR | FAIR | GOOD | UNKNOWN | UNKNOWN | POOR | POOR | GOOD | GOOD | GOOD | N/A | GOOD |
| | General Implementability | POOR | POOR | POOR | FAIR | FAIR | FAIR | POOR | POOR | FAIR | POOR | GOOD | GOOD | GOOD | N/A | GOOD |
| Cost | Unit Cost ($/AF) | $1,449 | $1,456 | $1,282 | 1600 AFY - $2,860<br>2600 AFY - $2,062 | 1600 AFY- $2,397<br>2600 AFY - $1,635 | More than CGM to Bisbee, less than CGM to Ft Huachuca | 20,000 AF $1,725<br>30,000 AF $1,594<br>40,000 AF $1,570 | 20,000 AF $1,411 - $1,847<br>30,000 AF $1,281 - $1,717<br>40,000 AF $1,267 - $1,693 | $689* | $1,016* | $23,780 | $7,778 | $2,675 | $0 | $6,944 |
| | Unit Cost ($/kgal) | $4.45 | $4.50 | $3.93 | 1600 AFY - $8.78<br>2600 AFY - $6.33 | 1600 AFY -$7.35<br>2600 AFY -$5.02 | More than CGM to Bisbee, less than CGM to Ft Huachuca | 20,000 AF: $5.29<br>30,000 AF: $4.89<br>40,000 AF: $4.82 | 20,000 AF: $4.33 - $5.67<br>30,000 AF: $3.93 - $5.27<br>40,000 AF: $3.86 - $5.20 | $2.11* | $3.12* | $72.96 | $23.87 | $8.21 | $0.00 | $21.31 |
| | 26) Unit Cost Rating/ General Cost | FAIR | FAIR | FAIR | POOR | FAIR | FAIR | FAIR | FAIR | GOOD | GOOD | POOR | POOR | POOR | GOOD | POOR |

All cost estimates, including those performed by BBC/Fluid Solutions use a 4% interest rate and 20 year payback period

Table 13: Overall ratings (effectiveness, implementability, cost) by USPP SWG/Tech/GAC workgroup

| Alternative | Overall effectiveness | Overall implementability | Overall cost |
|---|---|---|---|
| **Intra-basin transfer alternatives** | | | |
| **A1. Tombstone Mine Workings to the Fort WWTP** | **< 50 yr. POOR**<br>**> 50 yr. POOR**<br>Poor yield (500 afy). Small reduction in groundwater pumping, resulting in poor benefits to regional aquifer. Benefits to the river would be poor in the short term, fair in the long term. | **POOR:** Uses conventional technology. However, would need additional study to identify and address potential issues of subsidence and settling. Potential issues with existing mining claims. Opposition is likely from the Tombstone community. | **FAIR:**<br>$1,449 per acre foot |
| **A2. Tombstone Mine Workings to the SPRNCA Recharge** | **< 50 yr. GOOD**<br>**> 50 yr. FAIR**<br>Poor yield (500 afy). Does not reduce groundwater pumping to help regional aquifer, but the recharge location results in good benefits to the river in the short term, fair benefits in long term. | **POOR:** Uses conventional technology. However, likely AZPDES and APP permitting issues. Potential issues with existing mining claims. Would need additional study to identify and address potential issues of subsidence and settling. Opposition is likely from the Tombstone community. | **FAIR:**<br>$1,466 per acre foot |
| **B. Retire agriculture north of Benson to Fort Huachuca/Sierra Vista** | **< 50 yr. POOR**<br>**> 50 yr. FAIR**<br>Fair yield (3,375 afy). Reduced groundwater pumping in the Sierra Vista area would have fair benefits to the regional aquifer. Effects on the river would be poor in the short term, but fair over the long term. | **POOR:** Uses conventional technology. However, water recovered could be considered sub-flow subject to surface water regulations, complicating water rights issues. Many new competing uses in Benson Sub-watershed. Requires cooperation from Sierra Vista area water companies and changes in ACC regulations. Substantial opposition is likely from the Benson community. | **FAIR:**<br>$1,282 per acre foot |

Table13: Overall ratings (effectiveness, implementability, cost) by USPP SWG/Tech/GAC workgroup (continued)

| Intra-basin transfer alternatives (continued) | | | |
|---|---|---|---|
| **Alternative** | **Overall effectiveness** | **Overall implementability** | **Overall cost** |
| **C1. CQM to Fort Huachuca/ Sierra Vista** | **< 50 yr. POOR**<br>**> 50 yr. FAIR**<br>Fair yield (1,800/2,600 afy). Reduction in groundwater pumping results in fair benefits to the regional aquifer. Poor benefits to the river in the short term. Benefits to the river fair in the long term. | **FAIR:** Uses conventional technology. However, variability in water quality and lack of water quality data requires piloting to customize treatment process. Positive environmental impacts on CQM & Bisbee. Ownership issues may reduce long term reliability. Requires cooperation from Sierra Vista area water companies and changes in ACC regulations. Some opposition from Bisbee community likely. | **FAIR:**<br>1,800 afy:<br>$2,860 per acre foot<br><br>2,600 afy:<br>$2,062 per acre foot |
| **C.2 CQM to Bisbee and Naco** | **< 50 yr. POOR**<br>**> 50 yr. FAIR**<br>Fair yield (1,800/2,600 afy). Less effective as it stops pumping away from cone of depression and the river. Poor benefits to regional aquifer. Poor benefits to the river in the short term, fair in the long term. | **FAIR** : Uses conventional technology. However, variability in WQ and lack of water quality data requires piloting to customize treatment process. Positive environmental impact on CQM, Bisbee. Ownership issues may reduce reliability. Requires cooperation from Bisbee area water companies and changes in ACC regulations. Community support/opposition unknown. | **FAIR:**<br>1800 afy:<br>$2,397 per acre foot<br><br>2600 afy:<br>$1,635 per acre foot |
| **C3. CQM to SPRNCA Recharge (hybrid)** | **< 50 yr. GOOD**<br>**> 50 yr. GOOD**<br>Fair yield (1800/2600 afy). Does not reduce groundwater pumping, resulting in poor benefits to regional aquifer. However, location of recharge results in good benefits to the river, both short and long term. | **FAIR:** Uses conventional technology. However, variability in water quality and lack of water quality data requires piloting to customize treatment process. Positive environmental impact on CQM, Bisbee. Ownership issues may reduce reliability. Recharge near river would require AZPDES and/or APP Permit. Community support/opposition unknown. | **FAIR:** More than CQ Mine to Bisbee/Naco, less than CQ Mine to Ft. Huachuca/S.V. |

Table 13: Overall ratings (effectiveness, implementability, cost) by USPP SWG/Tech/GAC workgroup (continued)

| Inter-basin transfer alternatives | | | |
|---|---|---|---|
| **Alternative** | **Overall effectiveness** | **Overall implementability** | **Overall cost** |
| D1. CAP recharge and recovery of municipal supplies w/ San Pedro River recharge (hybrid) | < 50 yr. GOOD<br>> 50 yr. GOOD<br>Good yield (20,000/30,000/40,000 afy), sufficient to meet requirements to 2050 with a single project. Stopping pumping in Sierra Vista area and recharge would result in good benefits to regional aquifer, and the river, both short and long term CAP water higher in salts than groundwater. | POOR: Competition for CAP allocations will be extreme. Legal and regulatory issues also extremely challenging (State and Federal). Requires funding and construction of recharge facilities. Lack of community support. | FAIR:<br>20,000 acre feet: $1,725<br>30,000 acre feet: $1,594<br>40,000 acre feet: $1,570 |
| D2. CAP direct delivery of municipal supplies w/ San Pedro River recharge (hybrid) | < 50 yr. GOOD<br>> 50 yr. GOOD<br>Good yield (20,000/30,000/40,000 afy), sufficient to meet requirements to 2050 with a single project. Stopping pumping in Sierra Vista area and recharge would result in good benefits to regional aquifer, and the river, short and long term. CAP water is higher in salts than groundwater. | POOR: Competition for CAP allocations will be extreme. Legal and regulatory issues also extremely challenging (State and Federal). Requires large amount of funding for construction of treatment facilities. May be environmental issues with evaporation ponds if RO treatment is selected. Lack of community support. | FAIR:<br>20,000 acre feet:<br>$1,411 - $1,847<br>30,000 acre feet:<br>$1,281 - $1,717<br>40,000 acre feet:<br>$1,257 - $1,693 |
| E1. Douglas Basin to Bisbee<br><br>(WIE1a in BBC/Fluid Solutions Study) | < 50 yr. POOR<br>> 50 yr. FAIR<br>Poor yield (1,010 afy). Less effective as pumping stops away from cone of depression and the river. Fair benefits to regional aquifer. Poor benefits to river in short term, fair over long term. | FAIR: Permitted under A.R.S. 45-544, requires cooperation from Bisbee area water companies and changes in ACC regulations. Community support is unknown. | GOOD:<br>$689 per acre foot*<br><br>* Reclamation believes BBC/Fluid Solutions cost estimates are low |

Table13: Overall ratings (effectiveness, implementability, cost) by USPP SWG/Tech/GAC workgroup (continued)

| Inter-basin transfer alternatives (continued) | | | |
|---|---|---|---|
| **Alternative** | **Overall effectiveness** | **Overall implementability** | **Overall cost** |
| **E2. Douglas Basin to Fort / Sierra Vista** (WIE1c in BBC/Fluid Solutions Study) | **< 50 yr. POOR**<br>**> 50 yr. FAIR**<br>Fair yield (8,430 afy). Stopping groundwater pumping in Sierra Vista area would have good benefits to regional aquifer. Poor benefits to the river in the short term, fair over the long term. | POOR: Currently prohibited and would require changes in A.R.S. 45-544. Requires cooperation from Sierra Vista area water companies and changes in ACC regulations. Opposition from Douglas Basin is unknown, but probable. | GOOD:<br>$1,016 per acre foot*<br><br>* Reclamation believes BBC/FS cost estimates are low |
| **Local alternatives** | | | |
| **F1. Capture and Reuse of Residential Stormwater** | **< 50 yr. POOR**<br>**> 50 yr. POOR**<br>Poor yield (1,095 afy), resulting in poor benefits to the regional aquifer, and river short and long term. Offers a slight improvement in flood regime and river water quality. Highly dependent on rainfall. | GOOD: Uses conventional technology. Could have small beneficial impact by reducing excess runoff. No significant legal or regulatory issues. Could be implemented through ordinances & zoning regulations. Community support likely. | POOR:<br>$23,780 per acre foot |
| **F2. Capture and Reuse of Commercial Stormwater** | **< 50 yr. POOR**<br>**> 50 yr. POOR**<br>Poor yield (331 afy), resulting in poor benefits to the regional aquifer, and river short and long term. Offers a slight improvement in flood regime and river water quality. Highly dependent on rainfall. | GOOD: Uses conventional technology. Could have small beneficial impact by reducing excess runoff. No significant legal or regulatory issues. Could be implemented through ordinances & zoning regulations. Community support likely. | POOR:<br>$7,778 per acre foot |

Table13: Overall ratings (effectiveness, implementability, cost) by USPP SWG/Tech/GAC workgroup (continued)

| Local alternatives (alternatives) | | | |
|---|---|---|---|
| **Alternative** | **Overall effectiveness** | **Overall implementability** | **Overall cost** |
| G1. Recharge of Urban Runoff near the SPRNCA | < 50 yr. GOOD<br>> 50 yr. GOOD<br>Fair yield (1,800 afy). Poor benefits to regional aquifer, however, good benefits to river in short and long term. Water quality & flood regime benefits to river. Less rainfall dependent with banking | GOOD: Uses conventional technology. No significant legal or regulatory issues, though APP or Title 45 permits needed for recharge. Community support likely. | POOR:<br>$2,675 per acre foot |
| H. No Action | < 50 yr. POOR<br>> 50 yr. POOR<br>No benefit to regional aquifer, alluvial groundwater levels or river. | GOOD: No implementation impediments | GOOD:<br>$20 or 30 per acre foot |
| Linear Park Recharge (hybrid) | < 50 yr. POOR<br>> 50 yr. POOR<br>Poor yield, resulting in poor benefits to regional aquifer, and the river short and long term. May help engineer flood flows back to pre-development levels. | GOOD: Uses conventional technology. Avoids water rights issues by using detention facilities (not retention) in natural channels. No regulatory issues. | To be determined |

Table 14: Synopsis of alternative ratings

| Alternative type | Alternative | Overall effectiveness | Overall implementability | Overall cost (Annual cost over 20-year payback period, 4% interest rate) |
|---|---|---|---|---|
| Intra-basin transfer | A1. Tombstone mine workings to the Fort WWTP | Short-Term: Poor<br>Long Term: Poor | Poor | Fair ($1,449/afy) |
| | A2. Tombstone mine workings to the SPRNCA Recharge | Short-Term: Good<br>Long Term: Fair | Poor | Fair ($1,466/afy) |
| | B. Retire agriculture north of Benson to Fort/Sierra Vista | Short-Term: Poor<br>Long Term: Fair | Poor | Fair ($1,282/afy) |
| | C1. CQM to the Fort Huachuca/Sierra Vista | Short-Term: Poor<br>Long Term: Fair | Fair | Fair ($2,062 - $2,860/afy) |
| | C2. CQM to Bisbee/Naco | Short-Term: Poor<br>Long Term: Fair | Fair | Fair ($1,635 - $2,397/afy) |
| | C3. CQM to SPRNCA recharge | Short-Term: Good<br>Long Term: Good | Fair | Fair (less than C1, more than C2) |
| Inter-basin transfer | D1. CAP to Sierra Vista – Direct Delivery w/ San Pedro River Recharge (hybrid) | Short-Term: Good<br>Long Term: Good | Poor | Fair ($1,257 - $1,847/afy) |
| | D2. CAP to Sierra Vista – Recharge and Recovery w/ San Pedro River Recharge (hybrid) | Short-Term: Good<br>Long Term: Good | Poor | Fair ($1,570 - $1,725/afy) |
| | E1. Douglas Basin to Bisbee | Short-Term: Poor<br>Long Term: Fair | Fair | Good ($689*/afy) |
| | E2. Douglas Basin to Fort Huachuca/Sierra Vista | Short-Term: Poor<br>Long Term: Fair | Poor | Good ($1,016*/afy) |
| Local | F1. Capture and Reuse of Stormwater for New Residential Subdivision | Short-Term: Poor<br>Long Term: Poor | Good | Poor ($23,780/afy) |
| | F2. Capture and Reuse of Stormwater in New Commercial Construction | Short-Term: Poor<br>Long Term: Poor | Good | Poor ($7,778/afy) |
| | G1. Recharge of Urban Runoff near the SPRNCA | Short-Term: Good<br>Long Term: Good | Good | Poor ($2,675/afy) |
| | H. No Action Alternative | Short-Term: Poor<br>Long Term: Poor | Good | Good |
| | Linear Park Recharge | Short-Term: Poor<br>Long Term: Poor | Good | To be determined |

* Reclamation believes BBC/Fluid Solutions cost estimates are low.

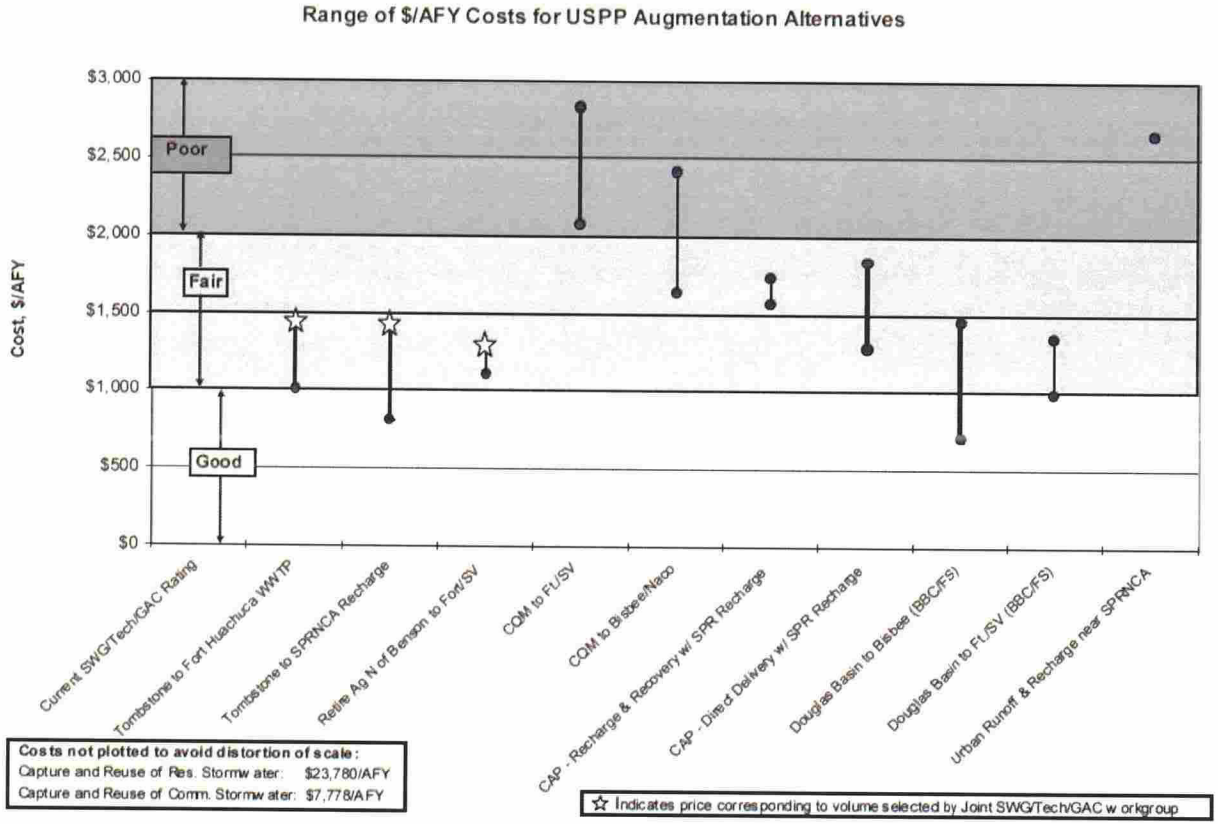



**Figure 12: Cost estimate ranges.**

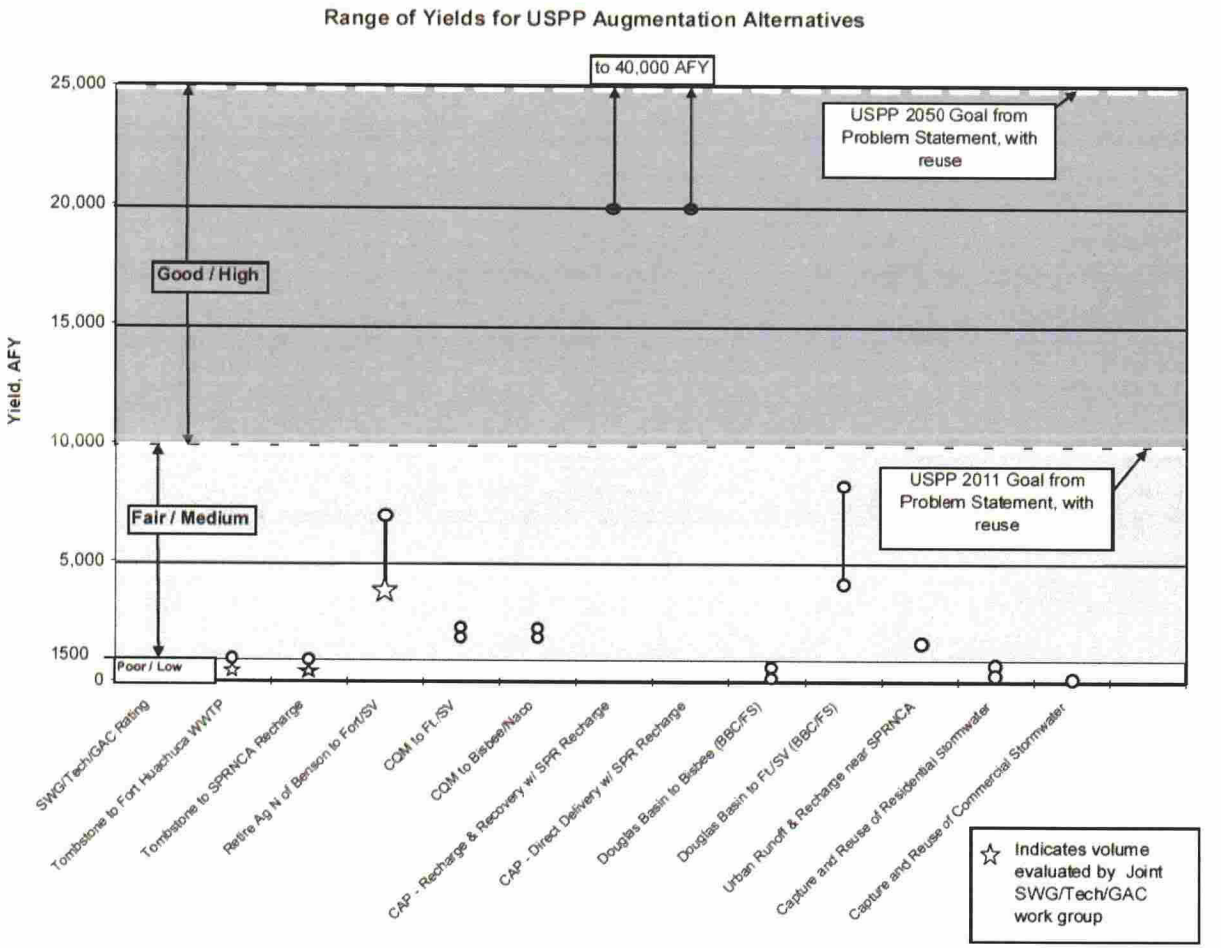



**Figure 13: Range of yields for USPP augmentation alternatives.**

## Recommendations to the USPP Partnership Advisory Commission

The Joint SWG/Tech/GAC workgroup began its decisionmaking process by dividing the alternatives into short term and long term projects. This ensured that while immediate needs were met, some recommended alternatives also focused on the long-term sustainability of conditions for the San Pedro River. Categorizing the projects clarified expectations and helped the group to reach consensus. Each agency recommended alternatives for the short-term and long-term feasibility study categories, and a consensus on the most promising alternatives was reached.

Alternatives were then classified into the following categories and sub-categories:

- Alternatives that should receive no further action by Reclamation or the USPP
- Alternatives that should be pursued in the short term (possible implementation in 3–10 years)
    - Alternatives not requiring Reclamation feasibility study for implementation
    - Alternatives requiring a Reclamation feasibility study
- Alternatives that should be pursued in the long term, that would likely be implemented in 10+ years
    - Alternatives requiring a Reclamation feasibility study
- Alternatives that should be held for consideration later

The USPP Partnership Advisory Commission held a work session on January 10, 2007 to consider the recommendations by the Joint SWG/Tech/GAC workgroup and to make a final decision regarding augmentation alternatives selected for further technical analysis. The PAC accepted the recommendations of the Joint SWG/Tech/GAC workgroup with some minor changes. The results and accompanying explanations are summarized in Table 15 and are discussed in the next subsections.

**Table 15: Synopsis of recommendations adopted by USPP PAC**

| | |
|---|---|
| **Alternatives recommended for a feasibility report and further technical study** | |
| Short-term | G1. Recharge Urban Runoff near to the SPRNCA |
| | C3. CQM to SPRNCA Recharge (hybrid) |
| Long-term | D1. CAP Recharge and Recovery of Municipal Supplies with San Pedro River Recharge (hybrid) |
| | D2. CAP Directly Delivery of Municipal Supplies with San Pedro River Recharge (hybrid) |
| Short and long-term | H. No Action Alternative (Used for NEPA and comparison purposes) |
| **Alternatives to be held for consideration later** | |
| Short-term | A2. Tombstone Mine to SPRNCA Recharge |
| | E1. Douglas Basin to Bisbee |
| | C2. CQM to Bisbee/Naco |
| **Alternatives to pursue without further study** | |
| Short-term | Linear Park Recharge |
| Long-term | F1. Capture and Ruse of Residential Stormwater |
| | F2. Capture and Reuse of Commercial Stormwater |
| **Alternatives set aside - no further action required** | |
| Short-term | A1. Tombstone Mine Workings to Fort Huachuca WWTP |
| | B. Retire Agriculture North of Benson to Fort/Sierra Vista |
| | C1. CQM to Fort Huachuca/ Sierra Vista Area |
| | E2. Douglas Basin to Fort Huachuca/Sierra Vista |

## Alternatives Set Aside—No Further Action Required

Four alternatives involved pumping water from other areas for use in the Fort Huachuca/ Sierra Vista area. These alternatives would reduce groundwater pumping near Sierra Vista. However, for most of these, there would be a huge challenge in changing the current ACC regulations to allow for these options and in overcoming likely community opposition, resulting in difficult implementation. Low effectiveness combined with difficult implementation eliminated these alternatives. The alternatives set aside include:

- **A1. Tombstone Mine Workings to the Fort WWTP**
- **B. Retire Agriculture North of Benson to the Fort/Sierra Vista**
- **C1. CQM to the Fort/Sierra Vista**

- **E2. Douglas Basin to the Fort/Sierra Vista (WIE 1c in BBC/Fluid Solutions)**

## Alternatives to Pursue without Further Study

Three alternatives are easy to implement, using conventional technology with no significant regulatory impediments. Though the yields are relatively low, these options offer other advantages, such as public awareness, support, and participation, as well as a sustaining flood flows and water quality for the river. Individual member agencies would implement these alternatives. However, the USPP should provide technical review to ensure that the methods used are effective.

- **F1. Capture and Reuse of Residential Stormwater**
- **F2. Capture and Reuse of Commercial Stormwater**
- **Linear Park recharge** (hybrid alternative)

## Alternatives Recommended for a Feasibility Report and Further Technical Study

### *Short-Term Alternatives*

The following alternatives had overall yields and a proposed recharge location near the river that offered good benefits to the river in both the short and long term. In addition, there seemed to be no significant legal or regulatory impediments to implementation. Technical issues would need to be resolved as part of future studies.

- **G1. Recharge Urban Runoff near SPRNCA**
- **C3. CQM to SPRNCA Recharge** (hybrid alternative)

### *Long-Term Alternatives*

The following alternatives would take longer to implement (10+ years), but offer substantial benefit if they are determined to be feasible. In fact, these were the only augmentation alternatives that met the 2050 requirements in a single project, or a combination of projects. It was decided that even though the CAP alternatives were not popular, even among the PAC members themselves, it was important to move them forward to feasibility level analysis, so as not to lose the potential for obtaining a CAP allocation in the future. PAC members noted that the CAP alternatives offer the most significant challenges, including:

- Competition for CAP allocations will be extreme and lengthy
- Significant legal and regulatory issues exist at the State and Federal level.
- Significant funding requirements will need to be met.
- Community opposition is likely.

These alternatives are:

- **D1. CAP to Sierra Vista – Recharge and Recovery of Municipal Supplies with San Pedro River Recharge** (hybrid alternative)
- **D2. CAP to Sierra Vista – Direct Delivery of Municipal Supplies with San Pedro River Recharge** (hybrid alternative)

## Alternatives to be Held for Consideration Later

The following alternatives offer fewer benefits than those that are moving forward to feasibility study and in some cases could not be implemented if the approved options are pursued because they use the same water. So, if approved alternatives are set aside as a result of feasibility studies, these alternatives could be considered:

- **A2. Tombstone Mine Workings to the SPRNCA Recharge.** While the relative yield is low; this recharge location could provide good benefits to the river. This alternative could be pursued if other, higher yielding alternatives are not implemented. It would need additional study to identify and address potential issues of subsidence and settling near Tombstone.
- **E1. Douglas Basin to Bisbee** (WIE 1a in BBC/Fluid Solutions). The relative yield is low; however, the alternative would allow the part of Bisbee located in the Douglas basin to be served by pumping in that basin, rather than pumps in the Sierra Vista Sub-watershed. This would provide some benefit, but would still require significant changes to ACC regulations and cooperation by private water companies. Benefit is considered small compared to the effort required. It could be pursued if other, more effective alternatives are not implemented.
- **C2. CQM to Naco and Bisbee.** This alternative is not considered as effective as CQM to SPRNCA. This also does not offer the strong long and short term benefits to the river the way CQM to SPRNCA does, but it could be a worthy of consideration if a second alternative is required by feasibility study guidelines.

## Discussion

The problem statement indicated that the USPP was looking to water augmentation to provide about 10,000 afy by 2011, with up to 26,000 afy by the year 2050. Of the recommended short-term alternatives, no single one will meet the goal. Even a combination of alternatives will have trouble solving the short-term problem. However, these alternatives provide a significant first step in mitigating the depletion of groundwater resources and its impact on SPR base flow. In addition, some alternatives have the potential for greater yield depending on project-specific factors, such as improved reverse osmosis efficiency and an increased collection area for urban runoff.

For the long term, the CAP to Sierra Vista alternatives (D) recommended for further analysis present the greatest obstacles. A cursory review of this alternative may give the reader a negative impression. However, the fact that this alternative could mitigate the entire projected groundwater overdraft, along with its relatively small unit cost, makes it worth further analysis.

Water augmentation is only one of several factors the USPP must address as a part of their overall water management plan. These include the need to:

- Ensure that water supply is considered as part of the development approval process
- Place a greater emphasis on water reuse and matching end use with appropriate water quality
- Increase emphasis on water conservation

The USPP must continue to investigate and analyze water augmentation as a part of the overall water management plan development.

## Additional Water Management Issues

In 1996, Reclamation provided funding for the Sierra Vista Water Reclamation Facility (SV WRF), which recharges treated effluent to the aquifer, thereby supporting base flows in the SPR. The SV WRF was completed in 2002 and consists of 50 acres of artificial wetlands, 30 acres of recharge basins, and 10 acres of sewage processing. The city of Sierra Vista is responsible for WRF operations and reports annually to Reclamation. In addition, Sierra Vista is required to develop a groundwater model report every 5 years to demonstrate the effectiveness of the SV WRF, through the year 2040. Reclamation reviews the reports to determine whether the effluent is being used in the most effective manner.

Upon review of Sierra Vista's 2006 annual report, Reclamation concurred that recharge is taking place at the SV WRF and that the facility benefits base flow in

the San Pedro River. In addition, the review identified a large volume of effluent that could not be accounted for. A minimum of 3,625 acre-feet of water were unaccounted for between 2003 through 2006. Data are not available for every month due to periodic meter malfunctions. Moreover, water has been observed to be daylighting in nearby Curry Draw, upstream from Murray Springs, which is located approximately midway between the SV WRF and the SPR. Flow has also been observed within the archaeologically significant Clovis "Murray Springs Site," which may be attributable to the SV WRF.

Reclamation has been coordinating a collaboration effort on these issues to integrate data collection and monitoring results with representatives of BLM, USGS, The Nature Conservancy, University of Arizona, Arizona Department of Water Resources, city of Sierra Vista, and USDA Agricultural Research Service.

Effluent treated at the SV WRF represents an important resource in the Sierra Vista Sub-watershed, and should be put to the most effective use possible. The discovery of lost water at the WRF and the unexpected daylighting near Murray Springs demonstrates the need for improved understanding of the hydrologic conditions at the SV WRF. This requires accurate data for a hydrologic model. This situation also reveals the unpredictability inherent in recharge projects, especially in an area known to have clay layers, like the Sierra Vista Sub-watershed.

The recharge taking place at the SV WRF accounts for a large portion of the management measures taken by USPP to offset groundwater overdraft. It also provides an excellent opportunity to study the feasibility of recharge projects in the Sierra Vista Sub-watershed. For both these reasons, Reclamation recommends that the USPP become more proactive in discovering the fate of the unaccounted for effluent, which has ranged from 27 percent to 46 percent of the total influent. In addition, ongoing research on the effects of the SV WRF should be used to conclude whether this project is the most beneficial use of effluent in achieving sustainability in the Sierra Vista Sub-watershed.

# Chapter V: Implementation

## Reiteration of Problem Statement

This appraisal study evaluated augmentation alternatives with respect to how they would solve the groundwater overdraft problem. The problem as agreed upon by the USPP was:

> *A set of water augmentation solutions is needed that would work toward sustainable yield by adding approximately 10,000 acre-feet a year (afy) by 2011 and 26,000 afy by 2050, to negate a portion of the 38,500 afy total demand projected by 2050.*

## Recommendations for Implementation

Reclamation recommends that the USPP develop an implementation strategy to follow up on the appraisal study. This strategy should outline the actions required to proceed with the study's conclusions. This chapter lays out such a plan, detailing two parallel activities that need to be carried out in the near future—a decisionmaking process and a legal/institutional process.

## PAC Actions Completed or Underway

To commence action on the selected alternatives, the PAC directed that:

- The USPP will pursue the legal authorization and funding necessary for a Feasibility Study.
- The USPP will contact new owners of the Copper Queen Mine, Freeport-McMoran Copper and Gold, to determine interest in pursuing the CQM to SPRNCA Recharge augmentation alternative.
- Stormwater capture for new residential and commercial construction alternatives will be included in the Partnership Strategic Plan under the "Reduce use" goal, so that action plans can be developed to encourage capture and use of stormwater.
- The USPP will continue investigating the acquisition of rights to Colorado River or CAP water.

A key impediment to implementing many of the augmentation alternatives is that the local political subdivisions within the USPP lack the legal authority to develop, own, or manage the necessary facilities. Local governmental entities have begun efforts to form a State-authorized "Upper San Pedro Water District". The water district is intended to be a legally binding body with perpetual authority, specifically adapted to the geographic and hydrologic requirements of the district. It may be able to provide the resources and authority to implement the augmentation alternatives that could not be constructed otherwise. The USPP PAC has endorsed the formation of the district in principle.

## Future Decisionmaking Needs for Implementing Augmentation

### Processes: Decisionmaking and Legal/Institutional

There are two parallel courses of action that need to take place in the near future: the decisionmaking process and the legal/institutional process. The decisionmaking activity involves elected officials, water managers, and the public in the next round of the augmentation alternative selection process. This consists of public education, community input, and a feasibility level process for selecting alternative(s). The legal/ institutional activity entails discussions of ownership, operation, financing, and repayment factors. The two activities move forward in parallel: interaction between them is essential for a successful outcome.

Several agencies represented on the USPP PAC will be the primary decision makers during this phase. Other organizations on the USPP PAC will have a direct interest in, or could be directly affected by, the selection of an alternative(s). Entities in the USPP can help by providing advice, facilitating public awareness, and assisting with implementation of both of these processes.

### The Decisionmaking Process

This appraisal study analyzed and compared a long list of fifteen augmentation alternatives in a fair amount of detail. An initial step in the decisionmaking process is to use the material from the appraisal study to educate policymakers and the public. Both groups need to fully understand, and then to discuss, the information presented in the study. Subsequently, a procedure should be developed for the final selection of an alternative(s), using the information from the feasibility study. Reclamation recommends that this procedure include the following elements:

- **Develop informational materials and data.** There is a need to communicate the tremendous amount of information presented in this appraisal report. An executive summary will not do justice to the complex issues that must be addressed. A dedicated public education process over an extended period of time is necessary.

- **Identify the most common issues and concerns.** Graphics and visual aids to help decisionmakers and the public understand the complex issues should be developed. An initial data gathering period to identify public concerns will be beneficial.

- **Provide education, public information, and public involvement**. Water managers, policymakers, and the general public must be educated on a myriad of issues, including cost, environmental impacts, and water quality impacts. It is appropriate to hold public meetings in which study results and conclusions can be presented. Initial public meetings will explain information in the study and request input—concerns, questions, and data gaps. The education and involvement process should be iterative, so that early meetings gather information on specific concerns that can be addressed in future meetings.

  The education and involvement process should focus on specific actions that will be needed for implementation of a given alternative. For example:

  - Water rights may have to be acquired.

  - Ownership, O&M, and repayment plans for a given alternative must be developed.

  Information must be customized to each water provider and other entities that may be involved or affected. The general aspects of the report should be tailored to each interest group (rates, water provider service area, infrastructure, etc). It must be acknowledged that although there are significant areas of common interest and concerns to the entire USPP, there are also unique concerns and issues that apply to one or two of the members.

## Data Gathering: Additional Recommended Technical Analysis and Piloting

A detailed list of information and actions that are required can be found in Chapter 3, "Common Issues For Action Alternatives." A summary of recommended technical investigations that are specific to particular alternatives is given below.

**Tombstone Mine Workings Alternatives (A):** A thorough investigation is needed to characterize the quality of the water in the Tombstone mine workings. This may involve long-term pumping drawdown tests. Feasibility studies **do not** provide funding for water quality sampling and testing that may be required.

**Alternatives requiring recharge**: Characterizing actual recharge rates is very complex. The appraisal level analysis of recharge alternatives used conceptual designs and typical infiltration rates to size basins and estimate in-channel recharge. Recharge facilities permitted by the State of Arizona typically spend several million dollars on potential site characterization and groundwater modeling. Investigation of recharge alternatives should include the following steps:

- At the feasibility level, potential recharge sites should be identified by using existing hydrogeology and modeling information.
- The site-specific hydrogeology through the vadose zone[6] must be understood. If there are no boreholes that provide this information, new ones must be drilled and logged. Feasibility studies **do not** provide funding for drilling and installation of monitoring wells.
- Long-term (approximately 1–2 years), pilot scale recharge should be investigated. Feasibility studies **do not** provide funding for pilot scale testing.

These data can then be incorporated into the feasibility analysis for recharge dependent alternatives.

**CAP to Sierra Vista Alternatives:** Options for the use of CAP water in the Sierra Vista Subwatershed include recharge and recovery, as well as treatment and direct delivery. The concepts and issues involved in the utilization of CAP water once it is delivered are complex. CAP water quality is different than that of native groundwater and water quality is the responsibility of the end user. Determining what water quality is acceptable (and the associated cost) is a local concern and this issue must be addressed by the end users.

**Copper Queen Mine Alternatives (C):** A thorough investigation is necessary to characterize the water quality in the CQM workings. This information is needed to determine the treatment method that should be used and the efficiency of the recovery. The following actions are recommended:

- Long-term pumping drawdown tests can be conducted. Feasibility studies **do not** provide funding for the drawdown tests that are required.

[6] The zone of aeration in the earth's crust above the groundwater level.

- A long-term pilot will eventually be required to determine the efficiency of the presumed reverse osmosis treatment. This will establish the acreage required for concentrate disposal. Feasibility studies **do not** provide funding for pilot scale water treatment tests.

## Selecting a Preferred Alternative

Selecting alternatives for implementation should start after completing the education and involvement activity and should dovetail into the legal/institution process described below. Preparation should include identifying and resolving prerequisites for implementation (e.g., acquiring water rights). These actions should be prioritized to prevent delays in the final selection process. In addition, designs must be refined in order to develop corresponding costs. An ongoing outreach program that educates the public on all aspects of implementation should be developed by the project sponsors.

## Legal and Institutional Process

The legal/institution process will address issues of facility ownership, O&M, financing, and repayment. The process must find reasonable options for dealing with ownership and financial factors. It must be coordinated with the education and involvement process, to keep decisionmakers and the public informed on how project funding will be undertaken and to get feedback on specific concerns. The Statewide Water Advisory Group has been examining ways to address financing and organizational structure for cooperative projects.

**Organizational structure:** To finance an alternative, the USPP will need to investigate various types of funding mechanisms, including multi-jurisdictional entities, districts, and cooperative agreements. If a new type of district were created, useful attributes would include:

- The ability to issue both general obligation and revenue bonds
- Special assessment power
- The ability to enter into intergovernmental agreements

Since several members of the USPP are governmental entities with special assessment power, the prospect of a multiparty agreement may be feasible. Rather than forming a new entity, each municipality could create its own special assessment area and apportion costs among the jurisdictions by mutual agreement. One caveat is that these special assessment areas cannot cover all the area of the municipal entity, so some (possibly small) areas would have to be excluded.

While a multiparty arrangement is legally feasible, the logistics are daunting. For example, negotiating cost allocation could be contentious without an overriding authority. Moreover, each of the entities would have different bond ratings and, thus, different interest rates.

**Investigate and develop financing strategies:** It is beyond the scope of the appraisal study to determine a funding mechanism for the relevant governing bodies. In the appraisal study, it is only necessary to identify the improvements and cost projections for the alternatives. Therefore, financing strategies must be investigated separately. The type of funding and financing that might be available is related to the type of organizational structure which would be used.

Federal funding (e.g., BLM or Department of Defense) may be a possibility. Federal participation in the design and construction of major portions or features of a given alternative may also be possible. State funding may be available through the Water Infrastructure Financing Authority (WIFA) and possibly the Central Arizona Water Conservation District. (New legislation would be required.) Local funding through bonds is another option. Interest rates and repayment periods depend on the source of funding. A municipal rate of 4.0 percent for 20 years was used in cost calculations for the alternatives in this study.

Preliminary discussions held at the State level have identified several financing mechanisms that might be available, including bonds, WIFA, tax-based, revenue-based, or a combination of each type. Tax-based financing may be preferable to revenue-based financing because the former is deductible. Bond availability would be contingent on a mechanism to ensure continued demand and revenue for repayment. WIFA financing might be an attractive option for a portion of the debt.

It is likely that a combination of financing strategies will be required, as well as a combination of Federal, State, and local funding sources. The full range of available financing mechanisms must be carefully considered before committing to a preferred alternative.

**Develop repayment strategies:** Two direct repayment methods are taxes and user fees. A cash flow analysis will be required to help identify repayment issues. The repayment entity must be authorized to pay for the use of facilities, including amortized capital cost and O&M expenses. In the first years of operation of a recharge facility, when excess capacity is available, it could be used by either the Arizona Water Banking Authority or the Central Arizona Groundwater Replenishment District.

As a plan develops, other entities might choose to participate, especially in the case of the CAP alternative (e.g., Tucson area water providers and Benson area interests). Having additional entities participate could help reduce the repayment burden and increase popular support for the alternative.

**Water storage permits:** As described in Appendix C, under ADWR regulations, multiple parties can hold water storage permits for a USF to acquire and store

water credits. For any of the recharge-dependent alternatives, permits for the facility, storage and recovery are recommended. A decision must be made as to the entities that will hold each permit.

**Facility ownership:** It is expected that facilities (e.g., pumping plants, pipelines, basins) will be jointly owned or by a regional entity.

**Operations and water costs:** Water costs for CAP alternatives have been calculated using the municipal and industrial rate schedule (CAWCD, 2007 <http://www.cap-az.com/management/rates>). The CAWCD's price for CAP water consists of a capital component and a delivery component, which covers maintenance and energy costs. The total cost is commonly referred to as the "postage stamp" rate, because it does not depend on the distance or elevation to which the water is pumped. It is unlikely the postage stamp rate will apply for CAP water used in the Sierra Vista Sub-watershed. A rate will need to be determined. The issues of water and operational costs must be discussed with the CAWCD.

The intermediate power cost is predicated on working out an agreement with the CAWCD to allow the project sponsors to buy power through the CAP system at a below-market rate. Peak use, power availability, and cost are key issues that must be addressed with the CAWCD.

## Schedule for Decision

**Decisionmaking**: It is estimated that the decisionmaking process will take 2 years. During the same 2 years, the legal and institutional process should be able to get to the point of establishing the organization needed for implementation. Design and financing activities can both probably begin within the last 6 months of the legal/institutional process.

**Federal project implementation process design and analyses**: Congressional authorization is required for the construction of a project that is recommended by a feasibility study. Projects funded in part or whole by the Federal Government require NEPA analysis and State aquifer protection permits. This process is expected to take at least 2 years. After completion of the final NEPA document, most likely an environmental impact statement, a Record of Decision (ROD) is required, which typically takes at least 3 months to complete. Once a project is selected, it is estimated that the design could be completed in 12 months and the financing in 9 months. Other activities that begin with the issuance of a ROD include land acquisition, development of design specifications, mitigation activities and construction. An example of a possible schedule with both Reclamation and local activities is shown in Figure 14.

Activities involving required Federal permits (e.g., NEPA compliance [i.e., an EIS]) and State recharge permits could take 2 years.

**Federal budget process cycle**: Since Federal funding may be sought, it is important to understand the Federal budget cycle. Reclamation functions on a 3-year budget cycle. In the fall of each year (the beginning of the fiscal year), Reclamation officially begins preparing the budget 2 years out. For example, in October 2007 (first month of fiscal year 2008), Reclamation program managers will identify and prioritize the FY 2010 program and budget. Then, the FY2010 budget goes through about 15 months of agency and departmental review before it is presented by the President to the Congress in February, 2009. For the next 6 months or so, congressional committees discuss the budget, adding or subtracting programs in cooperation with the President. The budget is passed by the Congress, signed by the President, and funding is appropriated in September (at least in theory) prior to the beginning of FY2010.

| ID | Name | Duration |
|---|---|---|
| 1 | **Decisionmaking process** | **26 mons** |
| 2 | Feasibility Study | 24 mons |
| 3 | Develop information materials | 21 mons |
| 4 | Education, public information & involvement | 24 mons |
| 5 | Select preferred alternative | 2 mons |
| 6 | **Legal, Institutional & Financial Process** | **18 mons** |
| 7 | Create organizational structure | 18 mons |
| 8 | Investigate and develop financing strategies | 18 mons |
| 9 | Develop repayment strategies | 18 mons |
| 10 | Business/contractual w/CAVWCD | 18 mons |
| 11 | **Obtain Construction Authority** | 13.3 mons |
| 12 | **Obtain Federal Construction Funding** | 42 mons |
| 13 | **Financing** | **12 mons** |
| 14 | **NEPA - Programatic** | **24 mons** |
| 15 | **Record of Decision (ROD)** | 6 mons |
| 16 | **Land Acquisition** | 12 mons |
| 17 | **Design - Augmentation Alternative** | **18 mons** |
| 18 | **Supplemental NEPA** | **12 mons** |
| 19 | **Design - Local facilities** | **9 mons** |
| 20 | **Construction - Selected Alternative** | **24 mons** |
| 21 | **Construction - Local Facilities** | **12 mons** |

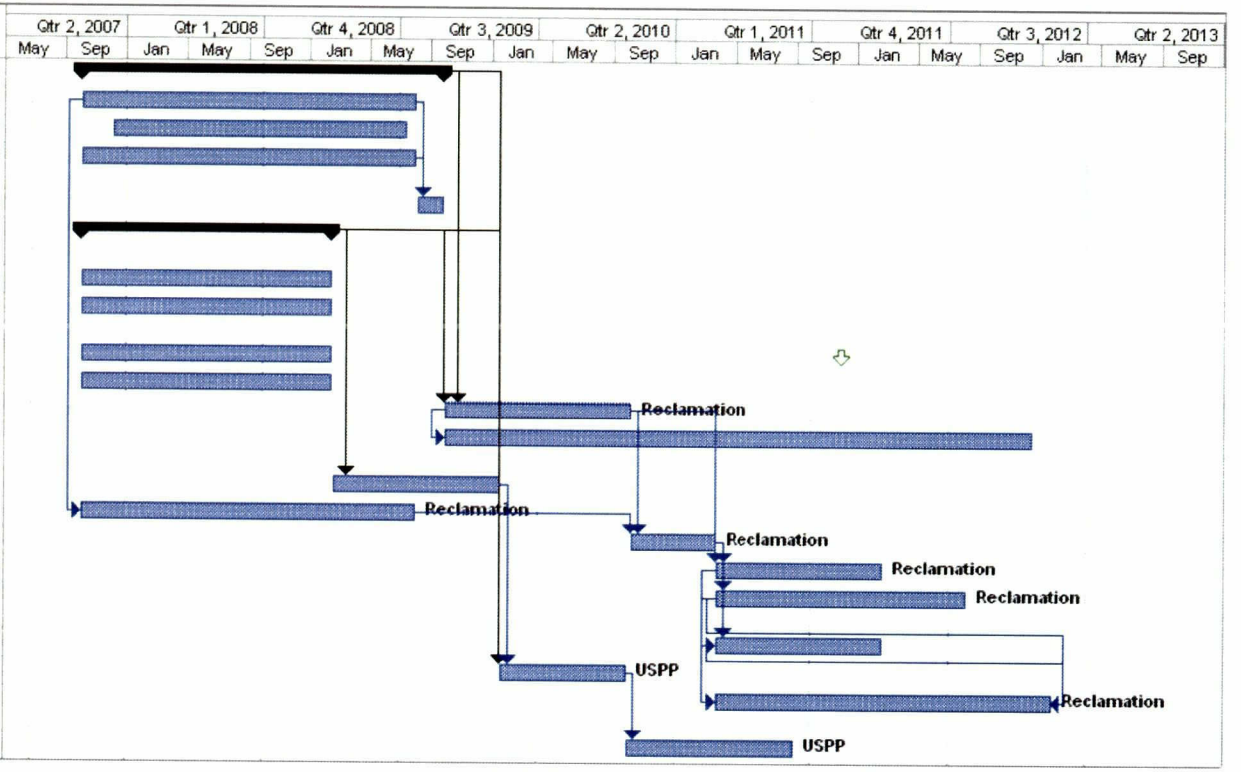



**Figure 14: Timeline for implementation.**

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