Middle Rio Grande Endangered Species Act Collaborative Program
Water Acquisitions and Management Plan

Final Report

Prepared by:

MIDDLE RIO GRANDE ENDANGERED SPECIES ACT COLLABORATIVE PROGRAM WATER ACQUISITIONS AND MANAGEMENT SUBCOMMITTEE
28 NOVEMBER 2005
Final Report

MIDDLE RIO GRANDE ENDANGERED SPECIES ACT
COLLABORATIVE PROGRAM
LONG-TERM WATER ACQUISITIONS AND
ADAPTIVE WATER MANAGEMENT PLAN

Prepared by:
Middle Rio Grande Endangered Species Act
Collaborative Program

Water Acquisitions and Management Subcommittee

28 November 2005
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle Rio Grande Endangered Species Act</td>
<td>1</td>
</tr>
<tr>
<td>Collaborative Program</td>
<td>1</td>
</tr>
<tr>
<td>Water Acquisitions and Management Subcommittee</td>
<td>1</td>
</tr>
<tr>
<td>1.0 INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>1.1 ESA Collaborative Program Goals</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Water Acquisitions and Management Subcommittee Goal and Objectives</td>
<td>2</td>
</tr>
<tr>
<td>1.3 Background</td>
<td>3</td>
</tr>
<tr>
<td>1.3.1 Middle Rio Grande Endangered Species Act Collaborative Program</td>
<td>3</td>
</tr>
<tr>
<td>1.3.2 Program Area</td>
<td>4</td>
</tr>
<tr>
<td>1.3.3 Constraints</td>
<td>4</td>
</tr>
<tr>
<td>2.0 PROGRAM WATER VOLUME, ACQUISITION, AND MANAGEMENT NEEDS</td>
<td>5</td>
</tr>
<tr>
<td>2.1 Supplemental Water Requirements</td>
<td>5</td>
</tr>
<tr>
<td>2.2 Water Supply Needed to Meet the 2003 Biological Opinion</td>
<td>6</td>
</tr>
<tr>
<td>2.3 Projected Program Water Volume Requirements</td>
<td>8</td>
</tr>
<tr>
<td>2.4 Analysis of Sufficiency of Unregulated Rio Grande Flows to Meet ESA Flow Targets</td>
<td>10</td>
</tr>
<tr>
<td>2.5 Water Management and Acquisition Alternatives to Meet Program Water Needs</td>
<td>12</td>
</tr>
<tr>
<td>2.6 Hydrologic Effects of Water Acquisitions on the Middle Rio Grande</td>
<td>14</td>
</tr>
<tr>
<td>2.7 Program Water Acquisition Costs</td>
<td>16</td>
</tr>
<tr>
<td>2.8 Program Water Management</td>
<td>16</td>
</tr>
<tr>
<td>3.0 RANKING OF WATER ACQUISITION AND MANAGEMENT PRIORITIES</td>
<td>19</td>
</tr>
<tr>
<td>3.1 Tier 1: Water Acquisition and Management High Priorities</td>
<td>19</td>
</tr>
<tr>
<td>3.2 Tier 2: Water Acquisition and Management Moderate Priorities</td>
<td>20</td>
</tr>
<tr>
<td>3.3 Tier 3: Water Acquisition and Management Low Priorities</td>
<td>21</td>
</tr>
<tr>
<td>4.0 IMPLEMENTATION</td>
<td>22</td>
</tr>
<tr>
<td>5.0 SUMMARY</td>
<td>25</td>
</tr>
</tbody>
</table>

---

**Attachment A**

Summaries of Water Acquisition and Management Concepts and Methods Assessed

**Attachment B**

Program Water Demand Assessment

<table>
<thead>
<tr>
<th>Section Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 INTRODUCTION</td>
<td>B-1</td>
</tr>
<tr>
<td>2.0 METHODOLOGY</td>
<td>B-1</td>
</tr>
<tr>
<td>3.0 RESULTS AND DISCUSSION</td>
<td>B-1</td>
</tr>
<tr>
<td>4.0 SUMMARY AND CONCLUSIONS</td>
<td>B-2</td>
</tr>
</tbody>
</table>
### Attachment C
#### Analysis of Sufficiency of Unregulated Rio Grande Flows to Meet ESA Flow Targets in the Middle Valley

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Introduction</td>
<td>C-1</td>
</tr>
<tr>
<td>2.0</td>
<td>Assumptions</td>
<td>C-2</td>
</tr>
<tr>
<td>3.0</td>
<td>Data</td>
<td>C-3</td>
</tr>
<tr>
<td>3.1</td>
<td>Descriptive Statistics</td>
<td>C-3</td>
</tr>
<tr>
<td>3.2</td>
<td>Duration Curve Analysis</td>
<td>C-4</td>
</tr>
<tr>
<td>3.3</td>
<td>Frequency Analysis</td>
<td>C-4</td>
</tr>
<tr>
<td>3.4</td>
<td>Low-Flow Frequency Analysis</td>
<td>C-5</td>
</tr>
<tr>
<td>4.0</td>
<td>Conclusions</td>
<td>C-6</td>
</tr>
</tbody>
</table>

### Attachment D
#### Preliminary Reservoir Storage Modeling Analysis

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Introduction</td>
<td>D-2</td>
</tr>
<tr>
<td>2.0</td>
<td>Background</td>
<td>D-2</td>
</tr>
<tr>
<td>2.1</td>
<td>The Middle Rio Grande Endangered Species Act Collaborative Program</td>
<td>D-3</td>
</tr>
<tr>
<td>2.2</td>
<td>Water Acquisition and Management Subcommittee (WAM)</td>
<td>D-3</td>
</tr>
<tr>
<td>2.3</td>
<td>The Utton Transboundary Resources Center</td>
<td>D-4</td>
</tr>
<tr>
<td>3.0</td>
<td>Framework for Preliminary Analysis</td>
<td>D-4</td>
</tr>
<tr>
<td>3.1</td>
<td>The Geographic Setting</td>
<td>D-5</td>
</tr>
<tr>
<td>3.2</td>
<td>Overview of Reservoirs</td>
<td>D-5</td>
</tr>
<tr>
<td>3.3</td>
<td>Overview of Rio Grande Compact</td>
<td>D-7</td>
</tr>
<tr>
<td>3.4</td>
<td>Water Uses - Demands and Projected Trends</td>
<td>D-7</td>
</tr>
<tr>
<td>3.5</td>
<td>URGWOM</td>
<td>D-7</td>
</tr>
<tr>
<td>3.6</td>
<td>URGWOPS</td>
<td>D-8</td>
</tr>
<tr>
<td>4.0</td>
<td>Preliminary Analysis</td>
<td>D-8</td>
</tr>
<tr>
<td>4.1</td>
<td>Summary of Process</td>
<td>D-8</td>
</tr>
<tr>
<td>4.2</td>
<td>The Alternatives</td>
<td>D-11</td>
</tr>
<tr>
<td>5.0</td>
<td>Recommendations</td>
<td>D-15</td>
</tr>
<tr>
<td>6.0</td>
<td>References</td>
<td>D-166</td>
</tr>
</tbody>
</table>

**Appendices**

- D-1 Summary of Minnow Litigation                            | D-17 |
- D-2 Draft Description of Work - WAMS Reservoir Storage Preliminary Analysis | D-21 |
- D-3 Additional Detail on Alternative Considered              | D-22 |
<table>
<thead>
<tr>
<th>Attachment</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-1</td>
<td>NEW MEXICO RIO GRANDE COMPACT DELIVERY AND CREDIT WATER</td>
<td>E-1</td>
</tr>
<tr>
<td>E-2</td>
<td>RIO GRANDE PROJECT USABLE WATER</td>
<td>E-6</td>
</tr>
<tr>
<td>E-3</td>
<td>COLORADO WATER</td>
<td>E-8</td>
</tr>
<tr>
<td>E-4</td>
<td>PROGRAM WATER ACQUISITION</td>
<td>E-10</td>
</tr>
<tr>
<td>E-5</td>
<td>MUNICIPAL AND INDUSTRIAL CONJUNCTIVE USE STRATEGIES</td>
<td>E-21</td>
</tr>
<tr>
<td>E-6</td>
<td>SUPPLEMENTING MRG FLOWS THROUGH IRRIGATION EFFICIENCY IMPROVEMENTS</td>
<td>E-29</td>
</tr>
<tr>
<td>E-7</td>
<td>VOLUNTARY IRRIGATION FORBEARANCE IN THE MRGCD SERVICE AREA</td>
<td>E-35</td>
</tr>
<tr>
<td>E-8</td>
<td>NATIVE AMERICAN WATER</td>
<td>E-38</td>
</tr>
<tr>
<td>E-9</td>
<td>NEW MEXICO ACEQUIA WATER</td>
<td>E-39</td>
</tr>
<tr>
<td>E-10</td>
<td>WEATHER MODIFICATION – CLOUD SEEDING WATER</td>
<td>E-41</td>
</tr>
<tr>
<td>E-11</td>
<td>SUPPLEMENTING MIDDLE RIO GRANDE FLOWS THROUGH ACTIVE WATERSHED</td>
<td>E-45</td>
</tr>
<tr>
<td>E-12</td>
<td>STORAGE AND MANAGEMENT OF PROGRAM WATER</td>
<td>E-54</td>
</tr>
<tr>
<td>E-13</td>
<td>COCHITI LAKE WATER ISSUES</td>
<td>E-67</td>
</tr>
<tr>
<td>E-14</td>
<td>RESERVOIR EVAPORATION WATER</td>
<td>E-69</td>
</tr>
<tr>
<td>E-15</td>
<td>EVAPOTRANSPERSION AND WATER SALVAGE</td>
<td>E-73</td>
</tr>
<tr>
<td>E-16</td>
<td>FLOODPLAIN LAKES AND FLOOD FLOW RETENTION BASINS</td>
<td>E-77</td>
</tr>
<tr>
<td>E-17</td>
<td>SUPPLEMENTING MIDDLE RIO GRANDE FLOWS THROUGH GROUNDWATER PUMPING</td>
<td>E-80</td>
</tr>
<tr>
<td>E-18</td>
<td>SUPPLEMENTING MIDDLE RIO GRANDE FLOWS THROUGH PUMPING FROM THE LOW FLOW CONVEYANCE CHANNEL (LFCC)</td>
<td>E-85</td>
</tr>
<tr>
<td>E-19</td>
<td>STUDY OF RECONFIGURATION FOR THE SAN ACACIA REACH</td>
<td>E-92</td>
</tr>
</tbody>
</table>
1.0 INTRODUCTION

The water and natural resource management and use activities that fostered agricultural, urban, and recreational development along the Middle Rio Grande (MRG) changed natural river flows and dependent habitat, ecosystem, and species relationships. Loss of several native species resulted and various remaining threatened and endangered species are now accorded protection under both Federal and New Mexico endangered species laws and regulations. In particular, the Rio Grande silvery minnow (silvery minnow; *Hybognathus amarus*) and southwestern willow flycatcher (flycatcher; *Empidonax traillii extimus*) are listed as endangered species with habitat in the MRG.

The Middle Rio Grande Endangered Species Act Collaborative Program (Program) was established to address current and future water management and related decisions with respect to these species. *The Program’s Water Acquisition and Management Subcommittee (WAMS) was assigned the responsibility for developing a comprehensive water management and supply plan to aid meeting the goals of the Program*, as described below. The intent of this document is to provide a framework for addressing water supply needs for endangered species management issues in the MRG, while also protecting to the maximum possible all existing and planned management and use activities surrounding and dependant upon the water of the MRG.

1.1 ESA Collaborative Program Goals

The following goals are defined for the Program in its 2003 Draft Program Document.

**Goal 1 – Improve endangered species status and their habitats to the extent that the species do not need the program:**

Within the Middle Rio Grande Program area, act to prevent extinction, preserve reproductive integrity, improve habitat, support scientific analysis, and promote recovery of the listed species. The Program will strive to accomplish this in a manner that benefits the ecological integrity, where feasible, of the Middle Rio Grande riverine and riparian ecosystem. Actions undertaken by the Program should benefit other protected species, maintain wild populations, improve the efficiency of water use and management, and provide water to sustain the listed species. The ultimate goal of the Program is to complete activities that, along with other activities by the action agencies and interested parties, meet established criteria in the Middle Rio Grande for its contribution to delisting of the listed species, such that the Program within the Middle Rio Grande area will no longer be necessary.
Goal 2 – Develop agreements for water management beneficial to listed species:

To develop agreements with water users and water management entities that will make supplemental water available, and manage the storage and release of water in ways that contribute to the recovery of listed species.

Goal 3 – Implement consultation under the Endangered Species Act in an effective manner to allow water development and use:

Implement creative and flexible options under the ESA so that existing, ongoing, and future water supply and water resource management activities and projects can continue to operate and receive necessary permits, licenses, funding, and other approvals so that the Signatories and other water users in the Program area are deemed by the Service to be in compliance with the ESA. These water supply and water resource activities and projects include, but are not limited to, maintenance of water conveyance facilities and other actions to meet New Mexico’s downstream compact obligations; flood control; legal uses of native Rio Grande water; and diversion and consumptive use of Stage I of the San Juan-Chama Project water as provided by the Colorado River and Upper Colorado River Basin Compacts for its authorized, contracted, and legal purposes, as provided by contracts and in accordance with the San Juan-Chama Project authorizing legislation.

Goal 4 – Protect water rights, compact deliveries and other obligations:

Achieve Goals 1 and 2 (recovery and water management goals) in such a way that the Program does not impair: valid state water rights; federal reserved water rights of individuals and entities; San Juan-Chama contractual rights; the State of New Mexico’s ability to comply with interstate stream compact delivery obligations; and Indian trust assets including federal reserved Indian water rights, prior and paramount, and time immemorial water rights while exercising creativity and flexibility in order to address the needs of the listed species.

1.2 Water Acquisitions and Management Subcommittee Goal and Objectives

The WAMS was created by the Program to evaluate water acquisition and management opportunities to support the goals of the Program and it functions under the direction of the Program. All work is being conducted in conjunction with other subcommittees and related work groups established through various Program activities. The objectives of the WAMS are directed toward meeting the above stated Program goals. Executive summaries of concepts and methodologies assessed by the WAMS are listed in Attachment A. Attachment B holds a report from the WAMS’ Water Demand Team tasked with estimating the water demand requirements for the Program, as defined in meeting the requirements of the 2003 BO. The full text of the WAMS position and background papers are presented in Attachment C.

Goal of the WAMS: To ensure that water is available in that portion of the Middle Rio Grande, as determined by the Program, to promote the conservation and contribute to the recovery of the Rio Grande
silvery minnow and the southwestern willow flycatcher, while concurrently, to the maximum extent possible, protecting existing and planned management and use activities dependant on the river’s water.

Under this objective, the WAMS has established five guiding objectives:

- **WAMS Objective 1.** Research, develop, evaluate, and assist with implementation of alternatives to lease and/or otherwise acquire water.

- **WAMS Objective 2.** Research, develop, evaluate, and assist with implementation of water management alternatives (to include but not limited to: supplemental water, Low Flow Conveyance Channel pumping, timing of flows, reservoir operation, groundwater pumping, storage, irrigation, Compact delivery operations and floodplain modifications).

- **WAMS Objective 3.** Research, develop, evaluate, and assist with implementation of alternatives for efficient water use.

- **WAMS Objective 4.** Research, develop, evaluate, and assist with implementation of alternatives intending to offset depletions caused by habitat restoration efforts, actions to supplement river flows, or other action supported through Program efforts that increase basin depletions.

Objectives 1-4 will be implemented utilizing the following strategies:

- **Strategy 1.** Identify alternatives.
- **Strategy 2.** Employ methods (i.e. contracts) to evaluate alternative feasibility.
- **Strategy 3.** Provide written evaluations of water acquisition and management alternatives (i.e. position papers, reports) to the Program.
- **Strategy 4.** Seek approval and funding for implementation of projects derived from evaluations.
- **Strategy 5.** Work toward project implementation.
- **Strategy 6.** Monitor project success and modify projects as necessary to achieve desired outcomes.

- **WAMS Objective 5.** Support and respond to Program needs and direction.
  - **Strategy 1.** Modify WAMS operations and actions to meet Program needs.
  - **Strategy 2.** Participate in and provide information to the Program.

1.3 Background

The following subsections provide brief descriptions of the Program, the geographical area included within the Program’s considerations and authority, and constraints limiting Program and WAMS efforts.

1.3.1 **Middle Rio Grande Endangered Species Act Collaborative Program**

The Program is composed of federal, tribal, state, and local governmental and nongovernmental entities with interests in developing solutions that contribute to the survival and recovery of the silvery minnow and flycatcher, while respecting existing water rights and New Mexico’s Rio Grande Compact
obligations. The Program provides a platform for evaluating compliance with the Endangered Species Act (ESA; 16 U.S.C.) associated with existing and future water development, management, and use activities. A detailed description of the goals and structure of the Program is presented in the 2003 Program Document, which is substantively complete, but not finalized pending the results of the National Environmental Policy Act (NEPA) process. The Program was established through a Memorandum of Understanding adopted by governmental and nongovernmental signatories that work together to oversee the Program.

1.3.2 Program Area

In the context of the Program, the MRG is defined as the headwaters of the Rio Grande, including tributaries, from the New Mexico-Colorado state line downstream to the elevation of the spillway crest of the Elephant Butte Dam (4450 feet Mean Sea Level) upstream of its reservoir. Pueblo and Tribal lands and resources within the Program area will not be included in activities under the Program without the express written consent of these entities.

1.3.3 Constraints

The Program document identifies various legal and institutional constraints that must be considered by the subcommittees and/or addressed in association with their activities. A non-inclusive list of legal and institutional constraints are presented below; additional discussion of these constraints are included within many of the Position and Background Papers attached to the back of this Plan, as indicated with each of the following constraints.

- Limitation of total depletions of native non-Indian Rio Grande waters upstream of Elephant Butte Dam in New Mexico to the New Mexico apportionment defined by the Rio Grande Compact (Attachment E-1);
- Consumptive use of imported San Juan-Chama Project waters as provided by the Colorado River and Upper Colorado River Basin Compacts for its authorized, contracted, and legal purposes, as provided by contracts and in accordance with the San Juan-Chama Project authorizing legislation (Attachment E-2, E-4, and E-5);
- The Colorado River, Upper Colorado River, and Rio Grande interstate compacts (Attachment E-1, E-2, and E-3);
- State water laws (permits, priority administration, beneficial use, etc.) and valid state water rights (Attachment E-2, E-3, E-4, E-5, E-6, E-9, and E-17);
- Pueblo and tribal water rights (Attachment E-6, E-8, E-13);
- Federal trust responsibilities to affected Pueblos and Tribes (Attachment E-8);
- Existing authorities and appropriations of all federal and non-federal entities (Attachment E-1, E-2, E-3, E-5, E-6, E-9);
• Federal environmental compliance laws, including the ESA and NEPA (Attachment E-13);
• All applicable state, tribal, and federal laws and regulations (Attachment E-2, E-4, E-6, E-9, E-18);
• Applicable court decisions (Attachment E-1, E-2, E-13);
• State directives or decisions (Attachment E-2, E-4, E-5, E-6);
• State, tribal, and federal water quality laws, standards, and regulations (Attachment E-13);
• Existing and future water users/uses (Attachment E-1 to E-9, C12, E-13, and C18);
• Existing infrastructure (Attachment E-1 to E-9, E-12, E-13, and E-15 to E-19);
• Delivery obligations of the Middle Rio Grande Conservancy District (Attachment E-6 to E-9, E-12, and E-19).

While the attachments listed above provide introductory information for the listed constraints, they should not be considered to be “all-inclusive” or the final sources of information on these topics.

2.0 PROGRAM WATER VOLUME, ACQUISITION, AND MANAGEMENT NEEDS

Water supply needs required to meet the goals of the Program ultimately will depend on the findings of the studies on the water requirements necessary to support the habitat requirements defined for the listed species of concern to the Program. These needs also depend on potential changes in basin depletions resulting from habitat restoration actions take by the Program in addressing conservation and recovery requirements for the listed species. In addition, projects targeted toward modifying river elevations within sections of the MRG nearer to adjoining floodplain elevations may result in increased surface water areas, groundwater levels closer to soil surfaces, and increased depletions requiring increased water supplies committed to addressing these changes.

2.1 Supplemental Water Requirements

In the short-term, and extending until such times as collaborative water management activities produce significant benefits, water leasing and/or other water acquisition actions likely will be necessary to supplement river flows, and to support other goals and activities of the Program. At the present time, SJC Project water is the primary source of water available for lease to the Program. This water is expected to decrease with time. It is expected that the Program’s needs for this water will also decrease over time, as the Program progressively meets its longer term goals. In the long-term, habitat restoration efforts and collaborative water management actions involving participants of the Program are expected to minimize the need for the Program to lease or otherwise acquire water to supplement river flows. The WAMS considers that condemnation of water or water rights is an inappropriate approach to acquire any water
necessary to meet the goals of the Program.

2.2 Water Supply Needed to Meet the 2003 Biological Opinion

On March 17, 2003, the Service issued a Biological Opinion (BO) on the effects of actions associated with the “Programmatic Biological Assessment of Bureau of Reclamation’s Water and River Maintenance Operations, Army Corps of Engineers’ Flood Control Operation, and Related Non-Federal Actions on the Middle Rio Grande, New Mexico” (Service, 2003). The consultation involves two federal agencies, the DOI Bureau of Reclamation (Reclamation) and the U.S. Army Corps of Engineers (Corps), and two non-federal entities, New Mexico Interstate Stream Commission (NMISC) and the Middle Rio Grande Conservancy District (MRGCD). The Service concluded that water operations and river maintenance activities in the MRG, as proposed in the February 19, 2003 Biological Assessment, are likely to jeopardize the continued existence of the silvery minnow and flycatcher and adversely modify critical habitat of the silvery minnow (Service, 2003). The Program is attempting to address requirements in that BO, which are expected to be similar to the requirements issued in response to the proposed activities included within the Program’s actions.

The 2003 BO presents numerous Reasonable and Prudent Alternatives (RPAs) to avoid the likelihood of jeopardizing the continued existence of the silvery minnow and flycatcher and of destruction or adverse modification of silvery minnow habitat. Many of these RPAs affect water operations and flows for habitat maintenance and restoration. The first 15 RPAs address water management operations that vary depending on dry, average or wet water year conditions (Table 1). A dry year is defined as those years when the Natural Resource Conservation Service (NRCS) April stream flow forecast at Otowi Gage is less than 80 percent of average, and a wet year is one where it is 120 higher than average. Average water years are between these extremes, with the average flow defined by the NRCS as being the average streamflow at a point of reference (here, Otowi Gage) for the 30-year period from 1971 through 2000 (FWS, 2003). Table 1 also shows one RPA included from the habitat improvement elements requiring specific water management actions. A number of additional habitat enhancements are also specified in the 2003 BO.

As characterized in the Program’s Draft Habitat Restoration Plan and repeated in the WAMS’ attached Program Water Acquisition Position Paper (Attachment E-4), most habitat restoration actions that are likely to produce significant direct benefits to the MRG listed species will be accompanied by increases in total evaporation and/or transpiration. For example, potential restoration projects often aim at altering habitat conditions for the listed species by significantly increasing water surface areas and/or slowing overall downstream conveyance rates. Without additional actions to offset these water losses, increased
Table 1. Water Management RPAs in the 2003 BO (FWS, 2003).

<table>
<thead>
<tr>
<th>WATER OPERATIONS ELEMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A)</strong> Spawning Spike - Between April 15 and June 15 of each year, the action agencies, in coordination with parties to the consultation, shall provide a one-time increase in flows (spawning spike) to cue spawning. The need for, timing, magnitude, and duration of this flow spike will be determined in coordination with the Service.</td>
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<tr>
<td><strong>B)</strong> Maximum Persisting Habitat Reach - In coordination with the Service, Reclamation and the Corps shall release any supplemental water in a manner that will most benefit the listed species, i.e., produce the maximum persisting habitat reach.</td>
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<tr>
<td><strong>C)</strong> Channel Desiccation and Minnow Rescue - Reclamation, in coordination with parties to the consultation, shall conduct routine monitoring of river flow conditions when flows are 300 cfs or less at San Acacia, and report information regularly to the Service through the water operations conference calls and meetings.</td>
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<tr>
<td><strong>D)</strong> Pumping for active flycatcher territories - Reclamation, in coordination with parties to the consultation, shall ensure that active flycatcher territories supported by pumping from the LFCC are provided with surface water or moist soils in the Rio Grande from June 15 to September 1.</td>
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<tr>
<td><strong>Dry years and/or when storage restrictions from Article VI and/or VII of the Compact are in effect</strong></td>
</tr>
<tr>
<td><strong>E)</strong> Continuous River Flow from November 16 to June 15 - Action agencies, in coordination with parties to the consultation, shall provide continuous river flow from Cochiti Dam to the southern boundary of silvery minnow critical habitat from November 16 to June 15.</td>
</tr>
<tr>
<td><strong>F)</strong> 100 cfs at the Central Bridge gage - Action agencies, in coordination with parties to the consultation, shall provide year-round continuous river flow from Cochiti Dam to Isleta Diversion Dam with a minimum flow of 100 cfs at the Central Bridge gage.</td>
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<tr>
<td><strong>G)</strong> Managed River Recession - Reclamation shall pump from the LFCC as soon as needed to manage river recession. The pumping capacity must meet or exceed the total capacity of pumps used in the 2002 irrigation season (150 cfs). Pumping shall continue when it will benefit the flycatcher and its habitats.</td>
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<tr>
<td><strong>H)</strong> Continuous River Flow from November 16 to June 15 - Action agencies, in coordination with parties to the consultation, shall provide continuous river flow from Cochiti Dam to the southern boundary of silvery minnow critical habitat from November 16 to June 15.</td>
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<td><strong>I)</strong> Ramped Down the Flows - Action agencies, in coordination with parties to the consultation, shall, from June 16 to July 1 of each year, ramp down the flow to achieve a target flow of 50 cfs over San Acacia Diversion Dam through November 15.</td>
</tr>
<tr>
<td><strong>J)</strong> Year-round Continuous Flow from Cochiti to Isleta - Action agencies, in coordination with parties to the consultation, shall provide year-round continuous river flow from Cochiti Dam to Isleta Diversion Dam with a target flow of 100 cfs over Isleta Diversion Dam.</td>
</tr>
<tr>
<td><strong>K)</strong> LFCC Pumping - Reclamation shall pump from the LFCC if needed to manage river recession and maintain connectivity. The pumping capacity must meet or exceed the total capacity of pumps used in the 2002 irrigation season (150 cfs). Pumping shall continue when it will benefit the flycatcher and its habitats.</td>
</tr>
<tr>
<td><strong>Average Years</strong></td>
</tr>
<tr>
<td><strong>L)</strong> Continuous River Flow from November 16 to June 15 - Action agencies, in coordination with parties to the consultation, shall provide continuous river flow from Cochiti Dam to the southern boundary of silvery minnow critical habitat from November 16 to June 15.</td>
</tr>
<tr>
<td><strong>M)</strong> Ramped Down the Flows - Action agencies, in coordination with parties to the consultation, shall, from June 16 to July 1 of each year, ramp down the flow to achieve a target flow of 100 cfs at the San Marcial Floodway gage.</td>
</tr>
<tr>
<td><strong>N)</strong> Year-round Continuous Flow from Cochiti to Isleta - Action agencies, in coordination with parties to the consultation, shall provide year-round continuous river flow from Cochiti Dam to Isleta Diversion Dam with a target flow of 150 cfs over Isleta Diversion Dam.</td>
</tr>
<tr>
<td><strong>O)</strong> LFCC Pumping - Reclamation shall pump from the LFCC if needed to manage river recession and maintain river connectivity. The pumping capacity must meet or exceed the total capacity of pumps used in the 2002 irrigation season (150 cfs). Pumping shall continue to maintain river connectivity.</td>
</tr>
<tr>
<td><strong>WET YEARS</strong></td>
</tr>
<tr>
<td><strong>V)</strong> Overbank Flooding - Each year that the NRCS April 1 Streamflow Forecast is at or above average at Otowi and flows are legally and physically available, the Corps shall bypass or release floodwater during the spring to provide for overbank flooding. The overbank flooding will be used to create an increased number of backwater habitats for the silvery minnow and flycatcher. The timing, amount, and locations of overbank flooding will be planned each year in conjunction with the Service and may be conducted in coordination with compact deliveries.</td>
</tr>
</tbody>
</table>
basin depletions would result. The fourth goal of the Program includes the commitment that Program activities will not impair any existing water rights or the abilities to meet interstate compacts, etc. Since the Rio Grande is fully appropriated, Program actions must produce no net increase in depletions in the basin; any depletions generated by Program actions that produce depletions must be offset by water savings actions or water acquired through other program activities.

2.3 **Projected Program Water Volume Requirements**

A WAMS ad hoc group assessed and reported on the amount of water (as storage in upstream reservoirs) required to meet the needs of the Program under the March 2003 BO (Attachment B). This amount will vary from year to year, and is a function primarily of the following factors:

- Type of year (as defined by the March 2003 BO),
- Length of the MRGCD irrigation season (i.e., how much of the post-runoff irrigation season might be met by storage from El Vado Reservoir), and
- Strength of the summer monsoon season.

In summary, the estimate was based on:

- Categorizing the type of year per the BO,
- Estimating the amount of losses (including ET and seepage) during conveyance in each segment of the river between El Vado Dam and San Acacia,
- Estimating the number of days during the spring when supplemental releases might be needed to meet the requirement of continuous flow to Elephant Butte Reservoir, and
- Estimating the number of days after the snowmelt runoff when supplemental releases might be needed to meet the varying late-season flow targets of the BO

The Program water demand estimate is based on the different types of years as defined in the BO. Annual Program water demands are estimated to range from a low of about 21,000 AF in a wet year with a good snowpack runoff coupled with a good monsoon season to a maximum of 97,000 AF in an Article VII year with a poor snowpack runoff coupled with a dry monsoon season. The average annual Program demand has been *preliminarily* quantified at 55,000 AF per year using the Otowi Index Supply for the period from 1940 through 1999 to characterize the snowmelt runoff and the monsoon season. This preliminary quantification does not take into consideration any MRGCD carryover storage or its annual SJC allocation of 20,900 AF. Predicting the amount of any carryover storage and incorporating that volume into the Program demand quantification requires additional, more detailed modeling, beyond the present scope of the ad hoc group’s assignment. However, it must be recognized that this carryover storage, plus
the MRGCD’s annual SJC allocation would provide some additional flows that would indirectly assist with meeting the BO target flows. Thus, an annual average Program demand of 50,000

Table 2. Summary of estimated Program water demands in various water years and assumed runoff conditions.

<table>
<thead>
<tr>
<th>Type of Year</th>
<th>Snowmelt Runoff</th>
<th>Monsoon Season</th>
<th>Demand (AF)</th>
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</thead>
<tbody>
<tr>
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<td>Poor</td>
<td>Dry</td>
<td>97,000</td>
</tr>
<tr>
<td>Article VII</td>
<td>Poor</td>
<td>Average</td>
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</tr>
<tr>
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</tr>
<tr>
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<td>Average</td>
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<td>73,000</td>
</tr>
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<td>Average</td>
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<tr>
<td>Wet</td>
<td>Good</td>
<td>Wet</td>
<td>21,000</td>
</tr>
</tbody>
</table>

Average Annual Program Demand = 50,000 AF

AF, as quantified in Table 2, has been estimated by reducing preliminary Program demand by approximately 10 percent.

The volume of water (e.g., as storage in upstream reservoirs) required to meet the needs of the Program will vary from year to year. This volume is primarily a function of (1) the type of water year, as defined by the March 2003 BO; (2) length of the MRGCD irrigation season, i.e., how much of the post-runoff irrigation season might be met by storage from El Vado Reservoir; and (3) strength of the summer monsoon season. Analyses by the Program Water Supply Demand Team estimated that the average annual water demand to meet the BO is 55,000 acre-feet/year (AFY). This estimate was developed using the Otowi Index Supply for the period from 1940 through 1999 to characterize the snowmelt runoff and the monsoon season.

This estimate did not include consideration of MRGCD carryover storage or its annual San Juan-Chama
MRG ESA Collaborative Program Water Plan

(SJC) Project water allocation of 20,900 AFY. Predicting carryover storage and incorporating that volume into the Program demand quantification was beyond the scope of the Team’s assessment. Despite this, it must be recognized that both carryover storage and annual SJC allocations for MRGCD would provide additional flows that would at least indirectly assist in meeting BO target flows. Thus, the preliminary annual average water demand projected by the Team was reduced by approximately 10 percent, yielding an average annual Program demand projection of 50,000 AFY to meet the BO.

2.4 Analysis of Sufficiency of Unregulated Rio Grande Flows to Meet ESA Flow Targets

The ISC representative to the WAMS, in collaboration with the membership, completed an analysis of the likelihood of meeting the flow requirements defined by the March 17, 2003 BO in the absence of available reservoir storage (see Attachment xx). Flow targets for those years defined in the BO as Dry or Article VII years only are considered in this analysis. As characterized in the above subsection, dry years are defined as those years in which the April 1 snowmelt runoff forecast of the U.S. Natural Resources Conservation Service is less than 80 percent of average of the 30-year period from 1971 through 2000 at the Otowi gage. Article VII years are defined as those years in which the reservoir storage restrictions of the Rio Grande Compact are in effect. The gaging station at Embudo, operated by the U.S. Geological Survey (USGS), is the oldest continually operated gaging station in New Mexico, with records dating back to 1889. The USGS rates the accuracy of the record at the station as "good," meaning that 95 percent of the readings are within 10 percent of the true value.

From a water management and hydrologic perspective the flows recorded at the Embudo gage, located on the Rio Grande near a point where the river flows out of the Taos Plateau and into the Espanola Basin, are considered to be representative of the mainstem inflow into the middle Rio Grande valley. In dry years, in the absence of significant tributary inflow, flows at Embudo plus releases from storage from reservoirs on the Rio Chama essentially represent the surface water supply available to the middle Rio Grande valley.

A number of major assumptions were necessary to perform this analysis:

1. There would be no diversions for irrigation of any land in the middle valley. All diversions - both Indian and non-Indian - will be curtailed. (It must be strongly stated that this analysis does not advocate such curtailment, rather this is an assumption necessary to conduct the analysis.)

2. There would be no contributions to mainstem flows from the Rio Chama. There will be no storage available for release from El Vado or Abiquiu Reservoirs, and the natural flows of the Chama as measured at the La Puente gage above El Vado Reservoir will be insufficient to carry...
to the confluence of the Rio Chama with the Rio Grande. Similarly, there would be no contribution to mainstem flows from the Jemez River, or any other tributary streams between Embudo and Albuquerque.

3. The conveyance losses between Embudo and Cochiti Reservoir may be characterized by the loss rate coefficients developed for use in URGWOM (Upper Rio Grande Water Operations Model). These loss rate coefficients represent average conveyance losses over a long time period for a wide range of flows. The URGWOM loss rate coefficients (expressed as the percent of flow lost) vary by month (see Attachment C, Table 1).

4. A constant value of release from Cochiti Reservoir may be used to represent hydrologic conditions downstream. Based on observations during the 2003 irrigation season, it was determined that a relatively constant release of 210 cubic feet per second (cfs) from Cochiti Reservoir to the Rio Grande provided 100 cfs or more at Central Avenue during the months of July through October and that a release of 340 cfs plus augmentation by pumps moving water from the Low Flow Conveyance Channel to the Rio Grande provided continuous flow between San Acacia and San Marcial during the spring months of March through June. (It must be noted that this assumption may be overly optimistic in the absence of irrigation operations. The riverside drains, which flank the Rio Grande on both sides from Cochiti on down to San Acacia, intersect the shallow groundwater table and provide the hydraulic control on the system through much of the middle valley between Cochiti and San Acacia. In the absence of irrigation return flows, and with constant releases from Cochiti Reservoir, the water level in the drains most likely will reach a quasi-steady state wherein a significant portion of the flow will be derived as seepage loss from the river, more so than during 2003.)

The details of the analyses are presented in Attachment C. These analyses led to the following conclusions:

1. Historically, the average monthly flow at Embudo is insufficient to meet the March 17, 2003 BO flow targets as often as 26 percent of the time.

2. Analysis of duration curves for the Embudo gage indicate that there will be insufficient flow to meet the BO flow targets ranging from 5 percent of the time on average during the month of March to 29 percent of the time on average during the month of September. These results were verified by the frequency analysis which showed that the probability that the mean daily flow at Embudo will be insufficient to meet the BO flow targets in any given month ranges from a low of five percent during the month of March to a high of 29 percent during the month of September.
3. There is a 47 percent probability that the 7-day average low flow in any given year will not exceed 250 cfs. There is a 55 percent probability that the 7-day average low flow in any given year will not exceed 280 cfs. A low flow sequence this long in duration that is as little as 10 cfs less than either of these required flow values will result in insufficient flow to meet the BO flow targets. Stated differently, there will be a low flow event lasting seven days in which there will be insufficient flow to meet the BO target approximately one out of every two years on average.

In summary, there will be insufficient flow at Embudo to meet the Article VII or Dry BO-year flow targets approximately 1 year out of 2 on average. On average, the lowest flows occur in the summer months of July through September, with September being the month in which it is most likely there will be insufficient flows.

2.5 Water Management and Acquisition Alternatives to Meet Program Water Needs

No single source of water or water management activity can, by itself, satisfy the water supply requirements necessary to meet the goals of the Program. The WAMS developed background information and evaluated more than 18 issues (Attachment C) to acquire and manage water needed to accomplish the Program goals. The issues and alternatives that are being assessed for potentially incorporating into the WAMS’ long-term plan are included in Table 3.

The final selection of water sources used and management activities implemented will depend on the final water sources that become available to the Program over its 10-year life, and the actual water volume needs and delivery requirements for the Program. The Program’s Science and Habitat Restoration subcommittees are refining the latter two requirements. Present and future Biological Opinions (BOs) and the Reasonable and Prudent Alternatives (RPAs) also contribute to defining future water needs for the Program’s actions.

In general, potential sources of increased summertime river flows include expanded water conservation, more efficient water conveyance, and improved operational strategies. Within the Middle Rio Grande Conservancy District (MRGCD), the Program seeks to increase irrigation efficiencies. All such improvements take time to develop and implement, due to the complex nature of the MRGCD system. The Program could benefit from irrigation system efficiency improvements through a negotiated agreement that could provide some amount of stored water in El Vado Reservoir for use by the Program in exchange for funding efficiency improvements. The following subsection summarizes the findings from the WAMS of the various water management and water supply alternatives developed. Additional water management strategies that may contribute water for the Program needs are being explored.
Table 3. List of constraining issues, water supply potentials, and water management alternatives assessed in developing the Program WAMS Plan.

<table>
<thead>
<tr>
<th>Compact Issues Constraining the Program’s Water Management Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Rio Grande Compact Deliveries and Credit Water (Attachment E-1)</td>
</tr>
<tr>
<td>• Rio Grande Project Water (Attachment E-2)</td>
</tr>
<tr>
<td>• State of Colorado Water (Attachment E-3)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Potential Water Supply Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Program Water Acquisition (Attachment E-4)</td>
</tr>
<tr>
<td>• Municipal and Industrial Conjunctive Use Strategies (Attachment E-5)</td>
</tr>
<tr>
<td>• Irrigation Efficiency Water (Attachment E-6)</td>
</tr>
<tr>
<td>• Voluntary Irrigation Forbearance (Attachment E-7)</td>
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<tr>
<td>• Native American Water (Attachment E-8)</td>
</tr>
<tr>
<td>• New Mexico Acequia Water (Attachment E-9)</td>
</tr>
<tr>
<td>• Weather Modification/Cloud Seeding (Attachment E-10)</td>
</tr>
<tr>
<td>• Watershed Management (Attachment E-11)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water Management Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Management and Storage of Program Water (Attachment E-12)</td>
</tr>
<tr>
<td>• Cochiti Lake Water Issues (Attachment E-13)</td>
</tr>
<tr>
<td>• Reduced Reservoir Evaporation (Attachment E-14)</td>
</tr>
<tr>
<td>• Riparian evapotranspiration/Water Salvage (Attachment E-15)</td>
</tr>
<tr>
<td>• Floodplain Lakes and Flood Flow Retention Basins (Attachment E-16)</td>
</tr>
<tr>
<td>• Groundwater Pumping (Attachment E-17)</td>
</tr>
<tr>
<td>• Low Flow Conveyance Channel Pumping (Attachment E-18)</td>
</tr>
<tr>
<td>• Realignment of the San Acacia Reach (Attachment E-19)</td>
</tr>
</tbody>
</table>

Many water management alternatives assessed by the WAMS are intended to aid the achievement of Program goals, and many alternatives included in this NEPA assessment, depend on the ability to store water in upper basin reservoirs. During times of exceptional drought and/or when Article VII of the Rio Grande Compact is in effect, such storage may not be possible. Also, the total annual supply of SJC water may not be available during all drought years. Additional analysis will address how such limitations can affect the implementation of Program alternatives and how they may contribute to producing additional unavoidable impacts within the system.

Ongoing analyses are continuing to focus on approaches to meet the projected estimate of 50,000 AFY average annual water storage release demand. Currently, five general categories of source water are included as potentially contributing to meeting the water supply and acquisition goals:
1. Program activities that produce intrinsic basin water savings (e.g., saving through more efficient water operations, water salvage, habitat enhancement benefits, etc.);
2. The Bureau of Reclamation’s supplemental water program (i.e., purchases of SJC Project water);
3. Long-term water (i.e., long-term leases and permanent water rights dedicated to addressing the Program/ESA goals);
4. Voluntary agricultural forbearance and municipal conservation; and
5. Short-term, emergency, compact relinquishment, credit water.

Two examples of the different potential water acquisition schedules being assessed by the Program are shown in Figure 1. In the long-term (including beyond the projected 10-year life of the Program), it is anticipated that an established water management program involving annually dependable water sources and established upstream reservoir storage and delivery options will be essential to satisfy requirements to protect existing uses and water needs for ESA species downstream. For the short term, however, which may include most of the earlier years of the Program, Article VII of the Rio Grande Compact may commonly prohibit upstream reservoir storage of non-Indian native Rio Grande water, whenever downstream water storage of Rio Grande Project Usable Water in Elephant Butte and Caballo Reservoirs decreases below 400,000 AF. Therefore, the Program is developing dual short-term and long-term water management strategies for water acquisition, storage, and delivery options to address the water supply needed to accommodate both existing users and ESA requirements along the MRG. In 2005, the NM legislature authorized the ISC to establish a Strategic Water Reserve. This allows the ISC the option to purchase or lease surface and ground water from willing sellers or lessors, and to receive donated water or water rights or storage rights to develop a water reserve.

2.6 Hydrologic Effects of Water Acquisitions on the Middle Rio Grande

The WAMS estimates of the volume of water required to meet the flow targets of the 2003 BO considered only the flow component requirement. Among the number of measures through which water could be provided to meet the flow targets is the acquisition of water rights from willing sellers. One of the WAMS’ projects funded by the Program was aimed at addressing questions about how a water rights acquisition program in the Middle Rio Grande Basin might work, how water rights transfers might be effected, and the magnitude of the acquisitions that might be required (Hydrosphere 2005).

Though the WAMS identified water rights acquisitions as one source of supplemental water, it provided only an initial assessment of the feasibility of such an approach. The work that is the subject of this project was intended to make a more complete assessment of the utility and feasibility of using water rights acquisitions to supplement flows in the MRG. This project addressed two principal areas: How much consumptive use would result from a flow supplementation program of the magnitude estimated by
the WAMS, and how might water rights acquisitions be used to get “wet water” in the Rio Grande floodway to meet the flow targets of the BO.

Changes in water operations of any sort intended to meet the requirements of the BO will result in increased depletions from the basin, which is over-appropriated. Therefore, any new consumptive uses of water in the basin must be offset by a reduction in existing uses. A water rights acquisition program, acquiring water rights from willing sellers, is one way to offset new consumptive uses caused by changes in water operations. The project estimated that the consumptive use arising from the water operations contemplated by the WAMS analysis (i.e., release of an average of 50,000 acre-feet per year of water in storage) would average about 7,000 acre-feet per year. Based on a consumptive irrigation requirement of 2.1 feet per acre, this would require the acquisition of approximately 3,300 acres of irrigated lands and their appurtenant water rights within the MRG.

Based on the analyses presented, this project presented the following conclusions:

- Given the current management practices by MRGCD, current metering and measurement systems, and current administrative practices in the MRG, it is not likely that water rights transfers from lands within the MRGCD will provide any contribution to the flow component of the Flow Targets.

- Preliminary estimates of the depletions associated with a transfer from MRGCD to supplemental flows would be expected to average approximately 7,000 acre-feet/year, which would represent, on average, roughly 14 percent of the annual flow requirements identified by the WAMS.

- Numerous hydrological processes affect the magnitude and timing of depletions.

- The primary depletions associated with transferring water to supplemental flows are open water evaporation and riparian vegetation evapotranspiration in the vicinity of the river channel.

- A more rigorous calculation of expected depletions would necessarily involve application of hydrologic modeling tools that explicitly account for surface water – groundwater interactions.

- Conveyance losses from the upper basin reservoirs to the critical habitat locations south of Albuquerque are large, which is a disadvantage of delivery from upper basin storage.

- Delivering the transferred water via wells or pumping from MRGCD drains or the LFCC has the advantage of flexibility in timing and point of application.
• If some measure is not implemented to enforce the “drying up” of lands from which rights are transferred, and “District” water is used to re-irrigate these lands, net depletions will likely increase in the MRG.

2.7 Program Water Acquisition Costs

The WAMS estimated Program water costs using the acquisition scenarios shown in the lower graph of Figure 1; this scenario is also presented in Table 4 where the costs of water acquisition associated with the potential sources shown over the ten years of the Program. These costs include a 10% annual escalator. Starting base prices for each of the kinds of waters is shown in the table and other assumptions are shown at the bottom of the table. The BO-driven Program water cost to meet the March 2003 BO is projected to exceed $226 million over the 10-year life of the Program.

The WAMS also concludes that it is unlikely that the Program can acquire sufficient water through a voluntary program of water rights purchase (the scenario shown in the upper graph of Figure 1). Therefore, WAMS projects that individual water purchase would be required annually to meet the terms of the 2003 BO beyond the 10-year duration of the Program. In most years, the costs to purchase water for the Program are projected to exceed $20 million per year starting in 2015.

2.8 Program Water Management

The Middle Rio Grande Endangered Species Act Collaborative Program (Program) might seek to acquire or lease water rights, secure storage rights for any waters acquired, or otherwise negotiate for the use and storage of water to benefit the goals of the program.

Program options may include a possible staff position for Program hydrologist or engineer, whose responsibilities could include assisting Reclamation in the management and accounting for Program water. If water rights and storage to address the program goals are secured, the Program hydrologist or engineer might work with technical assistance from appropriate technical specialists and work groups, to identify the best uses of such water to benefit the listed species and to support other Program projects. The Program hydrologist or engineer might help coordinate requests for releases of Program water with the water management agencies including the Corps of Engineers, the Bureau of Reclamation, and the New Mexico Interstate Stream Commission.

The need exist to have the ability to call for a specified delivery of water to meet Program goals at designated places and times. Possible uses of Program water include, but are not limited to: augmentation of peak flows; releases to avoid intermittency; releases to support habitat restoration; and any other uses of benefit to the Program.
Figure 1. Two example water acquisition schedules assessed in the ongoing Program assessment efforts
Table 4.
Assumption Basis and the Projected Program 10-year Water Acquisition Schedule & Budget under March 2003 BO

<table>
<thead>
<tr>
<th></th>
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* Assumptions:
- SJC Project water will cost $47/AF in 2005, then jump to $500/AF in 2006, based on the price recently paid by Santa Fe.
- A continued supply of short-term, emergency water will be available to the Program.
- A maximum 10,000 AF of permanent water rights will become available for Program Purchases, with purchase as early as possible for the Program.
- A maximum 6,000 AF of conservation and forbearance water will become available for the Program.
- A continued, but declining supply of short-term San Juan-Chama Project water will be available to the Program.
- A maximum of 20,000 AFY of BO water demand can be met by improved water management efficiencies, salvage, and savings from habitat enhancements.
3.0 RANKING OF WATER ACQUISITION AND MANAGEMENT PRIORITIES

Many of the background and position papers developed by the Water Acquisition and Management Subcommittee (WAMS), attached to this plan, include within their summary and conclusions sections a selection of “next steps” associated with the assessed topic. These steps include specific projects, additional assessment requirements, or other actions that will allow improved implementation or a better understanding in addressing the consequences or effectiveness potentially resulting from implementing the considered actions. The WAMS compiled the specified issues, projects, and needs for proposals from across those WAMS papers. Then, each of the Program signatories with delegates participating with the WAMS were asked to rate each of these listed actions from 0 to 3:

- 3=High – Action has a high potential to benefit attainment of the Program goals, and should be included among those give highest priorities by the Program.
- 2= Medium – Action has potential benefit in helping to obtain Program goals, but should have secondary priority by the Program, relative to other potential actions.
- 1= Low – Action has potential benefit in helping to obtain Program goals, but should have minimal priority within the Program.
- 0= None – Action has no potential benefit to helping to obtain Program goals, and should receive no additional consideration by Program.

The ratings provided by the WAMS participants were compiled with the average ratings serving only as an initial guide for discussions by the WAMS members to establish three qualitative categories (as characterized in the first three categories above) for future project funding requests, assessments needs, and associated priority activities for the WAMS on behalf of the Program. The following bulleted tasks show the collaborative rankings established within the three priority tiers for future WAMS work. The task numbers shown are included only to aid in referencing the individual items. All tasks within each of three WAMS priority tiers are considered to rank relatively equally within their respective tiers; priority rankings differ only between each of the three tiers. Continuing efforts by the WAMS to act on these priorities are discussed in the Implementation section of the WAMS Plan.

3.1 Tier 1: Water Acquisition and Management High Priorities

Program Water Acquisition:

- Tasks 1 and 2: Identify willing lessors, sellers, etc., from whom the Program can acquire (1) short-term or (2) long-term water for use to benefit Program goals; such water acquisitions must
temporarily or permanently end consumptive uses of this water at the current place of use for the duration that its use is transferred to the Program.

**Management and Storage of Program Water:**

- **Task 3:** Develop and examine alternative modeling scenarios that reflect different combinations of water supply and storage options that could meet Program water supply requirements.

- **Task 4:** Finalize and implement viable storage alternatives for Program water, potentially including storage in Heron, El Vado, Abiquiu, Cochiti, and Jemez Canyon reservoirs, either separately or in combination.

- **Task 5:** Develop a system of monitoring and reporting to assure and account for Program water delivery.

- **Task 6:** Identify ways that any added water produced by Program support could become designated water available to meet Program goals.

**Reservoir Evaporation Water:**

- **Task 7:** Evaluate water saving potentials under alternative reservoir operation scenarios during wet and dry water years using realistic allocations of water storage volumes and surface areas. The objectives for these studies should be to define appropriate water operation alternatives to minimize reservoir evaporation losses and to maximize the conservation of water available to meet Program goals.

**Evapotranspiration and Water Salvage:**

- **Task 8:** Encourage the Program to support studies to assess the potentials for reducing ET-based depletions and increasing water salvage along the MRG and identify suitable alternates where non-native vegetation areas may be productively converted to native riparian communities to produce net water savings, with real potentials for increasing river flows.

- **Task 9:** To the extent possible, the Program should partner in saltcedar control efforts along the MRG to help ensure maximizing potential benefits obtainable under this Initiative in addressing potential water salvage benefits.

- **Task 10:** Lend Program support to the development of one or more comprehensive monitoring projects intending to assess potential benefits from Initiative supported large-scale saltcedar control projects in producing wet water flows along the MRG.

**Low-Flow Conveyance Channel Pumping:**

- **Task 11:** A pumping program in the San Acacia reach of the Rio Grande is required by the March 17, 2003 Programmatic Biological Opinion. The operation of such a pumping program maintains compliance with Reasonable and Prudent alternative H, which states that the USBR shall pump water from the LFCC to the river when intermittency is likely in the San Acacia reach of the Rio Grande.

### 3.2 Tier 2: Water Acquisition and Management Moderate Priorities

**Voluntary Irrigation Forbearance:**

- **Task 12:** Track progress of the MRGCD study to assess the feasibility of a potential voluntary irrigation forbearance program.
• **Task 13:** If a voluntary irrigation forbearance program is found to be feasible through the MRGCD study, support a project to conduct a survey to assess irrigator’s interests and requirements to participate in any potential voluntary irrigation forbearance program.

• **Task 14:** If the results from MRGCD’s feasibility study and from the survey of irrigator’s interest provide favorable indications, implement a volunteer irrigation forbearance program as one method to acquire water to help meet Program goals.

**Irrigation Efficiency Water:**

• **Task 15:** The Program should continue to support projects to study and implement irrigation efficiency improvements, and to evaluate whether and/or how these actions may help meet Program goals.

**Evaluation of a Potential Comprehensive Reconfiguration of the San Acacia Reach:**

• **Task 16:** The Program should either seek Federal funding for a study or should seek proposals for such a study to evaluate the potential positive and negative effects from a possible reconfiguration of the San Acacia Reach to provide a single channel system along the lowest part of the valley. Any such study should incorporate the existing evaluations, plans, and information available in the analysis of alternatives for this reach of the Rio Grande.

**Watershed Management:**

• **Task 17:** The Program should encourage appropriate land management agencies to provide an assessment estimating increased in water yield to the MRG possible through active watershed management activities. Information of interest includes a compilation of public and private watershed acreages potentially suitable for forest thinning, and a compilation and review of results from similar watershed management efforts in the region producing results potentially applicable to the MRG.

• **Task 18:** The Program should identify opportunities to cooperate with or actively involve watershed land management agencies in the ESA Collaborative Program to advance fire management, water yield, water quality, forest health, active watershed management, and multiple funding opportunities.

**Municipal Water Conjunctive Use and Conservation:**

• **Task 19:** The Program should promote and support good data collection and research into the groundwater-surface water interaction along the MRG.

• **Task 20:** Assess whether and how potential opportunities exists to coordinate operation the City’s Drinking Water Project to correspond to the biological needs of the listed species, particularly related to the BO defined flow requirements through the Albuquerque reach and downstream.

3.3 **Tier 3: Water Acquisition and Management Low Priorities**

**Supplementing Middle Rio Grande Flows through Groundwater Pumping:**

• **Task 21:** Support feasibility studies and/or pilot projects to investigate and evaluate the potential alternatives of using groundwater pumping as an alternative to supplement river flows during periods of low flow.
Weather Modification – Cloud Seeding Water:

- **Task 22:** Monitor the findings of the NMISC cloud seeding program, both in terms of success in reducing potential irrigation demands by seeding and increasing spring runoff production from seeding.

- **Task 23:** The Program should promote or fund a cost-share expansion of the NMISC winter seeding pilot program into the upper Rio Grande watershed, south of the CO-NM Stateline, to assess the potentials for cloud seeding to increasing snow pack and spring runoff. Any such project should focus on ground-based seeding to enhance snow pack water volumes as a potentially cost-effective method to increase stream flows. Funding could include a 3- to 5-year pilot program in north central NM at a cost of $150,000 to $250,000 per year. Potential proposals should include provisions for matching funding, to augment the Program’s support, for example, from ski areas in the upper Rio Grande watershed of New Mexico, which might benefit from such a program.

Floodplain Lakes and Flood Flow Retention Basins:

- **Task 24:** Support feasibility studies and/or pilot projects to investigate and evaluate the potential alternatives, including physical logistics, of capturing flood flows and re-supplying these delayed flows to the river as supplement flows.

- **Task 25:** Assess and address administrative concerns of how and when flood flow should be captured and who will be responsible for assuring that flood flow is appropriately captured, retained, and released.

### 4.0 IMPLEMENTATION

The WAMS has defined a diversity of water acquisition and management alternatives potentially available to help meet the needs of the Program (Section 2.4 and Table 3). These alternatives were assessed through a series of background and position papers (Attachments A and C). From this assessment the WAMS established a set of priority rankings (high, medium, and low) of issues, actions, and assessments for the WAMS to implement through its future activities (Section 3.0).

The activities included in the high priority rankings will serve as the basis for future requests for proposals (RFPs) issued by the Program on behalf of the WAMS. These RFPs will also allow for proposers to submit innovative proposals that address other lower ranked priorities or other topics likely to be of interest and concern to the WAMS. Funding priorities for proposals submitted for WAMS review will be based, in part, on the WAMS priority rankings and funding available. However, again depending on the funding available, the WAMS intends to retain the flexibility to support innovative proposals.

The WAMS evaluates water acquisition and management proposals based on their relative merits. Evaluation criteria used for water acquisition and management proposals include:
• Whether the proposal demonstrates a capability to provide short and/or long-term water to help meet Program goals
• Whether the proposal supports elements of the currently applicable BO
• Technical feasibility
• Ease of implementation
• Capacity of the proposal personnel and organization to accomplish the project
• Consistency with applicable federal and state laws
• Cost effectiveness

Based on the results of projects funded by the WAMS, new priorities for future activities and proposals will be identified and established through adaptive management until such time as an adequate water supply for the Program is obtained and management procedures are established to ensure that the water needs of the Program and future ESA requirements can reasonably be met. In particular, the WAMS intends to facilitate and work with Reclamation, to the extent possible, in identifying and securing water to help meet the long-term goals of the Program. Water sources pursued may include voluntary donations of water rights, offers to sell water rights, long- and short-term leases of water, voluntary forbearance programs, and other sources.

In continuing the effort by the WAMS to assess, identify, and refine appropriate water management strategies and potential water sources to meet Program goals, better information is needed to define more accurately the potential effects that Program actions will have on water demands along the MRG project area, how these demands may translate to effects on existing use, and appropriate alternatives to facilitate win-win solutions across all use demands. To address this challenge, the Program will need to develop alternative scenarios to reflect different combinations of water supply and storage options that could potentially meet Program water supply requirements. It then would need to evaluate potential river models to determine whether a tool exists that can be used or modified to test the scenarios. That is, several scenarios, under different hydrologic conditions, will need to be tested and the results evaluated. For any scenarios that appear worthwhile to pursue, there will be focused discussions with appropriate parties to identify areas of agreement and recommend Program actions.

The WAMS worked with the Utton Transboundary Resources Center at the University of New Mexico in an attempt to speed the development of this needed information. Specifically, the Utton Center and the WAMS developed alternative scenarios to model and compare to the current reservoir operations and storage approach (Attachment D). This effort was intending to identify water operations and storage alternatives that might benefit water supplies for the Program without impairing Compact deliveries or water users. The WAMS agreed that if any of these model alternatives could be agreed upon by all
parties, the WAMS would work with the URGWOM Tech Team to refine and ultimately run models of the scenarios. The model runs would aim to produce level of magnitude or better assessments on the possible water yields that might become available to the Program through potential management implementation of the operation alternative. A report summarizing this effort was approved by the WAMS for presentation to the Interim Steering Committee. Consensus has not been reached to allow a modeling assessment of any of the proposed alternatives. Although the parties have not yet agreed to allow this assessment effort to continue, the Utton report provides a useful summary of the issues and options for progressing with these analyses (Attachment D).

A major concern regarding the WAMS-Utton Center assessment is that it focused on reservoir storage and operation alternatives, but the MRG was projected at the time to likely to have any such activities constrained under Article VII of the Rio Grande Compact, which essentially prohibits non-Indian water storage in any reservoirs in New Mexico upstream of San Marcial constructed after 1929, whenever Usable Water in Rio Grande Project storage falls below 400,000 acre-feet (AF). In responses to concerns that the WAMS should focus on alternatives development for short-term water management possible under Article VII, the WAMS conducted an issues analysis of its efforts related to each of five priority water management focus areas to determine whether they were receiving an appropriate level of emphasis. Attachment YY presents the “Summary of Activities/Priorities and Potential Needs for Refining the Scope of the WAMS.” This report highlights the WAMS analysis of its past, ongoing, and planned efforts related to each of the five main focus areas:

1. Optimize management of direct flow water, especially through the Albuquerque reach, to minimize use of Program water
   a. Research relative system losses for routing water to Isleta using the river versus using the MRGCD Angostura diversion and Albuquerque Division canals and drains
   b. Assess the loss of river water to the drains in the Albuquerque reach.
   c. Assess how municipal groundwater pumping affects river flow.
2. Pursue alternatives for voluntary forbearance in the MRGCD to produce conservation water to help meet Program goals
3. Pursue alternatives to increase efficient irrigation water delivery and use along the MRG
4. Decrease total depletions along the MRG, especially south of the San Marcial RR Bridge
5. Secure management plan for managing use of Program water and develop recommendations for long-term reservoir storage flexibility that will assist the Program in minimizing the need for supplemental water

Future Program actions will need to include identifying and acquiring specific water sources and firm storage locations to meet Program goals to protect and improve the status of the listed species in the MRG,
while simultaneously protecting the existing and future water uses.

5.0 SUMMARY

The WAMS’ efforts have focused on identifying the potential water demands by the Program, water development strategies that yield potential water savings, approaches for managing storage and delivery of water, and activities that may result in improved river flows through restoration projects (i.e. reengineered floodplain in the San Acacia reach). Working with other components of the Program, the WAMS intends to refine estimates of the quantity of water necessary, under a variety of hydrologic conditions, to meet the water requirements of the Program through the best combination of upstream storage, control of releases, and consumptive rights required to meet the Program goals.

As new and improved information becomes available, the WAMS expects to update this Plan and identify additional objectives and strategies to best meet Program water acquisition and management requirements. This developing WAMS Plan includes adaptive management protocols to allow this plan to benefit from the expanding knowledge gained through experience in addressing BO requirements and Program goals. The WAMS will accommodate likely changes in potential water supply sources available to the Program, newly developed water management infrastructure and protocols, knowledge of evapotranspiration amounts and sources, and possible shifts in climatic and weather patterns.
ATTACHMENT A

SUMMARIES OF WATER ACQUISITION AND MANAGEMENT CONCEPTS AND METHODS ASSESSED

The following subsections present the set of summary findings and conclusions derived from the assessments and collaborative discussions that led to completion of the set of Position and Background Papers developed by members of the Water Acquisitions and Management Subcommittee, as presented in Attachment C.

1.0 COMPACT ISSUES CONSTRAINING THE PROGRAM’S WATER MANAGEMENT ALTERNATIVES

1.1 New Mexico Rio Grande Compact Delivery and Credit Water (Attachment E-1)

- The purpose of the Rio Grande Compact was to equitably apportion the uses of the waters of the Rio Grande among the states of Colorado, New Mexico and Texas, based on how that apportionment existed in 1929. The overarching goal of the Compact was to allow each state to develop its water resources at will, subject only to the delivery obligations set forth in the Compact.

- The Compact was signed by the three states on March 18, 1938. It was ratified by the legislature of each state, enacted as Public Act No. 96 by the 76th Congress, and signed into law by the President on May 31, 1939.

- The schedule of deliveries and responsibilities of each state under the Compact became effective January 1, 1940.

- The Compact is administered by the Rio Grande Compact Commission, which consists of a Commissioner from each of the three signatory states, plus a Federal representative appointed by the President who acts as Chairman of the Commission without vote.

- The portion of the Compact water allocated to the Middle Rio Grande Basin is fully appropriated.

- Any new use of water, such as the depletions that result from specified endangered species flow requirements, must come from some current existing use.

- The sustained, long-term use of Rio Grande Compact delivery water to meet specified flow requirements for endangered species would cause additional depletions on the system that would result in the eventual violation of the Compact by New Mexico. This is not a viable option for the Program.

- The use of Rio Grande Compact accrued credits to meet specified flow requirements for endangered species is not considered to be a sustainable option.
1.2 **Rio Grande Project Usable Water (Attachment E-2)**

- Reclamation’s Rio Grande Project is located along the Rio Grande valley in southern New Mexico and northwest Texas. The Secretary of the Interior authorized the Project in 1905 under the provisions of the 1902 Reclamation Act.
- Storage for the Project is provided by Elephant Butte and Caballo Reservoirs in southern New Mexico. All Rio Grande Project water operations at Elephant Butte and Caballo Reservoirs must be conducted in conformance with the Rio Grande Compact, as discussed above.
- Under the Compact, all water stored in Elephant Butte and Caballo Reservoirs is termed *Project Storage*. This includes credit water accrued by either New Mexico or Colorado by reason of deliveries in excess of required amounts, San Juan-Chama Project water stored in Elephant Butte pursuant to PL 97-140 and water available for release to downstream irrigation demand and to the Republic of Mexico (*Rio Grande Project Usable Water*).
- The Project supplies water for about 155,000 acres of irrigable lands in the Elephant Butte Irrigation District (EBID), located in the Rincon and Mesilla Valleys in New Mexico and the El Paso Water Improvement District No. 1 (EP No. 1), located in the El Paso Valley of far west Texas.
- By reuse of drain return flows, the normal release allows the full Project allocation of approximately 930,000 acre-feet per year to be delivered to the canal headings of EBID and EP No. 1, and to the heading of the Republic of Mexico’s Acequia Madre.
- Mexico receives 60,000 acre-feet of Project water per year, in accordance with 1906 and 1933 Treaty Conventions.
- Drainage from EP No. 1 also provides a supplemental supply for 18,000 acres of irrigated land in Hudspeth County south of El Paso. In recent years some Project water has been converted to municipal and industrial use for the City of El Paso.
- Due to the numerous parties involved, the complexity of Compact accounting, and various legal impediments (including international relations with the Republic of Mexico), compounded by a lack of available physical storage upstream of the MRG, the WAMS concludes that Rio Grande Project usable water would have no potentially viable role in addressing water needs for the Program.

1.3 **Colorado Water (Attachment E-3)**

- The Rio Grande basin in Colorado is fully appropriated.
- Under Colorado law, any Colorado water potentially acquired by the Program would be available first for use by other Colorado water users; then, any potentially acquired water crossing the Colorado-New Mexico State line would become part of Colorado’s delivery to New Mexico under the Compact.
- At the State line, any potentially acquired Colorado water would become public water of the State of New Mexico and, as such, this water would then be available for diversion and consumption by water users within the state of New Mexico above San Acacia.
- The WAMS concludes that acquiring water from Colorado and successfully delivering it to the Rio Grande below San Acacia appears to be impossible.
- Accordingly, the WAMS also concludes that no further discussion of the acquisition of water from sources within Colorado should be considered.
Finally, the Interim Steering Committee, at its November 18, 2002 meeting, directed the WAMS to discontinue investigation of seeking supplemental Program water from sources within the State of Colorado.

2.0 POTENTIAL WATER SUPPLY ALTERNATIVES

2.1 Program Water Acquisition (Attachment E-4)

- Since 1996, the Bureau of Reclamation or the Program has subleased San-Juan Chama water from contract-holders on an annual basis in order to supplement Rio Grande flows to support endangered species. This program of short-term leasing will need to be continued until longer-term strategies are implemented. The Bureau has also acquired short-term water from the state of New Mexico, and the present agreement with the state will provide supplemental water through 2005. However, there is no indication that water will be available in the future through such agreements.

- The Program will likely need to acquire a long-term water supply to offset the depletions associated with habitat improvements (such as increased evaporation from wider, shallower reaches of river channel, low-velocity side-channels, and overbank areas) and with increased in-stream flows during the warmer summer months, to the extent that these increases in depletions cannot be offset through Program water salvage projects. These depletions must be offset through the retirement of existing uses through the purchase of water rights or water contracts.

- The Program should initiate long-term or permanent acquisition of water to support the goals of the Program, through some combination of acquisition of native Rio Grande water rights or lands with appurtenant water rights, long-term sublease of San-Juan Chama water or other water available by contract with willing lessors, or implementation of a long-term, programmatic irrigation forbearance program with an annual target (in which, for instance, a number of irrigators agree to accept compensation in lieu of irrigating say once every five years, and this forbearance is rotated annually), if ongoing studies determine that such an approach is feasible.

- The amount of water that the program will be required to purchase to assure in-stream flows and near-stream habitats for the long-term conservation and recovery of the Rio Grande silvery minnow and the southwestern willow flycatcher will ultimately depend upon the success of the habitat restoration efforts, water salvage projects, voluntary irrigation forbearance programs, and water management efficiency improvements supported by the Program. The Program Management Subcommittee has determined that a comprehensive evaluation of the additional depletions associated with Program activities will need to be performed. The Depletions Subcommittee of the Program prepared a white paper on the state-of-knowledge related to the determination of depletions associated with activities or conditions on the river.

- When the Program leases, buys, or otherwise acquires water for use to benefit Program goals, assurance must be obtained that the willing seller actually owns the water right being transferred and that the seller actually ends consumptive use of this water when he sells its associated right.

- In order to effectively manage the acquired water, it will be necessary for the Program, or one of its signatories, to secure the right to store and manage the acquired water in one or more upstream reservoirs.

2.2 Municipal and Industrial Water (Attachment E-5)

- Albuquerque Basin groundwater pumping impacts the flows of the Rio Grande.
• Municipalities are required to own or lease water rights to offset their pumping effects.

• In 2006, the City of Albuquerque’s Drinking Water Project (DWP) is scheduled to begin directly using imported San Juan-Chama water in order to reduce its reliance on groundwater pumping. The City’s DWP permit from the OSE will contain conditions designed to prevent increased depletions below the Southside Wastewater Reclamation Plant (SWRP).

• After the City’s DWP is implemented, there may be an opportunity to consult with the OSE/ISC to time the release of offset water to accommodate Program flow requirements along with MRGCD and Compact delivery obligations.

• When DWP surface water diversions are curtailed and groundwater pumping resumes, City return flows will provide water to the river downstream of the Southside Water Reclamation Plant (SWRP).

• During the 1989-1998 period an average of 27,800 acre-feet of Albuquerque’s San Juan-Chama Project water flowed past the Albuquerque gage. After the DWP is implemented, most of this water will no longer be available.

• A primary goal of the City’s DWP curtailment strategy is ensuring that operations of the project do not adversely impact the silvery minnow habitat in the Albuquerque reach during times of low flow.

• City water conservation and reuse efforts are intended to help slow the increase of the City’s effects on the river, while municipal population continues to increase.

• The City and other entities will investigate aquifer storage and recovery to help diminish pumping effects on the Rio Grande.

• Data collection and research into the groundwater-surface water interaction should be continued.

2.3 Supplementing MRG flows through Irrigation Efficiency Improvements (Attachment E-6)

• This paper discusses the possibility of obtaining higher river flows, and other benefits, through irrigation efficiency improvements, including both off-farm and on-farm efficiencies in the surface-water irrigation system in the MRG. Between Otowi Gage and Elephant Butte Reservoir, the reach upon which this paper is focused, this irrigation is mainly under the jurisdiction of the six Middle Rio Grande pueblos, MRGCD and some acequias and community ditch systems.

• The MRGCD serves Pueblo and non-Indian lands, community ditch associations, independent acequias, NM Game and Fish lands, the Bosque del Apache National Wildlife Refuge, and urban lands. The competing demands of these different entities increase the complexity inherent in operation of the district by imposing additional constraints on water deliveries.

• Present estimates of the irrigated area of the MRGCD vary between 53,000 and 73,000 acres. The district’s gross diversions averaged approximately 600,000 acre-feet throughout the 1990s, but have been reduced to slightly more than 300,000 acre-feet (in the 2003 irrigation season), mainly through operational improvements.

• MRGCD is committed to improving the efficiency of the irrigation system for the benefit of its irrigators, and to increase its operational flexibility under the constraints of the Rio Grande Compact. Improvements have already been made and more are planned.

• Irrigation system efficiency improvements in the MRGCD may not directly produce additional water for the Program. That is, if water is conserved by such improvements, MRGCD has the
option (except in years of Article VII restrictions under the Rio Grande Compact) of holding that water in upstream storage. The potential benefits under such an option have not been fully assessed by either the WAMS or MRGCD.

- Irrigation system efficiency improvements could provide indirect benefits to the Program, including:
  - Reduction in MRGCD demand, which could extend the MRGCD irrigation season in water-short years, thereby potentially reducing the amount of supplemental water that the Program would need to deliver to support the BO and Program goals;
  - Increasing MRGCD carryover storage at El Vado could produce larger spring runoff volume and peak discharges, could achieve many of the Program’s long-term habitat restoration goals, and could decrease the need for Program water;
  - Increasing MRGCD efficiency to reduce evaporation from the floodway, fields, or canal surfaces would improve the State’s ability to meet Rio Grande Compact obligations and potentially benefit the Program through increased reservoir operational flexibility.
  - When Article VII restrictions of the Rio Grande Compact, which restrict storage in upstream reservoirs, are in effect, improvements in irrigation efficiency could allow a greater portion of native Rio Grande flows to flow in the river.

- Irrigation system efficiency improvement could provide direct benefits to the Program through a negotiated agreement that would provide some amount of stored water for use by the Program in exchange for funding efficiency improvements.

- The Program should continue to support projects to study and implement irrigation efficiency improvements, and to evaluate whether and/or how these actions may help meet Program goals.

2.4 Voluntary Irrigation Forbearance in the MRGCD Service Area (Attachment E-7)

- Irrigation forbearance is the commitment by a practicing irrigator to “forbear” the use of water for a period of time, either by leaving previously irrigated land fallow or simply not irrigating, and legally reassigning the water allocated for use on that land to other uses.

- In the MRG valley, where there has been no water-rights adjudication, forbearance would be of a right to divert and consume water, based on a history of such diversion and consumption.

- Participants could agree to forbear for a single season, multiple seasons, or at regular intervals (such as once every 5 years) for some period into the future.

- Voluntary irrigation forbearance may be a mechanism for the Program to acquire water to help meet Program goals. Any water secured by the Program through voluntary forbearance could be stored in an upstream reservoir and subsequently be released following an agreed-upon schedule to benefit endangered species, using procedures similar to those followed by irrigators.

- The Program should acquire a scientifically sound understanding of the flow regime required to support the listed species in order to determine the amount of supplemental water required by the Program.

- The MRGCD has initiated a study, with input from the WAMS, on the technical feasibility of forbearance in non-Pueblo portions of the District’s system, upon which a forbearance program could be designed. If technical feasibility is established through the MRGCD study, an assessment of the willingness of individual irrigators to participate in the forbearance program should then be conducted.
• The voluntary forbearance program should be entirely voluntary and it must carefully protect the water rights of participants from forfeiture or impairment.

• The voluntary forbearance program must protect the ability of the MRGCD to deliver water to its irrigators who are not forbearing.

• Ultimately, the Program and the MRGCD will need to work together closely to identify and implement collaborative approaches to help attain Program goals for the near- and long-term benefit of listed species.

2.5 Native American Water (Attachment E-8)

• Seven Pueblos are located along the mainstem of the Rio Grande. Three Pueblos have lands along the Rio Jemez. Six Pueblos are included within the MRGCD service area. Also, the Jicarilla Apache and the San Juan Pueblo hold leases for San Juan-Chama Project water. Therefore, consideration of potential water sources to aid meeting the goals of the Program would be incomplete without consideration of the potential role of Native American water holders.

• The Pueblos’ water rights are not subject to State law or governed by State administration. The inherent sovereign authority of the Pueblos over their water resources must be respected in regional water planning efforts.

• Pueblos hold the senior-most water rights along the Rio Grande.

• While Native Americans hold claim to a diversity of classes of water uses, it is their Prior and Paramount (P&P) water rights that are most commonly the focus of discussion. In 1928 Congress authorized Interior to contract with the MRGCD to provide conservation, irrigation, drainage, and flood control for the MRG Pueblo lands.

• Within the MRG Valley, the Pueblos hold Congressionally recognized P&P water rights sufficient to irrigate 8,847 acres.

• Reclamation maintains a storage pool in El Vado Reservoir for P&P water. Releases of this water are called for by the six MRG Pueblos, working with Reclamation and the Bureau of Indian Affairs. P&P for all of the six MRG Pueblos is managed as a single pool – the storage capacity of the individual Pueblos is not differentiated.

• There will be great difficulties associated with any attempt to institute a voluntary forbearance program on Pueblo lands. Forbearance at any Pueblo would involve complex political, cultural, and technical issues that could only be addressed by that Pueblo’s government.

2.6 New Mexico Acequia Water (Attachment E-9)

• An acequia is a community irrigation ditch and, in New Mexico, an acequia refers to a centuries-old system of communal management of water and to the community of farmers that cooperatively maintain the ditch and distribute irrigation water.

• Acequias are local units of government, political subdivisions of the state. As a political organization, an acequia, or a community ditch, is a public entity that functions to allocate and distribute irrigation water to the landowners who are its members.

• The community acequia or ditch association is composed of all owners of the lands irrigated by a ditch. Landowners are assessed dues by the acequia association for the operation and maintenance of, and improvements to the ditch system.

• An estimated 1,000 acequias exist in NM, which hold a significant portion of senior water rights
Acquiring acequia water for Program use would require the consent of the individual irrigators willing to forebear, other irrigators along that ditch or acequia, as well as those downstream with senior rights.

Limited water could also result via irrigation efficiency.

It is likely that the volumes of water available for acquisition would be small (most in the range of a few 10s acre feet per year for each agreement or efficiency improvement).

With the limited exceptions where the water rights have been adjudicated, legal ownership of most acequia/ditch water is unsettled. These exceptions include the Rio de Chama below Abiquiu Dam, including operations of the Rio de Chama Acequia Association.

During low-flow years, downstream irrigators with senior rights (including MRGCD) apparently could legally divert any native water acquired by the Program from individual acequia irrigators or acequia groups. (Acequias essentially have run-of-river diversion rights.)

In general, acequia water does not appear to be a reliable source of significant water volumes for the Program. It is presently beyond the means of the Program to contact individual irrigators to determine the extent of interest in leasing water to the Program.

Any direct offers of acequia water for Program use from forbearing individuals or groups of irrigators, or through irrigation efficiency improvements, should be evaluated on assurances of legal ownership and dependability of the water reaching areas designated for Program uses.

### 2.7 Weather Modification – Cloud Seeding Water (Attachment E-10)

Cloud seeding is also termed weather modification. The fundamental technology development started in the 1940s.

Today, the technology is applied most commonly to reduce cold fogs at airports using, predominately, dry ice dropped through or compressed gases released into the fog.

The second most common use is treatment of winter clouds rising over mountains to increase snowfall (commonly estimated to increase snowfall by 10 to 15%).

The third generally applied approach is the seeding of summer clouds to reduce hail damage and, secondarily, increase local precipitation.

Cloud seeding of summer clouds over flatter terrains to increase precipitation appears to have minimum potential benefit.

Cloud seeding is commonly portrayed as not reducing downwind precipitation volumes, ostensibly because the amount of water typically removed by cloud seeding is, at most, only 10% of the cloud water available before seeding. (The question of whether multiple, sequential seeding operations could produce a downwind decrease in precipitation has not apparently been assessed.)

Chemicals used in cloud seeding, especially silver iodide, appear to produce no significant adverse environmental impacts or to accumulate above background concentrations in seeding areas (very dilute in-cloud concentrations result from seeding).

At least ten states have active (aggressive) cloud seeding programs for precipitation enhancement and/or hail suppression.

State of New Mexico has provided, on average, approximately $100,000 per year for the past 5 years to support a cloud seeding demonstration project in eastern NM. Funding for this activity
was administered through a Joint Powers Agreement between the NMISC and local NM Soil and Water Conservation Districts. The west Texas underground conservation districts in conjunction with the NM Soil and Water Conservation Districts conducted the cloud seeding operations.

- The Llano Estacado Weather Modification Association with assistance from the NMISC is developing the Eastern New Mexico Precipitation Enhancement Program and has requested legislative/Water Trust Board funding of approximately $1M per year for five years to support an “expanded, State Managed Cloud Seeding Program.”
- The Program should monitor the findings of the NMISC seeding program, both in terms of success in reducing potential irrigation demands by seeding and increasing spring runoff production from seeding.
- The Program should consider the potential benefits of a cost-share expansion of the NMISC winter seeding pilot program into the upper Rio Grande watershed, south of the CO-NM Stateline, to assess the potentials for cloud seeding to increasing snow pack and spring runoff.
- The WAMS finds that ground-based seeding to enhance snow pack water volumes may be a cost-effective method to increase stream flow and a useful 3- to 5-year pilot program in north central NM could be undertaken at a cost of $150,000 to $250,000 per year.
- Proposals developed for clouding seeding pilot study should include provisions for matching funding, to augment the Program’s support, for example, from ski areas in the upper Rio Grande watershed of New Mexico, which might benefit from such a program.
- Finally, the Program should recognize that water potentially generated by increasing snow pack would become native Rio Grande water, and as such, would be divertible by downstream water users. Cloud seeding, therefore, would only be beneficial if it caused the snow pack to exceed the demand; even then, it might just end up in carryover storage in El Vado Reservoir, held for the next year's season.

2.8 Supplementing Middle Rio Grande flows through Active Watershed Management

(Attachment E-11)

- The Program should explore opportunities for increased or enhanced river flows through active watershed management. Can wet water supplies be increased sufficiently to benefit endangered species in the MRG?
- Watershed management alone has the potential to increase watershed yield ranging from 5 to 25 percent. When performed in conjunction with cloud seeding (the topic of a separate position paper), the potential water yield increase by an additional 5 to 15 percent.
- The cost of water gained through active watershed management appears attractive when compared to the cost of other water sources. However, well-documented costs for NEPA compliance, environmental permitting, and paired watershed monitoring were not available and further economic analysis should be undertaken to evaluate implementation costs relative to wet augmented water and paper water rights yields.
- The Program should encourage appropriate land management agencies to provide an assessment estimating increases in water yield to the MRG possible through active watershed management activities. Information of interest includes a compilation of public and private watershed acreages potentially suitable for forest thinning, and a compilation and review of results from similar watershed management efforts in the region producing results potentially applicable to the MRG.
- The Program should identify opportunities to cooperate with, or actively involve watershed land management agencies in the ESA Collaborative Program, to advance watershed management for
improving water yield, water quality, and forest health supported by multiple sources of funding and to the benefit of Program activities.

3.0 WATER MANAGEMENT ALTERNATIVES

3.1 Storage and Management of Program Water (Attachment E- 12)

- Upstream storage capacity available for Program water is limited by pool limitations on physical storage space in reservoirs; Congressional authorizations of water projects along the MRG ESA Project area; complex accounting that attempts to minimize negative impacts to water users basins, states, and Mexico; and meeting the many competing needs on the Rio Grande system.
- For the most part, the water to be stored and managed for this Program is already stored and managed in some fashion.
- The Water Acquisition and Management Committee envisions meeting Program water needs through improved water management and the voluntary annual lease or purchase of water from current users, storing such water in upstream reservoirs, with flows released as needed to provide for identified river needs.
- While the preponderance of ESA stream flow needs can be met through naturally occurring flows, an annual average of about 50,000 AF must be acquired, through voluntary transfers, to meet Program purposes.
- Obtaining Program water requires obtaining the physical ability to store water in reservoirs, defining how that water will be accounted for and moved through the system, and identifying who will do it.
- A number of difficulties must be negotiated, including the timing of storage, physical limitations on storage space, congressional authorizations, complexity in accounting and meeting all competing uses on the Rio Grande system.
- There is no single best alternative. All reservoir storage alternatives should be fashioned in a manner that would create for it the operation flexibility to maximize reservoir storage under an adaptive storage management scenario, allowing for exchanges of water. The ultimate system of storage and control must be undertaken in a fashion that prevents impairment of existing uses or conflict with statutory authorizations.

Storage

- A pool of Program water, including carry-over of unreleased water from previous years, must be secured to enable an optimal river management program for Program purposes.
- The five existing reservoirs that could store and release Program water vary in size, legislative authorization and potential to capture runoff. These include Heron, El Vado, Abiquiu, Cochiti, and Jemez Canyon reservoirs.
- The Program should pursue all options to secure and utilize space in the five reservoirs:
  - Heron Reservoir – Pursue if-and-when storage\(^1\) for Program water storage with Bureau; authorizing legislation.
  - El Vado Reservoir – Explore temporary storage options with MRGCD.

\(^1\) If-and-when storage means a contract to store water in the space contracted to another entity, which is not being used by that entity. If and when the original contract holder needs that space, the if-and-when stored water would be evacuated so as to not impair the original contract use of that space.
Abiquiu Reservoir – Pursue the firm storage for Program water that may be made available through Albuquerque Drinking Water project operations.

Cochiti Reservoir – Explore use as a re-regulating reservoir with Cochiti de Pueblo; study the costs and benefits of creating new storage to capture mainstem flows.

Jemez Canyon Reservoir – Explore temporary storage options

**Management**

- A system of monitoring and accounting is needed to provide reasonable accuracy and assurance of the delivery of Program waters as they move with waters for other purposes, with an appropriate allowance for sharing the transport/loss and gaging uncertainties.

- As an extension of the accounting system, the management of Program water will require a system of reporting to stakeholders, the public, and the Compact Commission. This necessary reporting will require development and inclusion into existing accounting reports for other waters.

- In 2005, the NM legislature authorized the ISC to establish a Strategic Water Reserve. This allows the ISC the option to purchase or lease surface and ground water from willing sellers or lessors, and to receive donated water or water rights or storage rights to develop a water reserve.

- Under the Program’s Authorizing Legislation for the Program, Reclamation is assigned the lead authority for water acquisition activities intended to benefit Program’s goals.

- Ideally, final water management activities directed toward meeting the Program goals would be governed through an overarching, collaborative management model, featuring full stakeholder access and appropriate local control; while day-to-day operation would be directed by designated local representatives from Reclamation, with input from the Program, NMISC, USFWS, and others to assure that federal and other Program signatory interests are maintained.

- Active participation of all stakeholders, including federal and state agencies, Pueblos, water users, and conservation groups, should be accommodated.

### 3.2 Cochiti Lake Water Issues (Attachment E-13)

- Various alternatives have been discussed on whether Cochiti Lake would or should have a role in water operations for the endangered Rio Grande silvery minnow within the Middle Rio Grande.

- Under the authorizing legislation for Cochiti Dam and Reservoir, The Army Corps of Engineers (Corps) operates Cochiti Lake for flood and sediment control. In addition, PL 88-293 specifically authorizes a permanent recreational pool of 1,200 surface acres (approximately 50,000 acre-feet) with 5,000 acre-feet provide annually by Reclamation from the San Juan-Chama Project.

- The 19 April 2002 Court Opinion and Order on the Minnow v. Keys case agreed with the Corps’ interpretation of its authorities for the operation of Cochiti Lake.

- The NM Interstate Stream Commission (ISC), U.S. Bureau of Reclamation, and the Corps are conducting an Environmental Impact Statement (EIS) to refine and update the water operations in the Rio Grande Basin under existing authorities. This assessment includes an evaluation of potentials to increase the maximum rate of release of water during flood control operations from Cochiti Dam from 7,000 to 12,500 cfs at the Albuquerque gage.

- The Corps is also working with the Pueblo de Cochiti in seeking funds to jointly conduct an Environmental Baseline Study, expected to take two years, to assess a variety of potential reservoir volume and pool elevation changes, including no change, draining to half the current pool, and completely draining the reservoir to support the needs of endangered species.
• The Corps adheres to the position that actions involving potential modifications to the operation of Cochiti Reservoir be deferred during the development of the interim plan to provide time for the Cochiti Pueblo and/or the Cochiti Pueblo and the Corps to complete the proposed Environmental Baseline Study.

• The WAMS concurs with this position and recommends that the Program maintain a communication dialog with the Cochiti Pueblo leadership to examine impacts and alternatives to all scenarios relative to a change in operations and program objectives of the ESA Collaborative Program.

• The WAMS additionally recommends that issues concerning the future operation of Cochiti Reservoir regarding the long-term goals of Program also be deferred until a decision is made on the results of the Environmental Baseline Study.

3.3 Reservoir Evaporation Water (Attachment E-14)

• Previous assessments estimated that reservoir evaporation for Elephant Butte Reservoir over the past 50 years ranged from less than 50,000 to greater than 250,000 acre-feet/year, and for Cochiti Reservoir between 1976 to 1999 to range from about 5,000 to 20,000 acre-feet/year.

• The WAMS produced an assessment of reservoir free-water surface evaporation rates for Heron, El Vado, Abiquiu, Cochiti, Jemez Canyon, Elephant Butte, and Caballo Reservoirs calculated using pan evaporation measurement data collected near each of the reservoirs during 1985-1999. These data year were compiled through the Upper Rio Grande Water Operations Model (URGWOM) program.

• Estimates of annual free-water surface reservoir evaporation rates range from 36 inches/year at Heron Reservoir to 77.9 inches/year at Elephant Butte Reservoir.

• Estimates of theoretical maximum annual free-water surface reservoir evaporation rates range from 233,596 acre-feet/year at Elephant Butte Reservoir to 8,337 acre-feet/year at El Vado Reservoir.

• Elevation incorporated 94% percent of the statistical variation occurring in the estimated evaporation at the reservoirs.

• Significant savings of water could be possible if greater proportions of New Mexico’s Rio Grande water were stored upstream of Elephant Butte Reservoir at locations of higher elevation.

• The magnitude of this saving would depend on operations and available reservoir capacities affecting the seasonal upstream storage volumes and surface areas of water stored in each reservoir.

• The information introduced here should be further developed through a subsequent study to evaluate water saving potentials under alternative reservoir operation scenarios using realistic allocations of water storage volumes and surface areas among these reservoirs for a selection of wet to dry water years. The objectives for these studies should be to define appropriate water operation alternatives to minimize reservoir evaporation losses and to maximize the conservation of water available to meet Program goals.

3.4 Evapotranspiration and Water Salvage (Attachment E-15)

• Evapotranspiration (ET) is the combined transfer to the atmosphere through evaporation of liquid water from water, soil, and other environmental surfaces plus the transpiration of liquid and gaseous water from plants.
• Estimated total average annual ET water losses along the Rio Grande from Otowi to Elephant Butte are 674,000 acre-feet per year, including groundwater uses. These basin depletions are distributed among crops (34 percent, 230,000 acre-feet per year), riparian plants (33 percent, 222,000 acre-feet per year), reservoir evaporation (19 percent, 128,000 acre-feet per year) and urban uses (14 percent, 94,000 acre-feet per year).

• Saltcedar stands are frequently reported to use more water per unit land area than native riparian species, but saltcedar transpiration rates have been found to be no greater than native riparian plants on a per unit leaf area basis.

• A significant difficulty in interpreting transpiration rates for native and non-native riparian plant species along the MRG is the lack of comparative measurements for both plant groups collected at equal groundwater depths.

• Saltcedar cleared from 21,500 acres of floodplain of the Pecos River between Acme and Artesia, NM was projected to increase baseflow in the river by 10,000 to 20,000 acre feet per year, but such flow gains were not subsequently observed in the stream-flow gage records; the potential gains for instream water flows may have been masked by variations in climate, increased groundwater pumping, and/or increases in groundwater recharge rates.

• Variations in measured ET values for non-native and native stands indicate that local differences in stand characteristics (e.g., leaf area densities), soils, ambient climate, depth to water table, and flooding complicate the extrapolation of ET data over time and space.

• Accurate determinations of riparian depletions along the MRG also require site-specific characterization of soil, groundwater depth, topography, flooding characteristics, groundwater, and vegetation condition, with quantitative understanding of vegetation responses to variations in these physical characteristics.

• The available data suggest that conversion of non-native to native riparian vegetation stands may not always result in reduced ET rates and reduced depletions. Available data indicate that after restoration of native riparian communities long-term increases may follow short-term reductions in ET, particularly if flood frequency is increased.

• Activities such as island shaving and removal (i.e., the conversion from either native or non-native vegetated island communities to open water surfaces, likely to result when stabilizing vegetation is removed from islands) may result in initial short-term (e.g., 1-2 year) reductions in ET, followed by longer-term increases in ET losses and depletions.

• Until ET relationships are better defined on a site-by-site basis, conservatively biased ET values may be used to estimate potential restoration related affects on ET.

• Encourage the Program to support studies to assess the potentials for reducing ET-based depletions and increasing water salvage along the MRG and identify suitable alternates where conversion of non-native habitat areas may be productively converted to native riparian communities to produce net water savings, with real potentials for increasing river flows.

• The Departments of Interior and Agriculture have launched a Cooperative Initiative to Control Saltcedar in the Southwest. To the extent possible, the Program should partner in this effort to help ensure maximizing potential benefits obtainable under this Initiative in addressing potential water salvage benefits along the MRG.

• Encourage the Program to lend support to the development of one or more comprehensive monitoring projects intending to assess potential benefits from Initiative supported large-scale saltcedar control projects in producing wet water flows along the MRG.
3.5  **Floodplain Lakes and Flood Flow Retention Basins (Attachment E- 16)**

- Another potential water management alternative available to meet the Programs goals is the possibility of retaining flood-flow water in ponds or lakes located along the floodplain of the MRG. The intent of retaining flood-flow water is to provide a short-term source of water for release in the event of reduced flows. The most likely application for this procedure is for the capture of excess water from summer thunderstorms.

- Potentials exist for utilizing the Bernardo and La Joya ponds for temporary short-term flood-flow retention and release. Potentials also exist to develop new ponds on Sevilleta National Wildlife Refuge for the same purpose. However, such operations would require renovating or replacing the inlet and outlet structures for the ponds, and addressing biological and legal concerns.

- Additional investigation and evaluation through a pilot project is required to define the physical logistics of capturing flood flows. For example, how will the timing and volume of flood flow diversions be determined? How will flood flow water be delivered and captured?

- Additional administrative concerns would need to be addressed. For example, who will determine when flood flow should be captured? And, who will be responsible for assuring that flood flow is appropriately captured, retained, and released?

- Based on the identified concerns, floodplain lakes and flood flow retention basins may have a potential for providing water to the river during dry periods. However, this alternative should be considered after other more feasible and long term alternatives have been exhausted.

3.6  **Supplementing Middle Rio Grande Flows through Groundwater Pumping (Attachment E- 17)**

- Groundwater pumping has been proposed as an alternative that could be used to supplement river flows during periods of low flow. This pumping could include:

  Pumping of shallow, alluvial groundwater: intermittent pumping from existing or new shallow alluvial groundwater wells in the MRG floodplain, allowing wells to recharge naturally during periods of non-pumping;

  Pumping of non-alluvial groundwater with natural recharge: intermittent pumping from non-alluvial wells in the Middle Rio Grande floodplain, or at locations further from the river, allowing wells to recharge naturally during periods of non-pumping;

  Pumping of non-alluvial groundwater with active recharge (aquifer storage and recovery): intermittent pumping from non-alluvial wells, coupled with active recharge of the aquifer during periods of non-pumping (i.e. development of an aquifer storage and recovery system); or

  Pumping and desalinization of deep saline groundwater: pumping and desalinization of deep, saline groundwater, and use of the desalinated water as needed to support river flows.

- The primary constraint on the first three of these options is water availability. It is well known that the surface water and groundwater supplies throughout the Middle Valley are, in almost all areas, hydraulically connected. It is also well known that surface-water supplies in the Middle Valley are fully appropriated. Consequently, application of any groundwater pumping plan involving one or more of the first three options would need to do one of the following:

  Utilize water contained in the basin that is currently unappropriated;
Affect water timing only, incurring little or no additional water loss to the system;
Incorporate leasing, or buying and retiring, water rights to offset the consumptive use incurred by the plan; or
Mine groundwater resources, which will deplete streamflow at some point in the future.

- The fourth option, pumping of deep, saline groundwater, involves mining of a groundwater resource, but would mine a new source of water to this system, and would be designed so as not to impact streamflows in the foreseeable future (the effects may not be felt on the river for centuries).
- All of these options would require approval from the New Mexico Office of the State Engineer (OSE), and the operations would be under the jurisdiction of the OSE.
- Groundwater pumping to supplement river flows is of most potential use to the Program as a method of short-term water storage and recovery, such as for storing of spring flows in the groundwater system of the floodplain for release or natural flow back to the river during low flows of the summer months.
- The volumes of water that could be supplied this way would likely be sufficient to supplement flows in critical reaches in low-flow periods, or to provide localized flooding to support southwestern willow flycatcher habitat, but would not be sufficient for such purposes as providing spawning pulses or overbank flows.
- The infrastructure required for groundwater pumping that could significantly affect flows would be very large. For comparison, the entire City of Albuquerque wellfield combined pumps a total of approximately 140 cfs.
- Additional depletions associated with the increased summer flows would have to be offset through the purchase or lease of water rights. However, the non-consumptive portion of these flows should be achievable through a permit from the NM Office of the State Engineer (OSE).
- Some potential also exists for the use of aquifer storage and recovery in deep wells either in or out of the floodplain, but less directly connected to the river than the floodplain wells. However, there are likely to be very few instances where excess water is available in the system for aquifer recovery, unless water rights are specifically purchased or leased for this purpose.
- River flow could also be supplemented through the pumping and desalization of deep, saline groundwater. This would likely be a very expensive option, but could be considered, should this technology become economically competitive and be ecologically sound.

### 3.7 Supplementing Middle Rio Grande Flows through Pumping from the Low Flow Conveyance Channel (Attachment E-18)

- During the irrigation season, flows in the Middle Rio Grande between the San Acacia Diversion Dam and the headwaters of the Elephant Butte Reservoir can become intermittent, particularly in dry years, potentially causing adverse impacts to the Rio Grande silvery minnow.
- This reach of the river channel (designated by Congress as the *Rio Grande Floodway*) is paralleled by a second conveyance, the Low Flow Conveyance Channel (LFCC), which now serves as a riverside drain and collects significant water from several sources, including the river, irrigation surface and subsurface return flows, stormwater inflow, and groundwater seepage.
- The Service’s Programmatic Biological Opinions, in effect for the past several years related to Water Management on the Middle Rio Grande, have specified that Reclamation shall pump water from the LFCC to the river when intermittency is likely. Currently, the operation of a pumping...
program in the San Acacia reach of the Rio Grande is required by the Programmatic Biological Opinion of March 17, 2003. The operation of such a pumping program maintains compliance with Reasonable and Prudent alternative H, which states that the USBR shall pump water from the LFCC to the river when intermittency is likely in the San Acacia reach of the Rio Grande.

- Reclamation has implemented a “temporary” pumping program, utilizing 17 portable diesel-driven pumps to transfer water from the LFCC to the Rio Grande Floodway since 2001. During the 2002 irrigation season, the pumps were located at five locations on the LFCC between Socorro and Elephant Butte Reservoir. This program has pumped 25,000 to 35,000 acre-feet of water from the LFCC into the Rio Grande floodway each of those years, and has been very successful in maintaining flows in some critical sub-reaches.

- The New Mexico Office of the State Engineer has imposed a maximum total pumping rate of 150 cfs on the USBR’s temporary pumping program.

- The WAMS allocated funds in FY 2003 to the USBR for the completion of a feasibility study for the construction of permanent pumping plants.

3.8 Reconfiguration of the San Acacia Reach (Attachment E-19)

- The current lack of the sustainability of low flows in the Rio Grande below San Acacia is due to excessive riparian depletions and the fact that the river channel is perched through much of the valley. As such, the present river channel receives no irrigation return flows and the current groundwater gradient is away from the river to the LFCC.

- The portion of the Middle Rio Grande Project designed and constructed below San Acacia (the LFCC and the Floodway) did not permanently solve the Compact delivery problem because it did not deal effectively with the real problem – the movement of sediment through the system below San Acacia.

- The combination of reduction in groundwater drainage away from the river, improved management of irrigation return flows, and decreased riparian depletions by reconfiguring the reach below San Acacia would result in improved river flows except under the most extreme drought conditions, thus reducing or eliminating the need for supplemental flows in this reach.

- Analysis of the existing irrigation surface water delivery system in the reach should be accomplished to assure alternative strategies for delivery to the MRGCD and Refuge. This analysis would determine whether to incorporate return flows to the river where possible or maintain those flows within the irrigation system if needed to offset loss of LFCC diversions. Alternatives for delivering reliable surface water supplies to MRGCD and Refuge would need to be developed.

- The combination of changes to groundwater drainage and decreased riparian depletions that could result by implementing one or all of the above four recommendations in the reach below San Acacia would need to be thoroughly analyzed. Potential benefits to perennial river flows, the need for supplemental flows in this reach, sediment management, the diversity of existing aquatic and riparian habitats, and surface water delivery to water users and Elephant Butte Reservoir would be a part of this analysis.

- The Program should either seek Federal funding for a study or should seek proposals for such a study to evaluate the potential positive and negative effects from a possible reconfiguration of the San Acacia Reach to provide a single channel system along the lowest part of the valley. Any such study should incorporate the existing evaluations, plans, and information available in the analysis of alternatives for this reach of the Rio Grande.
Attachment B

Water Supply Demand Assessment of the 2003 Biological Opinion

Prepared by the
WAMS Water Supply Demand Team

4.0 INTRODUCTION

On October 15, 2003 the WAMS established an ad hoc group that was tasked with estimating the water demand requirements of the Middle Rio Grande Endangered Species Act Collaborative Program. Membership, as defined by flow requirements specified in the March 2003 Biological Opinion (BO, USFWS 2003). The group consisted of:

Kevin Flanigan (Chair), representing the New Mexico Interstate Stream Commission
David Gensler, representing the Middle Rio Grande Conservancy District
Steve Harris, representing the Rio Grande Alliance
Dick Kreiner, representing the US Army Corps of Engineers
Dagmar Llewellyn, representing the New Mexico Office of the Attorney General
Leanne Towne, representing the US Bureau of Reclamation
Mark Yuska, representing the US Army Corps of Engineers

5.0 METHODOLOGY

The ad hoc group met periodically in the latter part of October and the first half of November of 2003. Due to the short deadline assigned to this task, the group decided to refine a methodology used by the Bureau of Reclamation employed for its internal planning purposes. In general, the methodology finalized by the group consisted of quantifying the amount of stored water required to meet flow requirements of the 2003 BO by estimating river conveyance losses between El Vado Reservoir and the target location, assuming various climatic scenarios and the presence or absence of concurrent irrigation releases by the Middle Rio Grande Conservancy District (MRGCD). More specifically, the methodology consisted of:

- Categorizing the type of year per the BO
- Estimating the amount of losses in each segment of the river between El Vado Dam and San Acacia,
- Estimating the number of days during the spring in which supplemental releases might be needed to meet the requirement of continuous flow to Elephant Butte Reservoir, based upon the strength and duration of the snowmelt runoff, and
- Estimating the number of days after the snowmelt runoff in which supplemental releases might be needed to meet the varying post-runoff flow targets of the BO, based upon the intensity and duration of the monsoon season, and the duration of MRGCD irrigation releases, if any.
6.0 RESULTS AND DISCUSSION

Tables B-1 through B-4 quantify the Program water demand for the four categories of BO years (Article VII, Dry, Average and Wet). Article VII years are those years in which Article VII of the Rio Grande Compact are in effect. Article VII prohibits storage of native Rio Grande water in post-1929 reservoirs upstream of Elephant Butte Reservoir whenever Usable Water in Rio Grande Project storage falls below 400,000 acre-feet (AF). Dry years are those in which the April 1 forecast issued by the US Natural Resources Conservation Service (NRCS) for runoff at the Otowi gage for the months of May through July is below 80 percent of the long-term average. Average years are when the April 1 forecast is between 80 and 120 percent of average and Wet years are those when the April 1 forecast is greater than 120 percent of average.

Table B-1 quantifies the volume of Program water (as storage at El Vado Reservoir) needed to meet the BO flow targets based on the various operational conditions determined by the snowmelt runoff, the monsoon season and MRGCD operations. The overriding assumption for Article VII years is that the MRGCD will have no storage available for supplemental irrigation releases during the year and that its operations throughout the year will consist solely of run-of-river plus the storage and release of Prior and Paramount water for the six Middle Rio Grande Pueblos. In addition, the MRGCD’s annual allocation of 20,900 AF of San Juan-Chama Project (SJC) water is ignored throughout this analysis.

Table B-1 considers three types of runoff years (Poor, Average and Good), coupled with three types of monsoon seasons (Dry, Average and Wet) to yield nine combinations of Program water demand. Notes in Table B-1 provide complete details on the assumptions and methods used to quantify the volumes. In summary during Article VII years, the Program could require as much as 97,000 AF during years of poor snowmelt runoff coupled with a poor monsoon, or as little as 27,000 AF during years of wet snowmelt runoff coupled with a wet monsoon.

Table B-2 quantifies the Program demand during years defined by the BO as Dry. It is assumed, on average, during Dry years that MRGCD will have sufficient storage to meet 45 percent of its post-runoff demand for supplemental irrigation releases. The remainder of the season would then consist of run-of-river and Prior and Paramount operations. In summary during Dry years, the Program could require as much as 66,000 AF during a poor monsoon season, 60,000 AF during an average monsoon season and 53,000 AF during a wet monsoon season.

Tables B-3 (Average BO years) and 4 (Wet BO years) are similar to Table B-2. It is assumed, on average, during Average years that MRGCD will have sufficient storage to meet 75 percent of its post-runoff demand for supplemental irrigation releases, and 90 percent during Wet years. During Average years the Program could require as much as 42,000 AF during a poor monsoon season, 37,000 AF during an average monsoon season and 32,000 AF during a wet monsoon season. During Wet years the Program could require as much as 30,000 AF during a poor monsoon season, 26,000 AF during an average monsoon season and 21,000 AF during a wet monsoon season.

Table B-5 provides a preliminary quantification of the average long-term demand of the Program. For the purposes of this analysis, the Otowi Index Supply, which adjusts the gaged flow at the Otowi gage to subtract any SJC water and to remove the influence of the upstream reservoirs (Heron, El Vado and Abiquiu) on the Rio Chama, was used to characterize the runoff and monsoon season. The runoff season was thus characterized as the sum of the Otowi Index Supply flows for the months of May, June and July for the period 1940 through 1999 and the monsoon season was characterized as the Otowi Index Supply flows for the months of July, August and September for the same period. Each year from 1940 through 1999 was then defined per the BO as either an Article VII, Dry, Average or Wet year and assigned the demand associated with each type of years from Tables B-1 through B-4. The average of each ten-year
sequence (i.e., 1940 through 1949, 1941 through 1950, etc.) were then calculated, with the long-term average annual Program demand defined as the average of these 51 sequences. That value is 55,000 AF per year.

7.0 SUMMARY AND CONCLUSIONS

The amount of water (as storage in upstream reservoirs) required to meet the needs of the Program will vary from year to year, and is a function primarily of the following factors:

- Type of year (as defined by the March 2003 BO),
- Length of the MRGCD irrigation season (i.e., how much of the post-runoff irrigation season might be met by storage from El Vado Reservoir), and
- Strength of the summer monsoon season.

Carryover storage and the MRGCD’s annual SJC allocation of 20,900 AF were not incorporated into the analysis.

In summary, the methodology employed to estimate the amount of water required by the Program consisted of:

- Categorizing the type of year per the BO,
- Estimating the amount of losses in each segment of the river between El Vado Dam and San Acacia,
- Estimating the number of days during the spring in which supplemental releases might be needed to meet the requirement of continuous flow to Elephant Butte Reservoir, and
- Estimating the number of days after the snowmelt runoff in which supplemental releases might be needed to meet the varying late-season flow targets of the BO.

The required days of release were adjusted in accordance with the amount of the post-runoff irrigation season met by release of MRGCD storage from El Vado (varying between 45 and 90 percent) and the strength of the monsoon season (varying from dry, average and wet). Minimal releases to conduct a spawning spike were included in Dry and Article VII BO years. It was assumed that during average and wet snowmelt runoff years that spawning spikes would occur naturally as part of the rising limb of the snowmelt runoff hydrograph on the mainstem of the Rio Grande.

Table B-6 provides a summary of the Program water demand based on the different types of years as defined in the BO. Annual Program water demands are estimated to range from a low of about 21,000 AF in a Wet year with a good snowpack runoff coupled with a good monsoon season to a maximum of 97,000 AF in an Article VII year with a poor snowpack runoff coupled with a dry monsoon season.

The average annual Program demand was preliminarily quantified at 55,000 AF per year using the Otowi Index Supply for the period from 1940 through 1999 to characterize the snowmelt runoff and the monsoon season. This preliminary quantification did not take into consideration any MRGCD carryover storage or its annual SJC allocation of 20,900 AF. Predicting the amount of any carryover storage and incorporating that volume into the Program demand quantification is beyond the scope of this paper. However, it must be recognized that this carryover storage, plus the MRGCD’s annual SJC allocation would provide some additional flows that would indirectly assist with meeting the BO target flows. Thus the preliminary annual average Program demand quantified in Table B-5 is reduced by approximately ten percent to arrive at an average annual Program demand of 50,000 AF.
### Table B-1
Program (BO) Water Demands During Years under Compact Article VII Upstream Storage Restrictions

<table>
<thead>
<tr>
<th>OPERATING CONDITIONS</th>
<th>DEMAND DUE TO REQUIREMENT FOR CONTINUOUS FLOW TO ELEPHANT BUTTE RESERVOIR FROM NOVEMBER 16 TO JUNE 15</th>
<th>DEMAND DUE TO REQUIREMENT FOR 100 CFS AT CENTRAL AVENUE IN ALBUQUERQUE FROM JUNE 16 TO NOV 15</th>
<th>SPANNING SPIKE (AF)</th>
<th>TOTAL (AF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNOWMELT RUNOFF</td>
<td>MRGCD OPERATIONS (OPS)</td>
<td>MONSOON SEASON</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NUMBER OF DAYS OF REQUIRED RELEASE HIGH (days)</td>
<td>PERCENT LOSSES EL VADO TO COCHITI (cfs)</td>
<td>RUNOFF EFFECT</td>
<td>PERCENT OF DAYS REQUIRING RELEASE</td>
</tr>
<tr>
<td>POOR</td>
<td>RuR &amp; PSP DRY</td>
<td>30 21%</td>
<td>30 65%</td>
<td>92 122 26%</td>
</tr>
<tr>
<td>POOR</td>
<td>RuR &amp; PSP AVERAGE</td>
<td>30 21%</td>
<td>30 65%</td>
<td>70 100 25%</td>
</tr>
<tr>
<td>POOR</td>
<td>RuR &amp; PSP WET</td>
<td>30 21%</td>
<td>30 65%</td>
<td>49 79 24%</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>RuR &amp; PSP DRY</td>
<td>15 19%</td>
<td>15 65%</td>
<td>92 187 26%</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>RuR &amp; PSP AVERAGE</td>
<td>15 19%</td>
<td>15 65%</td>
<td>70 85 25%</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>RuR &amp; PSP WET</td>
<td>15 19%</td>
<td>15 65%</td>
<td>49 64 26%</td>
</tr>
<tr>
<td>GOOD</td>
<td>RuR &amp; PSP DRY</td>
<td>0 17%</td>
<td>0 65%</td>
<td>92 92 26%</td>
</tr>
<tr>
<td>GOOD</td>
<td>RuR &amp; PSP AVERAGE</td>
<td>0 17%</td>
<td>0 65%</td>
<td>70 70 25%</td>
</tr>
<tr>
<td>GOOD</td>
<td>RuR &amp; PSP WET</td>
<td>0 17%</td>
<td>0 65%</td>
<td>49 49 26%</td>
</tr>
</tbody>
</table>

NOTES:
- COLUMN 1: The type of snowmelt runoff year. Poor is defined as less than 90 percent of the long-term May through July runoff average at Ft. Owen gage; average is between 80 and 120 percent and good is greater than 120 percent.
- COLUMN 2: It is assumed that during Article VII years that MRGCD will have no stored water available for release. MRGCD’s irrigation season will consist only of run-off from RuR operations and Prior and Paramount (PSP) storage and release for the six middle Rio Grande Pueblos.
- COLUMN 3: The length and intensity of the monsoon season.
- COLUMN 4: The number of days that releases of supplemental water will be required in the spring to maintain continuous flow below San Acacia. It is assumed, on average, that 30 days will be required during a poor snowmelt runoff season (since a poor snowpack is correlated with a dry winter and spring), that, on average, 15 days will be required during an average snowmelt runoff season, and that zero days will be required during a wet snowmelt runoff season.
- COLUMN 5: Estimated conveyance losses between El Vado and Cochiti, with less percent less loss during wetter climate and higher flows.
- COLUMN 6: Estimate (based on operational observations) of the average conveyance loss rate between Cochiti and the Isleta Diversion Dam.
- COLUMN 7: Estimate (based on operational observations) of the average conveyance loss rate between the Isleta Diversion Dam and San Acacia.
- COLUMN 8: Required flow at San Acacia during Article VII years necessary to maintain continuous flow to Elephant Butte Reservoir.
- COLUMN 9: Volume of El Vado storage required to meet the Column 8 target flow, based on the given operating conditions shown in Columns 1 and 2, the number of days of required release shown in Column 4 and the average less rates shown in Columns 5, 6 and 7.
- COLUMN 10: Number of days target flow is not met by snowmelt runoff.
- COLUMN 11: Percentage of worst case scenario (percent of days during monsoon season that supplemental releases will be required).
- COLUMN 12: Number of days target flow is not met by monsoon flows.
- COLUMN 13: Equals the sum of Column 10 plus Column 12 times the percent of days flow targets not met by MRGCD operations (Column 2).
- COLUMN 14: Estimated conveyance losses between El Vado and Cochiti, with less loss of supplemental water during wet monsoon seasons.
- COLUMN 15: Cochiti release necessary (based on operational observations) to meet the required flow target of 100 cfs at Central Avenue in Albuquerque.
- COLUMN 16: Volume of El Vado storage required to meet the flow target, based on the given operating conditions shown in Columns 2 and 3, the number of days of required release shown in Column 13 and the average less rates shown in Column 14.
- COLUMN 17: Volume of El Vado storage required for a spanning spike release, given the operating conditions shown in Columns 1 and 2.
- COLUMN 18: Annual volumes of El Vado storage required to meet the target flows, given the operating conditions shown in Columns 1, 2 and 3.
### Table B-2

Program (BO) Water Demands During Dry Years

<table>
<thead>
<tr>
<th>OPERATING CONDITIONS</th>
<th>NOV 16 TO JUN 15</th>
<th>JUNE 16 TO NOV 15</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CONTINUOUS FLOW TO EBR</td>
<td>100 CFS @ CENTRAL AVENUE</td>
</tr>
<tr>
<td>SNOWMELT RUNOFF</td>
<td>MRGC OPERATIONS</td>
<td>MONSOON SEASON</td>
</tr>
<tr>
<td>POOR</td>
<td>45% Rainfall in P&amp;O</td>
<td>DRY</td>
</tr>
<tr>
<td>POOR</td>
<td>45% Rainfall in P&amp;O</td>
<td>AVERAGE</td>
</tr>
<tr>
<td>POOR</td>
<td>45% Rainfall in P&amp;O</td>
<td>WET</td>
</tr>
</tbody>
</table>

**Notes:**

**COLUMN 1:** The type of snowmelt runoff year. Poorer Dry is defined as less than 50 percent of the long-term May through July runoff average at Otowi gauge.

**COLUMN 2:** It is assumed that during dry years that MRGC operations will have sufficient storage available for release to meet 45% of its post-runoff supplemental irrigation demand. MRGC operations after storage runs out will consist only of run-of-river (RoR) operations and Prior and Paramount storage and release for the six middle Rio Grande Pueblos.

**COLUMN 3:** The length and intensity of the monsoon season.

**COLUMN 4:** The number of days that releases of supplemental water will be required in the spring to maintain continuous flow below San Acacía. It is assumed, on average, that 30 days will be required during a poor snowmelt runoff season (since a poor snowpack is correlated with a dry winter and spring).

**COLUMN 5:** Estimated conveyance losses between El Vado and Cochiti, with less percent loss during wetter climate and higher flows.

**COLUMN 6:** Estimate (based on operational observations) of the average conveyance loss rate between Cochiti and the Isleta Diversion Dam.

**COLUMN 7:** Estimate (based on operational observations) of the average conveyance loss rate between the Isleta Diversion Dam and San Acacía.

**COLUMN 8:** Required flow at San Acacía during Dry years per the 2003 BOP.

**COLUMN 9:** Volume of El Vado storage required to meet the Column 8 target flow, based on the given operating conditions shown in Columns 1 and 2, the number of days of required release shown in Column 4 and the average loss rates shown in Columns 5, 6 and 7.

**COLUMN 10:** Number of days target flow is not met by snowmelt runoff.

**COLUMN 11:** Percentage of worst case scenario (percent of days during monsoon season that supplemental releases will be required).

**COLUMN 12:** Number of days target flow is not met by monsoon flows.

**COLUMN 13:** Equal to the sum of Column 10 plus Column 12 times the percent of days flow targets not met by MRGC operations (Column 2).

**COLUMN 14:** Estimated conveyance losses between El Vado and Cochiti.

**COLUMN 15:** Cochiti release necessary (based on operational observations) to meet the required flow target of 100 cfs at Central Avenue in Albuquerque.

**COLUMN 16:** Volume of El Vado storage required to meet the flow target, based on the given operating conditions shown in Columns 2 and 3, the number of days of required release shown in Column 13 and the average loss rates shown in Column 14.

**COLUMN 17:** Volume of El Vado storage required for a spawning spike release, given the operational conditions shown in Columns 1 and 2.

**COLUMN 18:** Annual volumes of El Vado storage required to meet the target flows, given the operational conditions shown in Columns 1, 2 and 3.
### Table B-3

Program (BO) Water Demands During Average Years

<table>
<thead>
<tr>
<th>Operating Conditions</th>
<th>Nov 16 to Jun 15 Continuous Flow to Elephant Butte Reservoir with 560 CFS at Isleta</th>
<th>June 16 to Nov 15 560 CFS at San Acacia with 100 CFS at Isleta</th>
<th>Flow Target Partially Met by MRGC Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snowmelt Runoff</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monsoon Season</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Days of Required Release (dpa)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Loss El Vado to Cochiti</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute Losses to Cochiti</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute Losses to San Acacia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Required Flow at San Acacia (cfs)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotal (af)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Runoff Effect</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monsoon Effect</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Days Release Required (dpa)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Loss El Vado to Cochiti</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute Losses to Cochiti</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute Losses to San Acacia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotal (af)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Days Release Required (dpa)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotal (af)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total (af)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**

1. **COLUMN 1:** The type of snowmelt runoff year. Average in defined as between 80 and 120 percent of the long-term May through July snowfall average at Chino.

2. **COLUMN 2:** Calculations made 17.5% of post-runoff supplemental irrigation demand. MRGC operations after storage run off will consist of only noncritical (NR) operations and Prior and Paramount storage and release for the six middle Rio Grande Basin.

3. **COLUMN 3:** The length and intensity of the monsoon season.

4. **COLUMN 4:** The number of days that releases of supplemental water will be required to maintain continuous flow below San Acacia. It is assumed, on average, that 15 days will be required during an average snowmelt runoff season.

5. **COLUMN 5:** Estimated conveyance losses between El Vado and Cochiti.

6. **COLUMN 6:** Estimate (based on operational observations) of the average conveyance loss rate between Cochiti and the Isleta Diversion Dam.

7. **COLUMN 7:** Estimate (based on operational observations) of the average conveyance loss rate between the Isleta Diversion Dam and San Acacia.

8. **COLUMN 8:** Required flow at San Acacia during Average VI years per the 2003 BO.

9. **COLUMN 9:** Volume of El Vado storage required to meet the Column 8 target flow, based on the given operating conditions shown in Columns 1 and 2, the number of days of required release shown in Column 4 and the average loss rates shown in Columns 5, 6 and 7.

10. **COLUMN 10:** Number of days target flows are not met by snowmelt runoff.

11. **COLUMN 11:** Percentage of worst case scenario (percent days during monsoon season that supplemental releases will be required).

12. **COLUMN 12:** Number of days target flows are not met by monsoon flows.

13. **COLUMN 13:** Equal to the sum of Column 10 plus Column 12 times the percent of days target flows not met by MRGC operations (Column 3).

14. **COLUMN 14:** Estimated conveyance losses between El Vado and Cochiti.

15. **COLUMN 15:** Estimate (based on operational observations) of the average conveyance loss rate between Cochiti and the Isleta Diversion Dam.

16. **COLUMN 16:** Estimate (based on operational observations) of the average conveyance loss rate between the Isleta Diversion Dam and San Acacia.

17. **COLUMN 17:** Volume of El Vado storage required to make the target flow after cessation of releases of MRGC supplemental irrigation water, based on the given operating conditions shown in Columns 2 and 3, the number of days of required release shown in Column 13 and the average loss rates shown in Columns 14, 15 and 16.

18. **COLUMN 19:** Number of days supplemental releases will need to occur while MRGC is releasing supplemental irrigation water.

19. **COLUMN 20:** Annual volumes of El Vado storage required to maintain the target flows, given the operational conditions shown in Columns 1, 2 and 3.
### Table B-4

Program (BO) Water Demands During Wet Years

<table>
<thead>
<tr>
<th>Operating Conditions</th>
<th>Nov 16 to Jun 15</th>
<th>June 16 to Nov 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snowmelt Runoff</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRGCD Ops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monsoon Season</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Days of Required Release (days)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Loss El Vado to Cochiti</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute Losses Isleta to San Acaca (kaf)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Required Flow at San Acaca (kaf)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotal (kaf)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Runoff Effect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent of Days Requiring Release</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monsoon Effect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Days Release Required (days)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Loss El Vado to Cochiti</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute Loss Isleta to San Acaca</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute Loss Isleta to San Acaca</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotal (kaf)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total (kaf)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
- **Column 1:** The type of snowmelt runoff year. Good or Wet is defined as greater than 120 percent of the long-term May through July runoff average at Orito.
- **Column 2:** It is assumed that during Good years that MRGCD will have sufficient storage available for release to meet 90% of its post-runoff supplemental irrigation demand. MRGCD operates after storage runs out consistent only of runoff (RAW) operations and Prior and Panamint storage and releases for the six middle Rio Grande Pueblos.
- **Column 3:** The length and intensity of the monsoon season.
- **Column 4:** The number of days that releases of supplemental water will be required in the spring to maintain continuous flow below San Acaca. It is assumed, on average, that 0 days will be required during a good snowmelt runoff season.
- **Column 5:** Estimated evaporation losses between El Vado and Cochiti.
- **Column 6:** Estimate (based on operational observations) of the average evaporation loss rate between Cochiti and the Isleta Diversion Dam.
- **Column 7:** Estimate (based on operational observations) of the average evaporation loss rate between the Isleta Diversion Dam and San Acaca.
- **Column 8:** Required flow at San Acaca during Wet years per the 2003 BOI.
- **Column 9:** Volume of El Vado storage required to meet the Column 0 target flow, based on the given operating conditions shown in Column 1 and 2, the number of days of required release shown in Column 3 and the average loss rates shown in Columns 4, 5, 6, and 7.
- **Column 10:** Number of days target flow is not met by snowmelt runoff.
- **Column 11:** Percentage of worst case scenario (percent of days during monsoon season that supplemental releases will be required).
- **Column 12:** Number of days target flow is not met by monsoon flows.
- **Column 13:** Equal to the sum of Column 10 plus Column 12 times the percent of days flow targets not met by MRGCD operations (Column 2).
- **Column 14:** Estimated evaporation losses between El Vado and Cochiti.
- **Column 15:** Estimate (based on operational observations) of the average evaporation loss rate between Cochiti and the Isleta Diversion Dam.
- **Column 16:** Estimate (based on operational observations) of the average evaporation loss rate between the Isleta Diversion Dam and San Acaca.
- **Column 17:** Volume of El Vado storage required to meet the flow target after cessation of releases of MRGCD supplemental irrigation water, based on the given operating conditions shown in Columns 2 and 3, the number of days of required release shown in Column 13 and the average loss rates shown in Columns 14, 15, and 16.
- **Column 18:** Number of days supplemental releases will need to occur while MRGCD is releasing supplemental irrigation water.
- **Column 19:** Volume of El Vado storage required to meet the flow target while MRGCD is releasing supplemental irrigation water, based on the given operating conditions shown in Columns 2 and 3, the number of days of required release shown in Column 13 and the average loss rates shown in Columns 14, 15, and 16.
- **Column 20:** Annual volumes of El Vado storage required to meet the target flows, given the operational conditions shown in Column 1, 2 and 3.
### Table B-5
Average Annual Program Water Demand

<table>
<thead>
<tr>
<th>YEAR</th>
<th>RUNOFF (SUM OF MAY, JUNE AND JULY OWI INDEX SUPPLY FLOWS)</th>
<th>MONSOON (SUM OF JULY, AUGUST AND SEPTEMBER OWI INDEX SUPPLY FLOWS)</th>
<th>ARTICLE VII YEARS (RUNOFF YEAR)</th>
<th>TYPE OF SNOWMELT RUNOFF YEAR</th>
<th>TYPE OF MONSOON YEAR</th>
<th>ANNUAL DEMAND (FROM TABLES 1 THROUGH 4)</th>
<th>10 YEAR AVERAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1940</td>
<td>1981.1</td>
<td>48.3</td>
<td>NO</td>
<td>DRY</td>
<td>DRY</td>
<td>66</td>
<td>88</td>
</tr>
<tr>
<td>1941</td>
<td>1915.1</td>
<td>346</td>
<td>NO</td>
<td>WET</td>
<td>WET</td>
<td>21</td>
<td>63</td>
</tr>
<tr>
<td>1942</td>
<td>1291.3</td>
<td>164.6</td>
<td>NO</td>
<td>WET</td>
<td>DRY</td>
<td>30</td>
<td>42</td>
</tr>
<tr>
<td>1943</td>
<td>227</td>
<td>79</td>
<td>NO</td>
<td>DRY</td>
<td>DRY</td>
<td>66</td>
<td>66</td>
</tr>
<tr>
<td>1944</td>
<td>949.0</td>
<td>146.7</td>
<td>NO</td>
<td>WET</td>
<td>DRY</td>
<td>26</td>
<td>42</td>
</tr>
<tr>
<td>1945</td>
<td>985</td>
<td>53</td>
<td>NO</td>
<td>WET</td>
<td>WET</td>
<td>30</td>
<td>42</td>
</tr>
<tr>
<td>1946</td>
<td>96.4</td>
<td>72.6</td>
<td>NO</td>
<td>DRY</td>
<td>DRY</td>
<td>66</td>
<td>49</td>
</tr>
<tr>
<td>1947</td>
<td>397.6</td>
<td>160.7</td>
<td>NO</td>
<td>DRY</td>
<td>DRY</td>
<td>66</td>
<td>49</td>
</tr>
<tr>
<td>1948</td>
<td>827.7</td>
<td>79.1</td>
<td>NO</td>
<td>WET</td>
<td>DRY</td>
<td>30</td>
<td>52</td>
</tr>
<tr>
<td>1949</td>
<td>965.5</td>
<td>222.4</td>
<td>NO</td>
<td>WET</td>
<td>WET</td>
<td>21</td>
<td>59</td>
</tr>
<tr>
<td>1950</td>
<td>142.6</td>
<td>56.5</td>
<td>NO</td>
<td>DRY</td>
<td>DRY</td>
<td>66</td>
<td>63</td>
</tr>
<tr>
<td>1951</td>
<td>115.7</td>
<td>41.6</td>
<td>YES</td>
<td>DRY</td>
<td>DRY</td>
<td>97</td>
<td>68</td>
</tr>
<tr>
<td>1952</td>
<td>676.5</td>
<td>113.6</td>
<td>NO</td>
<td>WET</td>
<td>WET</td>
<td>21</td>
<td>65</td>
</tr>
<tr>
<td>1953</td>
<td>202</td>
<td>46.6</td>
<td>YES</td>
<td>DRY</td>
<td>DRY</td>
<td>97</td>
<td>65</td>
</tr>
<tr>
<td>1954</td>
<td>130.4</td>
<td>46.8</td>
<td>YES</td>
<td>DRY</td>
<td>DRY</td>
<td>97</td>
<td>65</td>
</tr>
<tr>
<td>1955</td>
<td>191.1</td>
<td>77.4</td>
<td>YES</td>
<td>DRY</td>
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80% OF AVERAGE:  
- 40.7  105.9  
- 50.3  132.3  
- 61.3  156.8  

AVERAGE: 54.7
### Table B-6

**Summary of Program Water Demand**

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**AVERAGE ANNUAL PROGRAM DEMAND = 50,000 AF**
ATTACHMENT C

Analysis of Sufficiency of Unregulated Rio Grande Flows to Meet ESA Flow Targets in the Middle Valley
Prepared by

Kevin Flanigan
New Mexico Interstate Stream Commission, in Collaboration with the Water Acquisition and Management Subcommittee

1.0 INTRODUCTION

The purpose of this memorandum is to analyze the likelihood of meeting the flow requirements of the March 17, 2003 Biological Opinion (BO) in the absence of available reservoir storage. Flow targets for those years defined in the BO as Dry or Article VII years only are considered in this analysis. Dry years are defined as those years in which the April 1 snowmelt runoff forecast of the U.S. Natural Resources Conservation Service is less than 80 percent of average of the 30-year period from 1971 through 2000 at the Otowi gage. Article VII years are defined as those years in which the reservoir storage restrictions of Article VII of the Rio Grande Compact are in effect. (Article VII prohibits the storage of native Rio Grande water in post-1929 reservoirs upstream of Elephant Butte Reservoir whenever there is less than 400,000 acre-feet of Usable Water in Rio Grande Project Storage. Usable Water is defined as the total content of Elephant Butte plus Caballo Reservoirs less any Colorado or New Mexico credit water and less and San Juan-Chama water in storage.) It is currently projected that, given an average snowpack, there will be sufficient storage available in 2005 to meet the BO flow targets, but that if drought conditions continue to prevail, there will be little or no storage available in 2006.

From a water management and hydrologic perspective the flows recorded at the Embudo gage, located on the Rio Grande near a point where the river flows out of the Taos Plateau and into the Espanola Basin, are considered to be representative of the mainstem inflow into the middle Rio Grande valley. In dry years, in the absence of significant tributary inflow, flows at Embudo plus releases from storage from reservoirs on the Rio Chama essentially represent the surface water supply available to the middle Rio Grande valley.

The gaging station at Embudo, operated by the U.S. Geological Survey (USGS), is the oldest continually operated gaging station in New Mexico. The drainage area contributing to flow at the station encompasses 10,400 square miles, including about 2,900 square miles within the Closed Basin of the San Louis Valley of southern Colorado. The USGS rates the accuracy of the record at the station as “good,” meaning that 95 percent of the readings are within 10 percent of the true value.

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2.0 ASSUMPTIONS

A number of major assumptions are necessary to perform the analysis:

The first is that there will be no diversions for irrigation of any land in the middle valley. All diversions – both Indian and non-Indian will be curtailed. (It must be strongly stated that this paper does not advocate such curtailment, rather this is an assumption necessary to conduct the analysis herein.)

The second is that there will be no contributions to mainstem flows from the Rio Chama. There will be no storage available for release from El Vado or Abiquiu Reservoirs, and the natural flows of the Chama as measured at the La Puente gage above El Vado Reservoir will be insufficient to carry to the confluence of the Rio Chama with the Rio Grande. Likewise, there will be no contribution to mainstem flows from the Jemez River, or any other tributary streams between Embudo and Albuquerque.

The third is that the conveyance losses between Embudo and Cochiti Reservoir may be characterized by the loss rate coefficients developed for use in URGWOM (Upper Rio Grande Water Operations Model). These loss rate coefficients represent average conveyance losses over a long time period for a wide range of flows. The URGWOM loss rate coefficients (expressed as the percent of flow lost) vary by month as shown in Table 1.

The fourth is that a constant value of release from Cochiti Reservoir may be used to represent hydrologic conditions downstream. Based on observations during the 2003 irrigation season, it was determined that a relatively constant release of 210 cubic feet per second (cfs) from Cochiti Reservoir to the Rio Grande provided 100 cfs or more at Central Avenue during the months of July through October and that a release of 340 cfs plus augmentation by pumps moving water from the Low Flow Conveyance Channel to the Rio Grande provided continuous flow between San Acacia and San Marcial during the spring months of March through June. (It must be noted that this assumption may be overly optimistic in the absence of irrigation operations. The riverside drains, which flank the Rio Grande on both sides from Cochiti on down to San Acacia, intersect the shallow groundwater table and provide the hydraulic control on the system. In the absence of irrigation return flows, and with constant releases from Cochiti Reservoir, the water level in the drains most likely will reach a quasi-steady state wherein a significant portion of the flow will be derived as seepage loss from the river, more so than during 2003.)

Based on these four assumptions, flows required at Embudo necessary to meet the BO flow targets are as shown in Table 2. These values are calculated as the required release from Cochiti Reservoir as described above less losses in the upstream reaches between Cochiti Reservoir and Embudo. All values are rounded to the nearest tens of cfs.

For example, the March value of 390 cfs is calculated as:

$$Q = 340/\{(1-0.05)(1-0.05)(1-0.04)\} = 392, \text{ rounded to 390}$$

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and the July value of 280 cfs is calculated as:

\[ Q = \frac{210}{(1-0.11)(1-0.11)(1-0.06)} = 282, \text{ rounded to } 280 \]

### 3.0 DATA

Values of daily mean flows dating back to 1889 are available for the Embudo gage, excepting the years 1905 through 1910. All data for the years, 1894, 1904, 1911 and 1912 were excluded since only a partial-year dataset was available for those years. Values listed by the USGS as estimated were treated as actual values. This pretreatment of the data led to a dataset consisting of 38,349 values of mean daily flow, or 105 complete years of daily mean flows out of the 115 years since the establishment of the station. The entire dataset, as well as specific subsets, were analyzed by several methods: examination of the descriptive statistics, preparation of duration curves, performance of a frequency analysis, and performance of a low-flow frequency analysis.

#### 3.1 Descriptive Statistics

Table 3 provides a summary of the descriptive statistics for the dataset and various subsets. The mean, median and mode are measures of the central tendency of the sample distribution. A much greater value of the mean versus the median indicates that the sample is strongly skewed to the right, as is the case for the entire dataset or the irrigation season subset. The range, standard deviation and coefficient of variation are measures of dispersion. The skewness and kurtosis are measures of the symmetry of the sample distribution. The skewness is a characterization of the degree of asymmetry of a distribution about its mean. A distribution with a long tail to either side is described as being highly skewed. The kurtosis is a characterization of the relative peakedness or flatness of a distribution as compared to that of the normal distribution.

The maximum mean daily flow for the period of record is 15,900 cfs. The minimum is 130 cfs. Both of these values occurred during the month of June. The mean, or average, flow for the period of record is 916 cfs. The median mean daily flow is 535 cfs - half of the values are greater than 535 cfs, and half are less. The relatively high value of the coefficient of skewness for the period of record indicates the dataset is strongly skewed in the positive direction. The high value of kurtosis indicates that the distribution is highly peaked.

Figure 1 presents a frequency histogram of the period of record dataset. This type of plot shows the relative frequency of occurrence of each of the data intervals shown on the x-axis. A histogram provides a quick visual description of the shape of the distribution of the dataset. Note the high peak and the long skewed tail in the positive direction. Cumulative frequency is also shown.

Figure 2 shows the mean daily flows for the period of record throughout the year. The annual hydrograph at Embudo is typical of western streams, showing a rising limb due to snowmelt runoff that typically commences in mid-to late April and peaking in late May or early June followed by a descending limb that terminates in early July at average baseflow levels on the order of 500 cfs or so. Figure 3 shows the mean monthly flows for the period of record.
Table 4 provides a comparison of the mean monthly flow for the period of record for the irrigation season at Embudo versus the required flows shown in Table 2. Table 4 also shows the percent of months of the dataset record in which the mean flow for the month was less than the required flow. For example, approximately three percent of the mean monthly flows for the month of March were less than 390 cfs, and approximately 97 percent where greater than 390 cfs.

Figure 4 graphically shows the percent of months in which the mean monthly flow is less than the required flows.

### 3.2 Duration Curve Analysis

Duration curves were developed for the period of record dataset, the subset consisting of mean daily flows during the irrigation season only (March 1 through October 30), and for each of the individual months of the irrigation season. A flow duration curve is a relative frequency curve that shows the percent of time during which specific flows were equaled or exceeded in a given time period. A duration curve is most properly defined as a relative frequency curve but it can be used to provide an estimate of the distribution of flows during a future period of time of sufficient length. Should the period on which the duration curve is based be representative of the long-term flow of the stream, the duration curve may be considered a probability curve and be used to estimate the percent of time that a specific flow will be equaled or exceeded in the future.

The duration curve for the period of record dataset is shown in Figure 5. Flows at Embudo have exceeded the highest required value (the first half of June value of 420 cfs) shown in Table 2 approximately 67 percent of the time, and the lowest value (the October value of 250 cfs) approximately 92 percent of the time. In other words, flows at Embudo were less than 420 cfs approximately 33 percent of the time, and less than 250 cfs approximately 8 percent of the time.

Figure 6 presents the duration curve for the irrigation season data subset. Flows during the irrigation season were insufficient to meet the highest required flow value of 420 cfs approximately 37 percent of the time and the lowest required flow value of 250 cfs approximately 12 percent of the time.

Figures 7 through 14 are duration curves for the period of record for each of the individual months (March, April, etc., respectively) of the irrigation season. The percent of time that flows at Embudo for each individual month have exceeded the amount necessary to meet the BO flow targets are shown in Table 5.

### 3.3 Frequency Analysis

Frequency analysis is a procedure for estimating the frequency of occurrence or the probability of occurrence of future hydrologic events. In general, a frequency analysis consists of selecting a theoretical probability distribution, estimating the parameters of the distribution from the sample data, and then evaluating the distribution function at various points of interest.

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For the purposes of this analysis, it was assumed that the log-normal probability distribution adequately describes flows at Embudo. Statistical software\(^6\) was used to define the log-normal probability density function for each of the dataset subsets as shown in Figures 15 through 22. The probabilities of occurrence of particular flow events of interest may be determined by calculating the area under the function (easily done by spreadsheet numerical integration) or by evaluating the function analytically. The probability that the daily mean flow at Embudo during any particular month of the irrigation season will be equal to or less than the required flow is shown in Table 6.

### 3.4 Low-Flow Frequency Analysis

An evaluation of the low-flow characteristics of the gaging data at Embudo is probably the most pertinent analysis for attempting to characterize the ability of the Rio Grande to meet the flow requirements specified by the BO. A low-flow analysis may be used to evaluate the ability of a stream to meet a specified flow target with a stated probability of experiencing a shortage.\(^7\)

The analyses described earlier (use of duration curves and frequency analysis) were based on evaluating a hydrologic event of a single day in duration. A one day dip in flow below the required values presented in Table 2 at Embudo would not necessarily result in insufficient flow at the Central Avenue gage in Albuquerque, since the dip would be attenuated as it moved downstream. However, a sustained period of several days in a row of low-flow would certainly result in insufficient flow at the target gage, provided the period is sufficiently long or the magnitude of the low-flow is sufficiently small. It is estimated that a sustained low-flow sequence of five days or more of 10 cfs or more below the required flow at Embudo would result in flows below the BO target at Central Avenue in Albuquerque. Such a low-flow spell or sequence in which flows (or the average flow for the sequence) are continuously below a specified threshold value is a distinct hydrologic event that may be described statistically.

The USGS has performed a limited low-flow frequency analysis at numerous gaging stations in New Mexico.\(^8\) That analysis fitted a log-Pearson Type III probability distribution (known to adequately describe extreme hydrologic events such as floods or low-flows) to each annual series of flows to produce a table of the non-exceedance probabilities for recurrence intervals of 2, 5, 10, 20, 50 and 100 years and the associated discharge.

The results of the USGS low-flow frequency analysis have been plotted in Figure 23. Use of Figure 23 is best understood by an example. Consider the point at which the 25 percent non-exceedence grid line intersects each of the low-flow frequency curves. At the intersection of the grid line with the 14-day event, the discharge value is approximately 210 cfs. This indicates that there is a 25 percent chance that the lowest 14-day average flow in any given year will not exceed 210 cfs.

A similar analysis of low-flow frequency probabilities based on the log-Pearson Type III probability distribution was performed on the Embudo gage for use in development of the Jemez y Sangre Regional Water Plan.\(^9\) That analysis used the period from 1912 through 1997 and developed the same type of plot as in Figure 23, but with the x-axis extended to the 100 percent non-exceedence probability. The common area of both plots is essentially identical.

\(^6\) @RISK, Palisade Corporation, Newfield, New York.  
Values of the non-exceedence probabilities for the minimum required flow at Embudo (250 cfs) and the maximum required flow (420 cfs), based on Figure 23 in combination with the analysis performed for the Jemez y Sangre Regional Water Plan, are shown in Table 7. The non-exceedence probability values for 280 cfs are also provided in Table 7, since the required flows during the summer period and fall period range from 250 to 280 cfs.

4.0 CONCLUSIONS

Based on the analyses presented above, it is concluded that:

1. Historically, the average monthly flow at Embudo is insufficient to meet the March 17, 2003 BO flow targets as often as 26 percent of the time.

2. Analysis of duration curves for the Embudo gage indicate that there will be insufficient flow to meet the BO flow targets ranging from five percent of the time on average during the month of March to 29 percent of the time on average during the month of September. These results were verified by the frequency analysis which showed that the probability that the mean daily flow at Embudo will be insufficient to meet the BO flow targets in any given month ranges from a low of five percent during the month of March to a high of 29 percent during the month of September.

3. There is a 47 percent probability that the seven-day average low flow in any given year will not exceed 250 cfs. There is a 55 percent probability that the seven-day average low flow in any given year will not exceed 280 cfs. A low flow sequence this long in duration that is as little as 10 cfs less than either of these required flow values will result in insufficient flow to meet the BO flow targets. Stated differently, there will be a low flow event lasting seven days in which there will be insufficient flow to meet the BO target approximately one out of every two years on average.

In summary, there will be insufficient flow at Embudo to meet the Article VII or Dry BO-year flow targets approximately one year out of two on average. On average, the lowest flows occur in the summer months of July through September, with September being the month in which it is most likely there will be insufficient flows.
### TABLE 1
URGWOM LOSS RATE COEFFICIENTS

<table>
<thead>
<tr>
<th>Month</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June (1st Half)</th>
<th>June (2nd Half)</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embudo to the Confluence with the Rio Chama</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>11</td>
<td>8</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Confluence with the Rio Chama to Otowi Bridge</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>11</td>
<td>8</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Otowi Bridge to Cochiti Reservoir</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

NOTE: Values shown are percent loss of inflow discharge.
### TABLE 2
FLOWS AT EMBUDO NECESSARY TO MEET BO FLOW TARGETS

<table>
<thead>
<tr>
<th>Month</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June (1st Half)</th>
<th>June (2nd Half)</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
</tr>
</thead>
<tbody>
<tr>
<td>BO Flow Requirement</td>
<td>Continuous to San Marcial</td>
<td>Continuous to San Marcial</td>
<td>Continuous to San Marcial</td>
<td>Continuous to San Marcial</td>
<td>100 cfs at Central Avenue Bridge in Albuquerque</td>
<td>100 cfs at Central Avenue Bridge in Albuquerque</td>
<td>100 cfs at Central Avenue Bridge in Albuquerque</td>
<td>100 cfs at Central Avenue Bridge in Albuquerque</td>
<td>100 cfs at Central Avenue Bridge in Albuquerque</td>
</tr>
<tr>
<td>Flow Needed at Embudo to Meet BO Flow Requirement</td>
<td>390</td>
<td>400</td>
<td>410</td>
<td>420</td>
<td>260</td>
<td>280</td>
<td>260</td>
<td>260</td>
<td>250</td>
</tr>
</tbody>
</table>
### TABLE 3
DESCRIPTIVE STATISTICS

<table>
<thead>
<tr>
<th>Period of Record</th>
<th>Sample Size</th>
<th>March Values Only</th>
<th>April Values Only</th>
<th>May Values Only</th>
<th>June Values Only</th>
<th>July Values Only</th>
<th>August Values Only</th>
<th>September Values Only</th>
<th>October Values Only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>38349</td>
<td>25725</td>
<td>3255</td>
<td>3150</td>
<td>3255</td>
<td>3150</td>
<td>3255</td>
<td>3255</td>
<td>3255</td>
</tr>
<tr>
<td>Maximum</td>
<td>15900</td>
<td>15900</td>
<td>2140</td>
<td>6790</td>
<td>12600</td>
<td>15900</td>
<td>8300</td>
<td>4440</td>
<td>4620</td>
</tr>
<tr>
<td>Minimum</td>
<td>130</td>
<td>130</td>
<td>230</td>
<td>205</td>
<td>183</td>
<td>130</td>
<td>140</td>
<td>145</td>
<td>145</td>
</tr>
<tr>
<td>Mean</td>
<td>916</td>
<td>1099</td>
<td>729</td>
<td>1129</td>
<td>2359</td>
<td>2316</td>
<td>852</td>
<td>497</td>
<td>435</td>
</tr>
<tr>
<td>Median</td>
<td>535</td>
<td>570</td>
<td>700</td>
<td>809</td>
<td>1730</td>
<td>1640</td>
<td>467</td>
<td>350</td>
<td>320</td>
</tr>
<tr>
<td>Mode</td>
<td>420</td>
<td>320</td>
<td>960</td>
<td>1280</td>
<td>3200</td>
<td>3100</td>
<td>210</td>
<td>210</td>
<td>320</td>
</tr>
<tr>
<td>Range</td>
<td>15770</td>
<td>15770</td>
<td>1910</td>
<td>6585</td>
<td>12417</td>
<td>15770</td>
<td>8160</td>
<td>4295</td>
<td>4475</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1196</td>
<td>1418</td>
<td>257.7</td>
<td>967.8</td>
<td>2061</td>
<td>2232</td>
<td>999.4</td>
<td>412.7</td>
<td>378.7</td>
</tr>
<tr>
<td>Coefficient of Variation</td>
<td>1.31</td>
<td>1.29</td>
<td>0.354</td>
<td>0.857</td>
<td>0.874</td>
<td>0.964</td>
<td>1.17</td>
<td>0.831</td>
<td>0.870</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>20.4</td>
<td>12.9</td>
<td>3.06</td>
<td>5.80</td>
<td>2.21</td>
<td>3.59</td>
<td>11.9</td>
<td>12.0</td>
<td>31.6</td>
</tr>
<tr>
<td>Coefficient of Skewness</td>
<td>3.93</td>
<td>3.13</td>
<td>1.30</td>
<td>2.25</td>
<td>1.44</td>
<td>1.61</td>
<td>3.03</td>
<td>2.93</td>
<td>4.62</td>
</tr>
</tbody>
</table>
# Table 4
Mean Monthly Flows Versus Required Flows

<table>
<thead>
<tr>
<th>MONTH</th>
<th>Mean Monthly Flow Period of Record</th>
<th>Required Flow</th>
<th>Percent of Months in Which the Individual Mean Monthly Flows Did Not Exceed the Required Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>728</td>
<td>390</td>
<td>2.8</td>
</tr>
<tr>
<td>April</td>
<td>1136</td>
<td>400</td>
<td>14</td>
</tr>
<tr>
<td>May</td>
<td>2375</td>
<td>410</td>
<td>11</td>
</tr>
<tr>
<td>June (1st Half)</td>
<td>2333</td>
<td>420</td>
<td>17</td>
</tr>
<tr>
<td>June (2nd Half)</td>
<td>2333</td>
<td>260</td>
<td>19</td>
</tr>
<tr>
<td>July</td>
<td>858</td>
<td>280</td>
<td>23</td>
</tr>
<tr>
<td>August</td>
<td>500</td>
<td>260</td>
<td>25</td>
</tr>
<tr>
<td>September</td>
<td>437</td>
<td>260</td>
<td>26</td>
</tr>
<tr>
<td>October</td>
<td>501</td>
<td>250</td>
<td>10</td>
</tr>
<tr>
<td>Month</td>
<td>March</td>
<td>April</td>
<td>May</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>Percent of Time Sufficient to Meet Flow Requiremnt</td>
<td>95</td>
<td>85</td>
<td>87</td>
</tr>
<tr>
<td>Percent of Time Insufficient to Meet Flow Requiremnt</td>
<td>5</td>
<td>15</td>
<td>13</td>
</tr>
</tbody>
</table>
# TABLE 6
PROBABILITY THAT MEAN DAILY FLOW AT EMBUDO WILL BE INSUFFICIENT TO MEET BO FLOW TARGETS

<table>
<thead>
<tr>
<th>Month</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June (1st Half)</th>
<th>June (2nd Half)</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability that Mean Daily Flow will be Equal to or Less than Required Flow</td>
<td>5</td>
<td>13</td>
<td>8</td>
<td>16</td>
<td>6</td>
<td>24</td>
<td>26</td>
<td>29</td>
<td>17</td>
</tr>
<tr>
<td>Low-Flow Sequence</td>
<td>3-Day</td>
<td>7-Day</td>
<td>14-Day</td>
<td>30-Day</td>
<td>60-Day</td>
<td>90-Day</td>
<td>120-Day</td>
<td>183-Day</td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>-------</td>
<td>-------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>---------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>Probability that the Lowest X-Day Average Flow will not Exceed 250 cfs in Any Given Year</td>
<td>53</td>
<td>47</td>
<td>42</td>
<td>34</td>
<td>26</td>
<td>19</td>
<td>15</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Probability that the Lowest X-Day Average Flow will not Exceed 280 cfs in Any Given Year</td>
<td>58</td>
<td>55</td>
<td>51</td>
<td>42</td>
<td>37</td>
<td>30</td>
<td>23</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Probability that the Lowest X-Day Average Flow will not Exceed 420 cfs in Any Given Year</td>
<td>93</td>
<td>92</td>
<td>90</td>
<td>87</td>
<td>75</td>
<td>68</td>
<td>60</td>
<td>49</td>
<td></td>
</tr>
</tbody>
</table>
FIGURE 2
AVERAGE MEAN DAILY FLOW
RIO GRANDE AT EMBUDO
(PERIOD OF RECORD)
FIGURE 3
MEAN MONTHLY FLOW
RIO GRANDE AT EMBUDO
PERIOD OF RECORD

MEAN MONTHLY FLOW (cfs)

MONTH
FIGURE 4
PERCENT OF MONTHS IN WHICH THE INDIVIDUAL MEAN MONTHLY FLOW ARE LESS THAN THE REQUIRED FLOWS
FIGURE 5
FLOW DURATION CURVE FOR PERIOD OF RECORD

MEAN DAILY FLOW (cfs)

PERCENT OF TIME EXCEEDED

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

250 cfs
420 cfs
FIGURE 6
FLOW DURATION CURVE FOR IRRIGATION SEASON

MEAN DAILY FLOW (cfs)

PERCENT OF TIME EXCEEDED

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

250 cfs 420 cfs
FIGURE 7
FLOW DURATION CURVE FOR MONTH OF MARCH

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000
1000
100
10
1

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

390 cfs
FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10

FIGURE 8
FLOW DURATION CURVE FOR MONTH OF APRIL

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

10000

1000

100

10
FIGURE 9
FLOW DURATION CURVE FOR MONTH OF MAY

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

410 cfs
FIGURE 10
FLOW DURATION CURVE FOR MONTH OF JUNE

- 260 cfs, 2nd Half of Month
- 420 cfs, 1st Half of Month
FIGURE 11
FLOW DURATION CURVE FOR MONTH OF JULY

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

280 cfs
FIGURE 12
FLOW DURATION CURVE FOR MONTH OF AUGUST

MEAN DAILY FLOW (cfs)

PERCENT OF TIME EXCEEDED

- 260 cfs
FIGURE 13
FLOW DURATION CURVE FOR MONTH OF SEPTEMBER

MEAN DAILY FLOW (cfs)

PERCENT OF TIME EXCEEDED

- 260 cfs
FIGURE 14
FLOW DURATION CURVE FOR MONTH OF OCTOBER

PERCENT OF TIME EXCEEDED

MEAN DAILY FLOW (cfs)

250 cfs
FIGURE 15
MEAN DAILY FLOW DURING MONTH OF MARCH
LOG-NORMAL DISTRIBUTION

P(X<=390) = 0.05

Q = 390 CFS
FIGURE 16
MEAN DAILY FLOW DURING MONTH OF APRIL
LOG-NORMAL DISTRIBUTION

P(X<=400) = 0.14

Q = 400 CFS
FIGURE 17
MEAN DAILY FLOW DURING MONTH OF MAY
LOG-NORMAL DISTRIBUTION

$P(X \leq 410) = 0.08$

$Q = 410 \text{ CFS}$
FIGURE 18
MEAN DAILY FLOW DURING MONTH OF JUNE
LOG-NORMAL DISTRIBUTION

1st HALF OF MONTH
P(X<=420) = 0.16

2nd HALF OF MONTH
P(X<=260) = 0.06

MEAN DAILY FLOW (CFS X 1000)

FREQUENCY X 10^-4

1st HALF FLOW REQUIREMENT
Q = 420 CFS

2nd HALF FLOW REQUIREMENT
Q = 260 CFS
FIGURE 19
MEAN DAILY FLOW DURING MONTH OF JULY
LOG-NORMAL DISTRIBUTION

\[ P(X \leq 280) = 0.24 \]

\[ Q = 280 \text{ CFS} \]
FIGURE 20
MEAN DAILY FLOW DURING MONTH OF AUGUST
LOG-NORMAL DISTRIBUTION

\[ \text{Q} = 260 \text{ CFS} \]

\[ P(X \leq 260) = 0.26 \]
FIGURE 21
DAILY MEAN FLOW DURING MONTH OF SEPTEMBER
LOG-NORMAL DISTRIBUTION

\[ P(X \leq 260) = 0.29 \]

Q = 260
CFS
FIGURE 22
DAILY MEAN FLOW DURING MONTH OF OCTOBER
LOG-NORMAL DISTRIBUTION

$P(X \leq 250) = 0.17$

$Q = 250 \text{ CFS}$
FIGURE 23
LOW FLOW FREQUENCY CURVES FOR PERIOD OF RECORD THROUGH 1985

AVERAGE FLOW (cfs) FOR INDICATED NUMBER OF DAYS

NON-EXCEEDENCE PROBABILITY

1 - DATA FROM WALTEMEYER (1989)
ATTACHMENT D

Preliminary Reservoir Storage Modeling Analysis

Prepared by

Susan Kelly
The Utton Transboundary Resources Center, University of New Mexico,
in Collaboration with the
Water Acquisition and Management Subcommittee

Table of Contents

1.0 Introduction .................................................................................................................................. D-2
2.0 Background .................................................................................................................................. D-2
  2.1 The Middle Rio Grande Endangered Species Act Collaborative Program ............................. D-3
  2.2 Water Acquisition and Management Subcommittee (WAM) .................................................. D-3
  2.3 The Utton Transboundary Resources Center ....................................................................... D-4
3.0 Framework for Preliminary Analysis ....................................................................................... D-4
  3.1 The Geographic Setting ......................................................................................................... D-5
  3.2 Overview of Reservoirs ...................................................................................................... D-5
  3.3 Overview of Rio Grande Compact ....................................................................................... D-7
  3.4 Water Uses - Demands and Projected Trends .................................................................... D-7
  3.5 URGWOM ............................................................................................................................ D-7
  3.6 URGWOPS ............................................................................................................................ D-8
4.0 Preliminary Analysis .................................................................................................................. D-8
  4.1 Summary of Process ............................................................................................................ D-8
  4.2 The Alternatives .................................................................................................................. D-11
5.0 Recommendations ................................................................................................................... D-15
6.0 References .................................................................................................................................. D-166

APPENDICES

D-1 Summary of Minnow Litigation ............................................................................................... D-17
D-2 Draft Description of Work - WAMS Reservoir Storage Preliminary Analysis ...................... D-21
D-3 Additional Detail on Alternative Considered .......................................................................... D-22

Water Acquisition and Management Subcommittee

D - 1

Version: 28 November 2005
1.0 INTRODUCTION

The goal of this project was to assist the Middle Rio Grande Endangered Species Act Collaborative Program (Program) in undertaking a Preliminary Analysis of various options for storage and management of water in order to minimize the need for the Program to acquire supplemental water. The Water Acquisition and Management Subcommittee (WAM), working with the Utton Transboundary Resources Center (Utton Center) at the University of New Mexico School of Law, evaluated potential hydrologic models, and worked cooperatively to develop scenarios for alternative reservoir management using the Upper Rio Grande Water Operations Model (URGWOM). These scenarios would represent potential long-term institutional changes to help optimize reservoir storage flexibility. The goal was to help improve water management in the Middle Valley and, potentially, provide additional water for Program objectives.

The objective of the Preliminary Analysis was to identify whether any water savings might potentially be gained by implementation of alternative reservoir management scenarios and quantifying the magnitude of those savings. It was never anticipated that the savings would automatically be available as supplemental water for endangered species. Rather, the concept was that improved efficiencies would result in the potential for some of the saved water to be available to be managed for Program purposes. Making the water available for Program purposes would involve significant further analysis, environmental and policy considerations and political action. Concerted negotiations among stakeholders would be necessary. The institutional changes under consideration were envisioned to promote the long-term sustainability of Program accomplishments.

The process within WAMS of developing scenarios to model and the discussion of their potential advantages and constraints was a consensus process. As WAMS discussed this, every scenario proposed raised concerns on the part of at least one critical stakeholder opposed to modeling a revised reservoir operation scheme. This report will provide a summary of alternatives proposed and give a brief summary of the background concerning each. Although we did not reach agreement on proceeding with modeling any scenarios at this time, it is hoped that the process will provide some information and direction to future endeavors to examine potential revised reservoir operations.

2.0 BACKGROUND

The listing in 1994 of the Rio Grande silvery minnow (minnow) as endangered under the Endangered Species Act (ESA) and the drought conditions experienced in the Middle Rio Grande Valley since 1996 led to a lawsuit being filed in late 1999. Several environmental groups filed suit in federal district court in New Mexico against the Bureau of Reclamation and the U.S. Army Corps of Engineers. The lawsuit, Minnow v. Keys, has been through numerous hearings in district court and several issues have been appealed to the Tenth Circuit Court of Appeals. Since the date that the Preliminary Analysis was concluded, Congress has enacted legislation prohibiting the use of the San Juan-Chama Project water for endangered species, the City of Albuquerque has entered into a settlement agreement with the Plaintiffs, and the District Court has ruled on title to the Middle Rio Grande Conservancy District works. Further detail on the course of the litigation is contained in Appendix 1. Although not directly related to the Program, the on-going litigation has been in the background and will continue to effect the development of the Program.

Many believe that it is imperative that Middle Valley water users agree on alternative management strategies for the river to serve the needs of water users, meet the conditions of the Rio Grande Compact (Compact) and provide for minimum stream flows for the minnow. Failure to do so may mean protracted and costly litigation, uncertainty for water development projects, and potentially the extinction of a species.
2.1 The Middle Rio Grande Endangered Species Act Collaborative Program

Water management responsibilities in the Program area are presently divided among many different entities, including the State of New Mexico, federal agencies, Native American Pueblos and one Indian Nation, local governments, the MRGCD, and others. There are also important agencies involved that are not responsible for water management but are integral in the river management decision-making process, such as the U.S. Fish and Wildlife Service. The Collaborative Program provides a venue for all of these agencies and interest groups to talk with one another about river management concerns.

The Program is comprised of federal, tribal, state, and local governments, as well as non-governmental organizations, and universities. With significant funding from Congress, the Program funds projects for the benefit of the minnow and the southwestern willow flycatcher (flycatcher) in the areas of habitat restoration, water acquisition and management, and science. The Program seeks short and long-term solutions to the recovery of the endangered species with the goal that in promoting recovery, water users’ plans will not be imperiled by the legal obligation of the federal government to protect these species. One of the purposes of the Program is to develop and exercise creative and flexible options under the Endangered Species Act (ESA) so that water use and development can proceed in compliance with applicable state and federal laws.

Although there is no direct link between the on-going litigation and the Program, many participants believe that the Program, if successful, provides the best opportunity to promote recovery of the species and potentially address some of the concerns of the parties to the litigation.

2.2 Water Acquisition and Management Subcommittee (WAM)

One of the most difficult challenges of the Program is to obtain sufficient water and adjust water management and operations to meet minimum flows for the minnow. WAMS was formed to address this important aspect of the Program. WAMS was created to evaluate water acquisition and management opportunities to support the goals of the Program and it functions under the direction of the Program. WAM’s objectives include researching, developing, evaluating and assisting in implementation of alternatives to lease or otherwise acquire water, implementation of water management alternatives, implementation of alternatives for efficient water use, and implementation of alternatives intended to offset any depletions caused by Program activities. Reservoir storage and operation is one component of water management and potentially, supply. The Preliminary Analysis was intended to make progress in this area.

There was some concern expressed on the part of Program participants that WAMS should be focusing on the water needs of the ten-year Program, not on long-term institutional changes. It is true that although there may be reservoir operational strategies that will assist in the short-term, the major benefit of the Preliminary Analysis would be long-term: institutional changes that would allow the Middle Valley to optimize its water supply including taking advantage of storage flexibility in wet years. In response, most WAMS members believed that some portion of the committee’s work should be looking at the long-term. The Preliminary Analysis has required a relatively minor amount of WAM’s time. Other activities have been of higher priority.

The drought conditions during 2004 while the Preliminary Analysis was discussed have provided the backdrop. Annual renewable water supply, not the ability to store it, has been the overwhelming problem. The need to find enough water to meet the needs of the ten-year Program has been WAM’s focus. WAMS has supported installation of gages for quantifying water flow, development of a decision support system for rotational delivery of irrigation water in the Middle Valley, creation of a water demand budget and support for many activities directed toward meeting the water needs of the ten-year Program.

1 Water Acquisition and Management Plan, Program Review Draft (February 9, 2004).
2.3 The Utton Transboundary Resources Center

The Utton Center is housed at the University of New Mexico School of Law to carry on the work of the late Professor Albert E. Utton to promote equitable and sustainable management and utilization of transboundary resources. The Utton Center offers impartial expertise and scholarship in examining and analyzing problems from a multidisciplinary standpoint. Although UNM is signatory to the Program, it does not have a direct stake in the outcomes of the decisions to be made regarding Program water supply. Thus, the Utton Center is in a position to act as a neutral party to assist in organizing and furthering the water management discussions.

The Utton Center felt this was an important project and that the representatives to WAMS could provide the expertise to develop and evaluate scenarios. The Utton Center offered to work cooperatively with WAMS on the Preliminary Analysis, by volunteering to assist in providing support to the process, scheduling meetings, developing and distributing scenarios, preparing meeting notes, providing progress reports, and coordinating among various stakeholders. Dick Kreiner, former co-Chair of WAMS and recently retired Project Manager with the Corps of Engineers, was an integral part of the project.

3.0 FRAMEWORK FOR PRELIMINARY ANALYSIS

WAMS previously developed a paper as part of its long-term plan entitled, Storage and Management of Program Water. As identified in that paper, the Program area has a limited amount of physical storage capacity in reservoirs that might be utilized by the Program, and legislative authorities govern the volume of water the Program area reasonably can expect in the future, depending upon climatic conditions. The difficulties that must be negotiated are timing, physical limitations on storage space, congressional authorizations, Treaties and Rio Grande Compact obligations, complex accounting, and meeting the many competing needs on the Rio Grande system.

The purpose of the Preliminary Analysis was to develop by consensus a range of alternatives to be objectively evaluated by WAMS using an agreed upon modeling tool. The concept was to develop reservoir storage scenarios to help improve management of the water storage system and minimize the need for acquisition of supplemental water for the Program. The goal was to show modeled quantification of water savings that could potentially be achieved through revised storage scenarios. WAMS would then be prepared to make recommendations for the Program to pursue. These recommendations might include: Program-sponsored studies to further technically evaluate alternative reservoir authorizations and operations; structured negotiations between critical stakeholders; and more detailed development of the legal, political, and environmental issues. It was always understood that the analysis was preliminary and that further work would be necessary in order to optimize reservoir management.

Because a variety of entities have interests in the waters of the Rio Grande and its reservoir storage facilities, it is important that a wide variety of interests be represented in any discussion of these issues. The Collaborative Program provides this setting more so than any other organization at this time. A diverse group of Middle Rio Grande water interests are involved in the Program, and participation is open to any interest group that chooses to participate. There is a common stated goal of protecting existing and future water use as well as promoting recovery of the endangered species. There are, however, critical stakeholders, for example, Cochiti Pueblo and the City of Santa Fe, who have chosen not to actively participate in the Program. Still, for the purposes of this project, the Collaborative Program provided a good venue for Middle Rio Grande water interests to look jointly at the reservoir storage system and its constraints, and to find whether, by working together creatively, we can collectively manage the river more effectively.
3.1 The Geographic Setting

The area of concern in the Collaborative Program is defined as the headwaters of the Rio Chama Watershed and the Rio Grande, including tributaries, from the New Mexico-Colorado state line downstream to elevation 4,450 feet, which is the spillway crest of Elephant Butte Dam. It includes land within many counties and cities in New Mexico as well as land within 18 Indian Pueblos and one Indian Nation. The average annual precipitation in the area is between 7 and 15 inches. In the high mountain areas, it exceeds 25 inches, much in the form of snow. Thunderstorms are frequent during the summer monsoon months, but the greatest flood producing storms occur in the transitional seasons, March through May and September through October.

The water supply for the region comes from the natural flow of the Rio Grande and its tributaries and from transbasin diversions from the San Juan-Chama project, which imports water from the Colorado River Basin. In addition, there is significant reliance on ground water, primarily for municipal use.

The majority of the surface water comes from snowmelt. The spring runoff usually begins in April and may continue through June and sometimes into July for high snow pack years. At the Otowi Bridge where New Mexico’s upper index Compact gage is located, the Rio Grande’s average annual flow is 1.1 million acre-feet. At San Marcial, above Elephant Butte, at the low end of the Middle Rio Grande Valley, the average annual flow is 923,000 acre-feet. Generally, the Rio Grande is a gaining stream above Otowi and a losing stream below Otowi. During the summer months, precipitation from thunderstorms may be a significant contributor to streamflow for short durations and many of the Rio Grande’s largest tributaries in the Middle Rio Grande flow usually in response to these events. These tributaries include the Tijeras Arroyo, Rio Salado, Rio Puerco and Rio Jemez (although the Rio Jemez may more frequently have snowmelt runoff).

3.2 Overview of Reservoirs

The Bureau of Reclamation’s San Juan-Chama Project (SJC) is a transbasin diversion system that imports water from tributaries of the San Juan River to supplement the native flow of the Rio Grande. The water is delivered through the Azotea Tunnel that runs under the Continental Divide to Willow Creek. Heron Reservoir was constructed in 1971 as part of the SJC on Willow Creek. Water is delivered to the Rio Chama and then to the Rio Grande. Since diversions for the project were initiated in 1970, the project has imported an average of 94,200 acre-feet into the basin annually. This water is not included in accounting under the Rio Grande Compact. The SJC water is primarily to be used for municipal/industrial and agricultural uses.

The next reservoir below Heron on the system is El Vado Reservoir, which was built as part of the MRGCD works in 1935. El Vado Reservoir is primarily used to store native Rio Chama flows for use by the MRGCD for irrigation. It is also where the Bureau of Reclamation stores prior and paramount water for the six Middle Rio Grande Pueblos.

Below El Vado, on the Rio Chama, is Abiquiu Reservoir, about 30 miles upstream of its confluence with the Rio Grande. This reservoir was built in 1962 for flood and sediment control purposes by the U.S. Army Corps of Engineers (COE). In 1981, the authorizing legislation was amended to allow storage of SJC water.

Further down on the system is the only reservoir in the Middle Valley that exists on the mainstream of the Rio Grande, Cochiti Reservoir. Cochiti Dam was built for flood and sediment control

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2 Memorandum of Understanding, Middle Rio Grande Endangered Species Act Collaborative Program (2002).
4 Ibid.
purposes, primarily to protect the City of Albuquerque. Authorizing legislation was added in 1964 to provide a recreational pool, and 5,000 acre-feet of SJC water was allocated annually for this purpose.

At the bottom end of the Middle Valley is Elephant Butte Reservoir, which is where New Mexico’s Compact water to Texas is delivered. About 57% of the water delivered to “Texas” under the Compact, is actually delivered to southern New Mexico farmers. More detail on the authorizations for the reservoirs is included in Appendix 3. On the following page is a U.S. Bureau of Reclamation graphic of the system.
3.3 Overview of Rio Grande Compact

The Rio Grande Compact (Compact)\(^5\) is an agreement between Texas, New Mexico and Colorado apportioning the waters of the Rio Grande above Ft. Quitman, Texas. New Mexico’s annual water allocation available for use within the Middle Rio Grande is a maximum of 405,000 acre-feet of the flow of the Rio Grande as determined based upon the measurement at the Otowi index gage. New Mexico deliveries are measured as the releases from Elephant Butte Dam plus the change in storage in Elephant Butte, thus the evaporation loss is counted against New Mexico’s Compact allocation. New Mexico is allowed to consume all of the tributary inflows into the Rio Grande between the Otowi gage and Elephant Butte. The Compact requires annual water accounting and provides for a system of annual debits and credits. Water must be retained in storage in reservoirs constructed after 1929 to the extent of each state’s debits and cannot be used. It must be released upon demand of the downstream state. Article VII of the Compact provides that if usable storage in Elephant Butte and Caballo Reservoirs is less than 400,000 acre-feet, neither Colorado nor New Mexico may increase the amount of water stored in upstream reservoirs constructed after 1929. Water imported from the Colorado River Basin, in particular the San Juan-Chama water supply, is not subject to the Rio Grande Compact apportionment. The Compact does not affect the obligations of the United States to Indian tribes or impair Indian water rights. The obligation of New Mexico to deliver water is based upon single calendar years.

3.4 Water Uses - Demands and Projected Trends

Agricultural irrigation is the largest surface water use in the Collaborative Program area. It is estimated to account for approximately 40% of the water used between Cochiti and Elephant Butte (the “Middle Valley”). This figure does not include evaporative losses on water stored for agricultural purposes, which would constitute another 20% of the water evaporated.\(^6\) The largest area for evaporative losses is Elephant Butte Reservoir.

Consumption of surface water for municipal and industrial purposes is smaller, but in the Middle Valley is a larger proportion of use than in other parts of New Mexico. That use is currently estimated to be approximately 7% of water used in the Middle Valley. Many of the municipalities along the Middle Rio Grande that have contracts for the use of San Juan-Chama project water are planning to use that water.

Another major component of water use in the Middle Rio Grande occurs in the riparian zone. Riparian consumption by trees, other vegetation, river and soil evaporation is estimated to be approximately 37% of the usage in the Middle Rio Grande Valley.

This Preliminary Analysis project is focused on the evaporative loss component of depletion in the Middle Valley. From Elephant Butte, this is estimated as a range between 80,000 and 265,000 acre-feet per year, depending upon the quantity stored, temperature, wind, etc.\(^7\)

3.5 URGWOM

The Upper Rio Grande Water Operations Model (URGWOM) program is intended to develop a computer model that is capable of simulating water storage and delivery operations in the Rio Grande from the Colorado/New Mexico stateline to below Caballo Dam in New Mexico. The intent is to use the model for flood control operations, water accounting, and evaluating water operations alternatives. The effort is a cooperative effort of six federal agencies which began in 1996. The agencies include the

\(^7\) Ibid.
Bureau of Reclamation, the U.S. Fish and Wildlife Service, the U.S. Geological Survey, the Bureau of Indian Affairs, the International Boundary and Water Commission (U.S. Section), and the U.S. Army Corps of Engineers. The Corps of Engineers has been the lead agency. Since 1996 a vast amount of data has been developed and stored in the URGWOM database. The data include climatic conditions, riparian evapotranspiration, evaporative losses at reservoirs, evaporative losses on river reaches, seepage, water operations, water usage, snowmelt runoff, and thousands of other pieces of information relative to the hydrology of the Upper Rio Grande watershed.

One difficulty expressed in WAMS with regard to using URGWOM is its accuracy in quantifying gains and losses after discrete quantities of water are released from reservoirs. Middle Valley gains and losses are difficult to estimate accurately between Cochiti and Elephant Butte. Further data gathering is needed, particularly regarding the connection between shallow ground water and river flows. It will take time to obtain and integrate these data into the model. (As an aside, WAMS has included support for model development and maintenance in its Program priorities. WAMS sees the need to continue to develop data regarding ground water and surface water interaction in the Middle Valley, because the seasonal variation in annual renewable water supply affect these values on an inter-annual basis.)

3.6 URGWOPS

The Upper Rio Grande Basin Water Operations Review (URGWOPS) is a separate project that is utilizing the URGWOM model to conduct a comprehensive system-wide review of water operations activities that are conducted under existing legal authorities of the joint lead agencies, which are the Corps of Engineers, the Bureau of Reclamation (BOR), and the New Mexico Interstate Stream Commission. These operations consist primarily of storage and release of water at reservoirs. All alternatives evaluated will consist of water operations under existing authorities. The review will be the basis of the water operations Environmental Impact Statement (EIS). The EIS will be prepared by the parties in accordance with NEPA and will present alternatives for the exercise of discretionary authority of the BOR, the Corps of Engineers, and the New Mexico Interstate Stream Commission with regard to operations at federally operated facilities in the Upper Rio Grande Basin. The EIS will evaluate the environmental, economic and social effects of these alternatives. The draft EIS is scheduled to be released for public comment in Calendar year 2005.

The Preliminary Analysis that is the subject of this report was anticipated to look at potential scenarios beyond what is already authorized by existing authorities. The original plan was that upon completion of the URGWOPS EIS (originally scheduled for October 2003), the URGWOM technical team (Tech Team) would still remain intact and the timing would be ideal for WAMS to request that the Tech Team evaluate the WAMS scenarios. These would include scenarios not included in the EIS, either because they went beyond existing authorities or the scenario was not promoted by the entity that owned the water and the right to store it.

4.0 PRELIMINARY ANALYSIS

4.1 Summary of Process

This project began in January 2004. The parties to the Minnow v. Keys litigation were in negotiations sponsored by the Governor’s Office and the negotiations had come to a standstill. In discussing issues and needs with WAM, the Utton Center suggested that WAMS attempt to develop a variety of water management scenarios and test them using an agreed-upon computer modeling tool. It would thus be possible to evaluate which strategies helped the system and which did not. The focus of WAM’s discussion could then be narrowed to look at the most promising alternatives in more detail. The concept was to develop a project that would result in Program funding being used to help evaluate water
management changes that might benefit the supplemental water needs of the Program and also insure that the demands of water users are met.

Initially, the work was to be done by a subcommittee of WAM. The Utton Center was tasked with developing a scope of work that outlined an approach. There was a general discussion about the different models that might be available. The Utton Center prepared a draft outline describing a process which was revised as the discussion progressed.\(^8\)

WAMS held “technical issues” meetings throughout Spring 2004. Initially, these meetings consisted of formulating the project and discussing models. There was broad discussion of the issues and possibilities before the project that is the subject of this report was narrowed to be a Preliminary Analysis of reservoir storage alternatives.

For example, an interesting suggestion was made to examine a South African process, whereby different groups formed teams to create their own planning visions. The visions were then available for the parties to negotiate long-range solutions. As applied to the WAM/Utton Center project, the idea would be to form different groups, each with its own viewpoint on best management practices for the Middle Rio Grande. Each group would develop its own scenario and WAMS would then locate an appropriate tool to evaluate the hydrologic implications of the scenarios. This was not a computer model, but at this stage, a range of river management strategies, such as irrigation efficiencies, forebearance, etc., were under consideration.

It quickly became apparent that it was necessary to know the capabilities of various models in order to decide how to proceed and, at that point, the discussion turned to gaining a better understanding of the models available for the Middle Rio Grande. The list that was compiled of related efforts included these models, among others:

- HEC-RAS, a GIS based river flow model being used by Dr. Julie Coonrod at the UNM Department of Engineering;
- National Heritage Plan Rio Grande Basin Model;
- Flow2D;
- Upper Rio Grande Water Operations Model; and
- Sandia National Laboratories System Dynamics Model.

The Utton Center began research on the models and spoke to representatives from UNM, Sandia National Laboratories, and the U.S. Army Corps of Engineers. Several WAMS members were familiar with these and other tools and were able to provide information. During several meetings we discussed the various models and their ability to fulfill the needs of the project we were formulating.

The WAMS technical issues subcommittee met with the URGWOM Tech Team. Within WAMS there had been some skepticism of URGWOM’s usefulness in testing the scenarios. The basic issue, as mentioned before, was that Middle Valley gains and losses were not considered very accurate especially during low flow conditions. Several key members of WAMS did not think URGWOM would be useful to model river operations beyond reservoir operations. The URGWOM Tech Team also questioned whether URGWOM had the capability to meet specific daily flow targets. (URGWOM’s capabilities to model specific target flows have been significantly enhanced over the past year.) There were no alternative models presented which would be able to test a variety of water operations scenarios. The

\(^8\) See Appendix 2 for the most recent draft of the outline for the Preliminary Analysis.
project became focused on modeling reservoir storage opportunities and operations. URGWOM quite clearly was the best tool for this work and WAMS proceeded to have several joint meetings with the URGWOM Tech Team.

The URGWOM Tech Team asked that WAMS prepare specific scenarios and give those scenarios to URGWOM for modeling. It was understood that there might be funding needed in order to make rules adjustments for URGWOM to be able to test scenarios developed by WAM. From the URGWOM Tech Team’s perspective it was critical that the project look at all stakeholder interests, not just endangered species needs. They wanted WAMS to obtain broad agreement on how ownership of storage rights, water rights, and releases would be modeled. In the Tech Team’s opinion at that time, WAMS needed to be able to show who the water users would be (in addition to two endangered species) and how the water rights were owned. Others on the URGWOM Tech Team questioned whether WAMS should be considering scenarios that went beyond the legal authorizations for each reservoir.

Within WAM, the question was asked, “If we are modeling reauthorization of storage and trying to optimize storage, are we ignoring the endangered species purposes?” The conclusion was that WAMS should focus on finding management strategies to create more water for the Middle Valley. A next step would be attempting to negotiate some portion of the saved water as minimum flows for the minnow. There was discussion about the testing that would be done using URGWOM for the URGWOPS draft Environmental Impact Statement and that some of this testing might be able to incorporate WAMS ideas.

The URGWOM Tech Team prepared a preliminary draft scope of work for discussion purposes and WAMS used this draft to discuss how it could work with URGWOM to develop different reservoir storage accounts at Abiquiu, Heron and El Vado.

At the same time that WAMS discussed these issues, there were important related matters being discussed such as estimating the projected Program water demand. Another background discussion related to Article VII status of the Rio Grande Compact, and its projected effect to continue for much of the life of the Program. Some Program participants believed WAMS should only be looking at immediate water management strategies. Long-term flexibility for storage of water was not considered a priority. Most WAMS members agreed that long-term storage flexibility was of lower priority, but that it should be one component of WAM’s effort. But the result was that the reservoir storage discussions became a fairly minor part of the WAMS work.

WAMS met again with representatives of URGWOM and made the case that, as a first step, it made sense to look at optimization, rather than engaging all entities in water negotiations. After showing potential water supply gains, the project could proceed to actively engage all stakeholders. During this time frame, it was made clear that any alternatives to be modeled in this Preliminary Analysis would be by agreement of all WAMS members. Also, before proceeding with any modeling work, the approval of the Program’s Interim Steering Committee would be sought.

Intermixed in the discussion was whether the flow targets of the B.O. were realistic. A decision was made not to re-examine the flow targets as part of this project. Another bottom line in every discussion was that each scenario had to address Compact delivery requirements.

Early in the process it became clear that virtually all alternatives being considered posed problems to one water user group or another. The Utton Center continually tried to focus the project on the physical system at this stage; and to resist making judgments about ownership of water rights. The modeling analysis was intended as a preliminary analysis to help guide WAMS and the Program to focus attention on approaches that might offer the greatest potential benefit toward meeting Program goals. The Preliminary Analysis could provide information for a more focused analysis to consider alternatives. All parties were invited to suggest scenarios.
4.2 The Alternatives

The process within WAMS of developing scenarios to model and discussing their potential advantages and constraints was a consensus process. WAMS agreed that if there was not agreement on modeling an alternative, that alternative would not be pursued. As WAMS discussed this, virtually every scenario proposed raised concerns on the part of at least one critical stakeholder opposed to modeling a revised reservoir operation scheme. This report will provide a summary of alternatives proposed and give a brief summary of the background concerning each. Although there was not consensus to proceed to model any scenarios at this time through this project, the discussion may provide information and direction to future endeavors to examine potential revised reservoir operations.

Several scenarios were brought up and dropped quickly because of immediate and strong opposition by a stakeholder. The discussion of these alternatives was short and cursory. Other scenarios were discussed at length and in some detail before serious concerns were voiced. These alternatives were more fully developed with regard to potential operational benefits, the feasibility of modeling, and the constraints that would need to be addressed in order to implement institutional changes. The variation in the level of detail is reflected in this report.

1. Cochiti. Of the scenarios that were raised, discussed briefly, and dropped, Cochiti Reservoir was the most prominent. Many participants in the discussion were interested in the potential of modeling changed reservoir storage operations at Cochiti Reservoir. One particular interest was to model limited storage of native water in Cochiti to smooth releases from El Vado when summer thunderstorms occur below the Otowi Gage. This would preserve native water when releases have been made from El Vado to meet irrigation demand and a thunderstorm in the Middle Valley obviates the need for the water. The released water could be trapped in Cochiti and possibly used subsequently for irrigation, thereby potentially decreasing the need for supplemental water for the Program.

Another proposed idea was to model the creation of a native water pool to be managed for the Program to meet the obligations of the Rio Grande Compact. The concept was that this would replace the San Juan-Chama pool at Cochiti. Significant detail was presented on this potential alternative.

The Utton Center, being aware of the sensitivity of these issues to Cochiti Pueblo, requested that there be no further discussion of Cochiti Reservoir without concurrence of the Pueblo. A discussion of Cochiti had taken place in the Collaborative Program in 2002 and representatives of the Pueblo came to the Interim Steering Committee and voiced objection to any consideration of re-operation or reauthorization of Cochiti pending completion of a baseline study to be conducted by the Pueblo in cooperation with the Corps of Engineers. The baseline study is in progress and will evaluate the potential impacts of a range of water management changes at Cochiti Reservoir. In the summer of 2004, there was some indication that the Pueblo might be interested in discussing the potential benefits of various operations of the lake (in particular, the possibility of storing prior and paramount water) with broader Middle Valley interests and it was decided to make outreach to the Pueblo on this subject.

The Utton Center contacted the Pueblo to learn whether there was interest in working with the Program to model any scenarios at Cochiti. A letter was directed to the Governor requesting a meeting. The purpose of the letter was to suggest that several technical working meetings be held to discuss whether there was an opportunity to model scenarios that would provide beneficial information to both the Pueblo (as input into the baseline study) and to WAM. It soon became clear that the Pueblo was not ready to discuss the lake until completion of the baseline study. WAMS respected this decision and there was no further pursuit of these ideas.

2. Closed Basin

Another idea proposed was timing of delivery of water from the San Luis Closed Basin Project in Colorado. The suggestion was to work with the BOR and the State of Colorado to model increased water
deliveries during July, August, September and October. Once again, this was a dead end when reminded that the Interim Steering Committee specifically directed the WAMS not consider water sources from within Colorado. A commitment had been made on the part of the State of New Mexico and the Collaborative Program not to seek contribution to the Program from Colorado and there was correspondence from the Division Engineer in Alamosa, Colorado to this effect.

3. **Forbearance.** A suggestion was made to model forbearance in the MRGCD. This was immediately opposed by the MRGCD and several reasons were provided for its opposition. The scenario as drafted would have modeled a 5% MRGCD demand reduction. As drafted, it would have been up to the MRGCD to determine how the savings could be achieved, although WAM’s intention was to look at voluntary agricultural forbearance.

   Without it being clear that the alternative was contemplating compensation to irrigators who would voluntarily forebear, MRGCD viewed this as modeling an arbitrary reduction in MRGCD water. Further, a feasibility study for forbearance has recently (July 28, 2005) been completed and MRGCD staff felt that any further investigation of forbearance prior to completion of the study was premature. MRGCD also maintained that it has a fixed volume of losses depending upon flow, time of year, etc., so that it is not accurate to model a percentage of demand reduction. In addition, MRGCD maintained that the water does not belong to the MRGCD, but rather to the individual landowners. Finally, they felt that Middle Valley gains and losses are not refined sufficiently in the URGWOM model to model a forbearance alternative. For these reasons, and also the sense on the part of some WAMS members that this alternative did not fit with the reservoir storage focus of the Preliminary Analysis, this alternative was dropped pending the results of the feasibility study.

4. **Abiquiu.** Of the scenarios that were discussed in detail, two concerned Abiquiu Reservoir. Under one scenario, Abiquiu Reservoir operations would be modeled to retain water in Abiquiu in lieu of release to Elephant Butte Reservoir in May or June. Storage of native water would take place in unused city storage space and the remaining flood pool. Currently, when the inflow to Abiquiu Reservoir exceeds downstream channel capacity, water is stored and by July 1st, the water typically would have been released. However, after July 1st, when the natural flow at Otowi gage falls below 1,500 cfs, the Corps must postpone flood water evacuation until November 1st. Flood storage that is retained through the summer is released after November 1 and must be fully evacuated by March 31 of the following year. The release of the carryover flood water in storage is normally set at uniform rate. The problem with releases in May and June is that there could be higher loss rates through the Middle Valley and higher evaporation rates if the water is stored in Elephant Butte Reservoir. This scenario looks at storing compact delivery water and holding the water until November 1. Channel losses, compact deliveries, peak flows in the Middle Rio Grande Valley and reservoir losses would be compared to determine impacts and benefits.9

   Concerns were raised about brown trout spawning and fishery habitat in the Rio Chama below Abiquiu Dam. Based upon this concern, several different options were proposed. One would be to evacuate storage between November 1st and December 25th at a uniform rate, rather than as in the past, delivering all the water in late December. The second would be to evacuate the storage beginning November 1st through March 1st. At all times the release rate from Abiquiu Reservoir during the irrigation season (at times when Abiquiu would be storing) would be set in accordance with MRGCD demand and other demands downstream (BO requirements) at Cochiti Dam, less mainstream flow. Abiquiu Reservoir operations would be modeled to maintain the minimum flows of the Biological Opinion when storing native water. No storage would take place if downstream demands are not being met. As envisioned, the irrigation demand would be set at the 2004 demand, as provided by the MRGCD, although other years are available.

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9 See Appendix 3 for more details.
Modeling such a scenario raises issues with regard to ownership of the water. This is where the Program’s discussions with the MRGCD, the State, the City, and the federal agencies could be productive in trying to reach a negotiated solution. The initial concept, however, was to model the potential water gains before beginning any discussion of management of the water.

The City of Albuquerque expressed reservations about pursuing any modeling studies of changed operations of Abiquiu. The City has a contract with the Corps of Engineers for reservoir storage and easements on the land upon which the reservoir is located. The City’s concern is based on a belief that the Collaborative Program places too much emphasis on looking at the City for solutions and does not seek solutions from the other parties to these discussions. The City has expressed that it may consider working with the Collaborative Program on this alternative, and the one following, if other entities would agree to model changed reservoir operations in other reservoirs. The City in particular believes Cochiti Reservoir offers great potential.

Another proposed scenario to model at Abiquiu was based on retaining water in Abiquiu when not needed for delivery to Elephant Butte to meet Compact deliveries. The modeling time frame was to be a 40-year period, with the beginning condition an Article VII year, replicating the current drought cycle. After that, the model would utilize the sequence that URGWOPS uses, which is a random sequence of wet, average, and dry years. The alternative as it had been drafted was based on “if and when” storage space was not needed by the City of Albuquerque and its subcontractor. Details on how this would be characterized for the model runs would need to have been developed. This scenario is similar to previous proposal except the time frame is extended for a forty year period and any storage would be within the City’s storage space.

The first phase would quantify the potential gains in water supply over a 40-year period for the Middle Valley based upon this revised operation. Subsequent work would be required in order to reach agreement on how to manage this water. The expectation was that there would be significantly less evaporative losses by storing the water in Abiquiu as opposed to delivering it to Elephant Butte.

Again, ownership of the conserved water would be a significant issue. The City of Albuquerque holds storage space easements at Abiquiu and there would need to be significant discussion over arrangements for storage and management of the water. Environmental evaluation would be needed, as well as appropriate legal instruments for water storage. In order to benefit the Program, there would need to be agreement among the State of New Mexico and other Middle Valley water users that some portion of the conserved water should be managed to help achieve minimum flows and other goals for recovery of the minnow and flycatcher. The State would need assurance that if any additional consumptive use occurred as a result of an alternate release scenario, those depletions be offset by Program-acquired water. Environmental analysis and clearance would be necessary. Finally, approval of the Compact Commission would be necessary because this is a change to operation of Abiquiu Reservoir under P.L. 86-645 and P.L. 100-522.

As previously mentioned, the City of Albuquerque has concerns about working with the Collaborative Program on any modeling at Abiquiu. Assuming that solutions to these valid concerns can be found, steps would need to be taken in order to implement this alternative, including developing consensus among Middle Valley water users on proposed operational revisions, approval of the Rio Grande Compact Commission, environmental analysis and documentation, a permit to store water from the State of New Mexico, and legal agreements for water storage.

5. **Heron.** WAMS also wanted to look at revised operations at Heron Reservoir. The idea was to look at system efficiencies and determine the best place to store Program-acquired supplemental water. The water would be San Juan-Chama water acquired from willing lessors. WAMS wanted to evaluate the ability to carry over storage of San Juan-Chama water in Heron instead of forcing the Program to move

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the water to Abiquiu or El Vado if not needed in a particular year. One alternative involved comparing the operation of the City of Santa Fe’s 2003 San Juan-Chama water if delivery had been taken at Heron Reservoir instead of forcing the City of Santa Fe to move the water to Abiquiu. Management of City of Santa Fe water was used as an example to quantify the difference in evaporative loss in storing the water in Heron rather than moving it to Abiquiu. Currently, SJC water contractors must take delivery of contracted water in storage at Heron Reservoir by the end of the year, either by use, sale, or by contracts for storage elsewhere. Contracted water not called for by December 31 remains in Heron Reservoir as part of project water supply and no longer belongs to the individual contractor. The BOR, in the past, has negotiated temporary waivers with contractors that allow carryover until April 30 in order to provide release rates on the Rio Chama that enhance the fishery between El Vado and Abiquiu Reservoirs during the winter and provide flexibility in managing river flows. Temporary waivers in the past have extended beyond April 30th.

This alternative would require significant rules changes to the URGWOM model. Currently contracted water not called to be released by December 31st remains in Heron Reservoir as part of the project supply and no longer belongs to an individual contractor.

The Heron alternative is more complicated than Abiquiu due to the inter-connectedness between the authorizing legislation for the San Juan-Chama Project and the various compacts on the Colorado River and the Rio Grande. The City of Albuquerque believes that any modification to the “no carryover” provision in the City’s San Juan-Chama Project water service contract with the Bureau of Reclamation for delivery of water at Heron Reservoir outlet works would require an amendment to that contract. The City is not interested in this scenario.

A second Heron scenario was to look at evaluating the capture of native Chama flows in Heron. These flows are currently bypassed as Heron is only authorized for storage of imported San Juan-Chama water. The potential magnitude of native inflow to Heron is relatively small, on the order of 20,000 acre-feet per year average over the past twenty years. Potential operational benefits are minor. The legislative authority to store native water in Heron clearly does not currently exist. Modeling this alternative would require significant rules changes. Because Heron currently is only modeled with accounts for contractors’ San Juan-Chama water, a new set of hypothetical rules would need to be developed.

Ownership of native Rio Grande water rights and the right to store would be required in order to store water in Heron Reservoir. The acquisition of Rio Grande or Rio Chama water rights would be expensive as previous WAMS analyses have illustrated. Unless these water rights are senior water rights, storage in Heron would not be allowed unless all downstream water rights had been satisfied.

Reauthorization of Heron would be required and as previously discussed, major stakeholders are opposed to seeking congressional changes to the authorization of Heron. It is possible that, given the constraints and the small amount of water that could potentially be stored, it is worthwhile to spend significant time and energy to model this alternative.

6. El Vado. Proposals regarding El Vado were not very well formulated. It was proposed to model relocating the prior and paramount water from El Vado to either Cochiti or Abiquiu. Since discussion of those two reservoirs had been taken off the table, discussion of El Vado was not carried further. During Article VII or drought years these discussion might be helpful. When Article VII is not in effect, El Vado fills frequently and thus is not available for Program water storage in many years.

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11 Ibid.
5.0 RECOMMENDATIONS

It is recommended that we conclude this initiative for the time being. The draft EIS for the Upper Rio Grande Water Operations Model is expected to be released in Calendar year 2005, when Phase 2 model testing will begin. Although this testing will be limited to operators and cooperators of URGWOM, it is possible that some concepts of interest to WAMS may be included in the testing.

We have been unable to address some concerns of stakeholders at this time. We hope this report will provide a starting point for future discussions of these important issues. WAMS should continue dialogue with the URGWOM Tech Team. The Preliminary Analysis can be resumed in the future if conditions are right.

We should keep several thoughts in mind for the Program. One, solutions to the water supply problems for the Program will need to come from a variety of strategies and sources. WAMS believes there will not be one individual solution, but rather, that a combination of water management strategies and sources may result in a sustainable supply. Thus, all possibilities should be evaluated, not just those that appear to have the most potential.

Second, the Middle Valley needs to be prepared for wet years when they come. It is interesting to look at the Corps of Engineers’ 1989 Reevaluation of the Rio Grande Operating Plan. In 1988, when meetings were held on this plan, Elephant Butte was spilling and every reservoir on the system was filled. The management backdrop was too much water. Eight of the ten years preceding 1988 had experienced higher than normal runoff, resulting in all conservation space in the basin’s reservoirs being filled, with pressure to use flood space for conservation purposes. Flooding occurred below El Paso and one of the goals of the plan was to optimize storage and release in Abiquiu, Cochiti, Jemez Canyon, Elephant Butte and Caballo Reservoirs.  

We are currently in a drought cycle and it is hard to envision the different management concerns that existed in 1988 and 1989. But the Middle Valley will have wet cycles again and we need to prepare for optimal operations of our reservoirs.

Early in the debates about how to address the water needs of the silvery minnow, six collaborating agencies prepared a White Paper (1996) outlining recommended management options. The Collaborative Program and WAMS should be credited with pursuing and continuing to explore many of these options. It is interesting to note that although the institutional changes contemplated in this report are characterized as “long-term,” by contrast, in the White Paper, operational and institutional changes to reservoirs (proposed two years after the listing of the minnow as endangered) were considered a high priority:

Attention should first be directed towards more immediately attainable actions such as upstream water management options which can be accomplished within existing authorities and the acquisition of water. Concurrently, existing institutional constraints to implementing potential actions should be examined and efforts should be initiated to make institutional changes as may be deemed appropriate to help accommodate both water users and the silvery minnow in the long term. Where additional studies are deemed required to fully evaluate a potential action, the agencies and entities represented in the preparation of this paper should cooperate in securing the necessary resources to complete such studies promptly.

We look forward to the water managers in the Middle Valley working together to optimize the use of our reservoirs: to meet the needs of water users, make New Mexico’s required Compact deliveries, and provide some help in meeting the minimum flow requirements for the minnow.

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14See Appendix 4.
15Appendix 4, at page 5.
6.0 REFERENCES


Water Acquisition and Management Subcommittee Background Paper: Storage and Management of Program Water

Flood Control Act of 1948


Public Law 87-483, June 13, 1962 (San Juan-Chama Project)

Flood Control Act of 1960 Public Law 86-645, July 14, 1960


Public Law 97-140 (1981) (Abiquiu – San Juan –Chama storage)


Public Law 88-293 (1964) (Cochiti rec pool)


A Legislative History of the Rio Grande Reservoirs in New Mexico, Albert E. Utton with the assistance of Robert Muehlenweg and Barbara G. Stephenson (June 29, 1979)


Upper Rio Grande Water Operations Model, Geographic Setting (website)

Memorandum of Understanding, Middle Rio Grande Endangered Species Act Collaborative Program (2002)

Rio Grande Compact, Section 72-15-23 (NMSA)
APPENDIX D-1

SUMMARY OF MINNOW LITIGATION THROUGH JULY 2005

Prepared by Susan Kelly,
Associate Director, Utton Transboundary Resources Center

The Rio Grande silvery minnow (minnow) was one of the most abundant species of fish in the Rio Grande watershed system, and because of the imminent threat of extinction, was listed as an endangered species under the Endangered Species Act (ESA) in 1994. At the time of its listing, the minnow had been eliminated from 95% of its historical habitat, and the majority of the minnows remaining were confined to the lowest 60 miles of the Rio Grande, between the San Acacia and Elephant Butte dams. Since the listing, minnow populations continue to decrease, and the Rio Grande continues to experience periods of time in which portions completely dry up.

1996 was the first year of significant drought in the Middle Valley in several decades. The entire river flow was diverted at San Acacia late in the summer with large associated minnow kill. The Bureau of Reclamation initiated the San Juan-Chama supplemental water operations program, whereby San-Juan Chama water was used for irrigation and native flows were by-passed.

Drought conditions worsened from 1996 to 1999. To prevent the extinction of the minnow, the Department of Interior issued its RGSM Recovery Plan in 1999. Under court order, the U.S. Fish and Wildlife Service (USFWS) Regional Director accepted the plan, and critical habitat was designated for the minnow consisting of 163 miles of the mainstem Rio Grande in New Mexico from Cochiti Dam on the north to Elephant Butte Reservoir in the south. A subsequent challenge to the designation was brought to court under the case MRGCD v. Babbitt, 206 F. Supp. 2d 1156 (D. NM 2000). The district court required the USFWS conduct an EIS for the critical habitat designation and this ruling was upheld in the court of appeals at Middle Rio Grande Conservancy District v. Norton, 294 F.3d 1220 (2002).

In November of 1999, environmental groups opposed the Bureau of Reclamation and Army Corps of Engineers failure to complete consultation with the USFWS over Middle Rio Grande water operations. Environmental groups filed their lawsuit under the name Minnow v. Keys. The lawsuit named the Bureau of Reclamation (BOR) and the U.S. Army Corps of Engineers (Corps) as defendants due to their role in the diversion and storage of Rio Grande water. Their claim was that the failure of the federal defendants to consult with the USFWS as required by the ESA jeopardized the existence of the minnow.

Other water claimants in the Middle Rio Grande, the City of Albuquerque, the Middle Rio Grande Conservancy District (MRGCD), and the Rio Chama Acequia Association intervened in opposition to the plaintiffs’ position. The State of New Mexico intervened for the reason that the disposition of the case would have a direct impact on the State Engineer’s ability to supervise the appropriation and distribution of the waters of the Rio Grande. The water sources subject to the litigation are claimed for other uses. The water in Heron is under contract to many different municipalities and other water users, primarily the City of Albuquerque and the MRGCD, for municipal and irrigation

* Law students Ignacio Gallegos and Zach Jones provided research assistance; Kevin Flanigan, New Mexico Interstate Stream Commission, provided valuable comments.
1 59 FR 36995, July 20, 1994, codified in 50 CFR §17.11.
2 Ibid.
3 64 FR 36274, July 6, 1999.
purposes. Native Rio Grande flows are used by Middle Rio Grande irrigators, other water users, and by the State of New Mexico to meet its obligations under the Rio Grande Compact.\(^5\)

Court-ordered mediation in the summer of 2000 resulted in two Agreed Orders\(^6\) that prevented drying of the lower sections of the river in the middle valley believed to hold the highest numbers of silvery minnows. Under those agreements, the City of Albuquerque, and to a much lesser extent, the MRGCD, were paid to provide water for the minnow. At the time, Abiquiu Reservoir was nearly full and Albuquerque had no place and no immediate need for its San Juan-Chama Project water. Almost 200,000 acre-feet of San Juan Chama water was used to maintain continuous flow down to Elephant Butte in 2000.\(^7\) At that time, there were virtually no silvery minnows in captivity. The Agreed Orders set in motion various actions by the parties to greatly increase captive population of silvery minnow.\(^8\) The minnow survived the 2000 drought summer.

Completion of consultation resulted in the issuance of a Biological Opinion (BO) by the FWS in June of 2001,\(^9\) which was subsequently challenged by the plaintiffs. They sought to require that the BOR exercise discretion to utilize San Juan-Chama water from Heron Reservoir and curtail deliveries of water to the San Juan-Chama contractors to meet the minimum flows required for the minnow. They also sought curtailment of native Rio Grande water deliveries to irrigators, primarily in the MRGCD.\(^10\)

The federal district court ruled in April 2002,\(^11\) upholding the 2001 BO but also holding that the BOR had discretion over use of both San Juan-Chama (SJC) and native water in the Middle Rio Grande Project for ESA purposes while the Corps did not have such discretion over its operations.\(^12\)

A Conservation Water Agreement executed between the State of New Mexico and the United States of America provided for up to 100,000 acre feet of Rio Grande Compact delivery water for species use and established a temporary Conservation Pool in Abiquiu and Jemez Canyon Reservoirs.\(^13\) The Rio Grande Compact Commission, by unanimous resolution in accordance with PL 86-645, provided its advice and consent to a deviation of normal operations of Abiquiu and Jemez Canyon Reservoirs to allow for Conservation Pool operations.

Significant drought in 2002 resulted in reinitiating consultation and issuance by FWS of second BO in September 2002.\(^14\) Negotiations among the parties broke down and the environmental plaintiffs filed for emergency injunctive relief to seek release of a limited amount of SJC water from Heron Reservoir in order to comply with the June 29, 2001 BO and avoid massive drying in the Middle Rio Grande.\(^15\) A hearing was held immediately and the court subsequently ruled in favor of the Plaintiffs that the September 2002 BO was arbitrary and capricious. However, the Court imposed its own interim

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\(^7\) Information provided by the Interstate Stream Commission


\(^11\) Ibid.

\(^12\) Ibid at pages 49, 33, and 41 respectively.

\(^13\) Conservation Water Agreement, June 29, 2001, between the State of New Mexico, U.S. Dept. of Interior and the U.S. Army Corps of Engineers.


\(^15\) Belin, supra at 209.
flow standards, allowing the U.S. to meet lower flow levels than those required by the 2001 BO and directed Reclamation to take SJC water from the contractors if necessary.\textsuperscript{16}

The ruling was immediately appealed to the Tenth Circuit Court of Appeals by the federal defendants and intervenors, which stayed the ruling pending the appeal. Oral arguments were heard in January 2003 before a three-judge panel, which affirmed the district court’s ruling in June 2003.\textsuperscript{17} The federal defendants and intervenors petitioned for rehearing \textit{en banc}. Meanwhile, the USFWS had issued a new Biological Opinion, dated March 17, 2003.

Many parties participated in confidential settlement negotiations sponsored by Governor Bill Richardson in the summer and fall of 2003.\textsuperscript{18} The federal government did not participate in the negotiations, which were ultimately suspended.

The State of New Mexico and the United States entered into an "Emergency Drought Water Agreement" in 2003. This agreement was actually an amendment to the Conservation Water Agreement. It provided that up to 217,500 acre-feet of relinquished Compact credit water, if available, to be divided among the Bureau of Reclamation (up to 70,000 acre-feet), the City of Santa Fe (up to 7,500 acre-feet), and the MRGCD (up to 140,000 acre-feet).\textsuperscript{19}

In October 2003, the Tenth Circuit requested additional briefing from all parties on the question of whether the case was moot and its June 2003 ruling should be vacated. On January 5, 2004 the Tenth Circuit vacated the panel opinion as moot because the time frame covered by the District Court’s 2002 ruling had expired. Furthermore, the New Mexico delegation had introduced, and Congress later enacted, legislation restricting the federal government from using San Juan-Chama project water to meet ESA obligations. The district court was ordered to determine whether there were unresolved issues to be tried.\textsuperscript{20}

The language in the Congressional appropriations bill also addressed the March 17, 2003 Biologic Opinion and is quoted here in full:

SEC. 205. (a) Notwithstanding any other provision of law and hereafter, the Secretary of the Interior, acting through the Commissioner of the Bureau of Reclamation, may not obligate funds, and may not use discretion, if any, to restrict, reduce or reallocate any water stored in Heron Reservoir or delivered pursuant to San Juan-Chama Project contracts, including execution of said contracts facilitated by the Middle Rio Grande Project, to meet the requirements of the Endangered Species Act, unless such water is acquired or otherwise made available from a willing seller or lessor and the use is in compliance with the laws of the State of New Mexico, including but not limited to, permitting requirements.

(b) Complying with the reasonable and prudent alternatives and the incidental take limits defined in the Biological Opinion released by the United States Fish and Wildlife Service dated March 17, 2003 combined with efforts carried out pursuant to Public Law 106-377, Public Law 107-66, and Public Law 108-7 fully meet all requirements of the Endangered Species Act (16 U.S.C. 1531 et seq.) for the conservation of the Rio Grande Silvery Minnow

\textsuperscript{17} Rio Grande Silvery Minnow v. Keys, 333 F.3d 1109 (10th Cir. 2003).
\textsuperscript{18} Belin, supra at 210.
\textsuperscript{19} Emergency Drought Water Agreement, April 23, 2003, between the State of New Mexico, U.S. Dept. of Interior and the U.S. Army Corps of Engineers.
\textsuperscript{20} Rio Grande Silvery Minnow v. Keys, 355 F.3d 1215 (10th Cir. 2004).
Minnow (Hybognathus amarus) and the Southwestern Willow Flycatcher (Empidonax trailii extimus) on the Middle Rio Grande in New Mexico.

(c) This section applies only to those Federal agencies and non-Federal actions addressed in the March 17, 2003 Biological Opinion.

(d) Subsection (b) will remain in effect until March 16, 2013. 21

Plaintiffs filed a Motion to Dismiss Remaining Claims without prejudice. 22 The defendants responded that the prior rulings (Memorandum Opinions and Orders of April 19, 2002 and September 23, 2002) should be vacated as for mootness and lack of subject matter jurisdiction. Subsequently, on April 26, 2004 plaintiffs withdrew their motion to dismiss. 23 Plaintiffs are asking Judge Parker not to vacate his rulings but to incorporate them into a final judgment that can be appealed yet again to the Tenth Circuit if defendants wish to do so. 24

The environmental Plaintiffs entered into negotiations with the City of Albuquerque and the Albuquerque-Bernalillo County Water Utility Authority to establish an "Environmental Pool" of 30,000 Acre Feet capacity within the Abiquiu Reservoir. 25 The parties reached an agreement on April 20, 2005. In return for the establishment of the "Environmental Pool," into which the Plaintiffs can store water legally acquired from voluntary purchases, leases and donations, the Plaintiffs will drop their remaining claims against the City and County and will refrain from challenging the legality of Section 205 of Public Law 108-447. 26 Court approval of Plaintiffs and City of Albuquerque’s Stipulation and Joint Motion for Dismissal of Any and All Claims Regarding the San Juan-Chama Project or San Juan-Chama Water is still pending due to the concerns of the State of New Mexico regarding the wording of the Stipulation.

In 2002 the MRGCD filed a cross-claim to quiet title to ownership of El Vado Reservoir and the Angostura and San Acacia Diversion Dams and other land and irrigation works within the MRGCD. MRGCD also sought a declaratory judgment interpreting the effect of their 1963 transfer of State Water Rights Permit No. 1690 to the United States. 27 The federal defendants opposed this claim and environmental plaintiffs sided with the federal government on this issue. On July 25, 2005, the Federal District Court ruled that ownership of these properties and certain specific tracts identified in the cross-claim is declared to be in the United States of America. 28 The Court also ruled that Permit No. 1690 must remain in the name of the United States unless Congress authorizes its conveyance to the MRGCD.

26 Maria O’Brien., supra.
APPENDIX D-2

DRAFT DESCRIPTION OF WORK (8/18/04)

WAMS RESERVOIR STORAGE PRELIMINARY ANALYSIS

Prepared for review by Interim Steering Committee of the MRG ESA Collaborative Program

Background: The Water Acquisition and Management Subcommittee (WAMS) envisions meeting Program Water needs through improved management and annual lease/purchases of water from current users, storing such water in upstream reservoirs, with flows released as needed to provide for identified river needs. For the most part, the water to be secured, stored and managed for the Program is already being stored and managed in some fashion because water delivered to Elephant Butte Reservoir has been relied upon to provide the bulk of the flows to meet the Program requirements.

Goal: WAMS plans to undertake a preliminary analysis of various options for storage and management of water in order to minimize the need for the Program to acquire supplemental water. This effort will result in a report and recommendations to the InSC and Executive Steering Committees of the Program. It is acknowledged that the preliminary analysis is only one piece of the work that will be needed for the Program to meet the Program water demand and also that any changed reservoir management will most likely be a long-term strategy vs. a short-term strategy.

Overview: WAMS will evaluate potential hydrologic models to determine whether a tool exists that can be used or modified to test various options. WAMS will work cooperatively to develop alternatives. Initially, it appears that the URGWOM model is the most suited to fulfill the needs of this preliminary analysis. WAMS will work with the URGWOM technical team to develop a Scope of Work for working together on modeling alternatives. The URGWOM team will not be able to work on this until after October, 2004. This project will also involve the development of information on other factors, such as authorization constraints, legal issues, environmental, economic and other considerations. This work will be undertaken in close consultation with the Interstate Stream Commission, Bureau of Reclamation, Corps of Engineers, Middle Rio Grande Conservancy District, City of Albuquerque and other critical management agencies. After the alternative scenarios have been modeled and the results analyzed, all of the information will be compiled into a report to the Interim Steering Committee and the Executive Committee. The report may include recommendations for the Program on how to proceed and suggest particular areas where negotiations have the potential to result in agreed-upon changes in reservoir management that would further Program goals. Necessary implementation steps will be identified.

The Utton Center\(^1\) will assist in coordinating this preliminary analysis, by providing support to the process in coordinating meetings, task management, progress reports, coordination between various stakeholders, and preparing the final report and recommendations.

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\(^1\) The Utton Transboundary Resources Center is a non-profit law and policy center at the UNM School of Law that is committed to using impartial expertise to help resolve transboundary resources conflicts, with the goal of helping to forge sustainable management plans for the future.
APPENDIX D-3

ADDITIONAL DETAIL ON ALTERNATIVES CONSIDERED

Abiquiu Reservoir Operation Alternative 1.

Using 2004 hydrology and reservoir conditions, retain Rio Grande water in storage in Abiquiu Reservoir during the 2004 irrigation season that would have otherwise been delivered to Elephant Butte Reservoir.

a. Set release rate from Abiquiu Reservoir during the March 1 through July 1 period in accordance with the following:
   i. MRGCD demand at Cochiti Dam less stream flow (if this difference >0); or
   ii. Biological Opinion (B.O.) flow target less stream flow (if this difference >0); whichever is less;
   iii. At all times maintain a minimum flow of 200 cfs below Abiquiu Dam or inflow to the Reservoir, whichever is less.

b. Evacuate storage beginning November 1st at a uniform rate so that all storage is evacuated by December 25th; alternatively,
c. Evacuate storage beginning November 1 through March 1.

Potential Operational Benefits

Currently under Public Law 86-645, Abiquiu Reservoir is operated for flood control and to meet downstream demand of the MRGCD and Rio Grande Compact deliveries. Under current operating procedures, normal inflows and releases from El Vado are passed through Abiquiu, without regulation except due to channel constraints below the dam. When channel capacities are met, flood control operations begin at Abiquiu. Flood storage generally occurs between April and June. As further described in the URGWOM Rules Documentation, December, 2002 Draft:

Typically, if Rio Grande inflows exceed downstream channel capacities during April and May, Abiquiu captures this peak of snowmelt runoff, and releases it during June and early July. However, any Rio Grande storage remaining after the natural flow at Otowi drops below 1,500 cfs (July 1st or later) is carried over ... and not released until November 1st or later.... Depending on the volume of water from spring runoff, Abiquiu Reservoir has either been able to safely pass inflow without any carryover or has locked-in as little as 3,500 (1994) acre-feet to as much as 212,000 acre-feet (1987).

The concept with this alternative is to capture some of the native water, hold it, and deliver it the following fall, or alternatively by March 1. The result of this alternative would be to determine if, for the modeled year, evaporative loss savings could be realized by altering the release schedule and holding more water upstream until later in the year. Although other years are available, 2004 was used as an example year.

Legislative and Other Operational Authority

Abiquiu Dam was authorized for construction by the Flood Control Act of 1948 (PL 80-858) and the Flood Control Act of 1950 (PL 81-516). Operational guidelines for the Middle Rio Grande Project are included in Public Law 86-645 (1960) which states that all reservoirs will be evacuated completely on or before March 31st of each year. Any deviations from normal operating criteria other than an emergency must be made with the advice and consent of the Rio Grande Compact Commissioners. PL-86-645 states in relevant part:
Cochiti Reservoir, Galisteo Reservoir, and all other reservoirs constructed by the Corps of Engineers as a part of the Middle Rio Grande project will be operated solely for flood control and sediment control, as described below:

(a) the outflow from Cochiti Reservoir during each spring flood and thereafter will be at the maximum rate of flow that can be carried at the time in the channel of Rio Grande through the middle valley without causing flooding of areas protected by levees or unreasonable damage to channel protective works …

(c) Subject to the foregoing, the storage of water in and the release of water from all reservoirs constructed by the Corps of Engineers as part of the Middle Rio Grande project will be done as the interests of flood and sediment control may dictate: Provided, That the Corps of Engineers will endeavor to avoid encroachment on the upper two hundred and twelve thousand acre-feet of capacity in Cochiti Reservoir, and all reservoirs will be evacuated completely on or before March 31 of each year …

(d) All reservoirs of the Middle Rio Grande project will be operated at all times in the manner described above in conformity with the Rio Grande compact, and no departure from the foregoing operation schedule will be made except with the advice and consent of the Rio Grande compact . . . .

Because operation of the reservoir as outlined in this alternative would deviate from standard operations for flood and sediment control, ultimately the advice and consent of the Rio Grande Compact Commission would be necessary.

Feasibility of Modeling

In informal discussion with the Tech Team, this alternative was not envisioned to require significant rules changes at this time. It appears to be very feasible to model and, in fact, it would be possible to model three different years instead of just 2004 hydrology. The demand for the additional years could be set at 2004 demand, as provided by the MRGCD. Because of developments to the URGWOM model in order to evaluate how to meet the target flows of the 2003 Biologic Opinion, the Tech Team has been inputting rules into the model that will help refine evaluation of this alternative. In particular, a better assessment of how flows between Cochiti and Elephant Butte will be routed is being developed. It may be possible to add another alternative which would model release rates to meet the BO target flows.

Constraints/Issues

There has been concern expressed in WAMS about the accuracy of the URGWOM model to describe how water is routed between Cochiti and Elephant Butte. The discussion in WAMS and with the technical team has pointed out several areas where this concern can be alleviated. First, this limitation of URGWOM is recognized, but the problem exists under both the control situation and the model runs. There can be a comparison of the relative losses. It was suggested that the routing might be better examined at from an analytical standpoint, in other words, looking at flow regimes, time frames, river volumes, riparian ET, and other selected factors. URGWOM could be used for the base run for the reservoir evaporation and release schedule and then other analytic tools would be applied to refine the comparisons. We concluded that the alternative is only intended to be an evaluation of the level of the magnitude of the change. If by using URGWOM there are benefits of significant magnitude, further detailed studies of this alternative would need to be pursued. There would need to be agreement among the WAMS members, the URGWOM Tech Team and other stakeholders regarding the details of the model run.

Abiquiu Reservoir Operation Alternative 2.

Model the 40 year URGWOM period: When water is not needed to meet Compact deliveries in a given year, retaining that water in Abiquiu to provide water to manage Middle Valley water deliveries in
the subsequent year(s). The evaporative loss savings over the modeled period will be calculated. This storage would be based on “if and when” the space is not needed by the City of Albuquerque, or its subcontractors, for storage of its water.

Legislative and Other Operational Authority

The same legislative authorities that apply to alternative 1, are applicable here. However, because this alternative involves conservation storage in Abiquiu, Public Law 97-140 (Dec. 29, 1981, 95 Stat. 1717, Sect. 5) and Public Law 100-522 (Oct. 24, 1988, 102 Stat. 2604) are also important.

P.L. 97-140 provides for the storage of San Juan-Chama project water in Abiquiu. The Corps of Engineers is authorized to enter into agreements with entities that have contracted for San Juan-Chama water for a total storage of 200,000 acre-feet in Abiquiu. The storage of San Juan-Chama project water is not to interfere with the authorized purpose of Abiquiu Dam and Reservoir Project (for flood control and a sediment pool).

Later, with the passage of P.L. 100-522, native storage of Rio Grande system water was authorized:

Section 1. Water Storage.
Notwithstanding any other provision of law, the Secretary of the Army, acting through the Chief of Engineers, is authorized to store 200,000 acre-feet of Rio Grande system water at Abiquiu Dam, New Mexico, in lieu of the water storage authorized by section 5 of Public Law 97-140, to the extent that contracting entities under section 5 of Public Law 97-140 no longer require such storage. The Secretary is authorized further to acquire lands adjacent to Abiquiu Dam on which the Secretary holds easements as of the date of enactment of this Act if such acquisition is necessary to assure proper recreational access at Abiquiu Dam. The Secretary is further directed to report to Congress as soon as possible with recommendations on additional easements that may be required to assure implementation of this Act.

Section 2. Limitation.
The authorization to store water and to acquire lands under section 1 is subject to the provisions of the Rio Grande Compact and the resolutions of the Rio Grande Compact Commission.

Since Congress has authorized native storage, a Congressional change to authorizing legislation would not be required in order to implement this alternative. In addition, because Abiquiu is a post-1929 reservoir, there should be nothing intrinsic in the operation of the Compact that would prohibit this operational change. However, because a change in operations under P.L. 86-645 would be necessary, approval of the Rio Grande Compact Commission would be required.

Feasibility of Modeling

In meeting with the URGWOM tech team, it was concluded that this alternative is capable of being modeled using URGWOM. In order to begin with an Article VII condition, modifications to the sequence of model years currently being used would be needed. In addition, because URGWOM conducts model runs in increments of ten years, adjustments would be needed to obtain a 40-year sequence. This would be worthwhile in order to see the magnitude of the potential long-term gains from this operational strategy. Because Public Law 100-522 authorizes native storage in Abiquiu, there would not need to be other significant rules changes in URGWOM. The major concern of the URGWOM tech team was ownership and management of the conserved water rights. We reached agreement that as a first step it would be feasible to evaluate the savings. After this project is completed, there would need to be
discussions among stakeholders on how the releases would be managed. Again, agreement among stakeholders on the details of this model run would be necessary, in particular, coordination with the City of Albuquerque regarding their planned scenario for use of storage space in Abiquiu.

If the model runs show that this alternative has significant potential benefits to water supply, coordination with the Middle Valley water users and the State of New Mexico to develop potential release scenarios would be needed as a second phase.

**Increase Storage Opportunities At Heron Reservoir Alternative 1.**

Take delivery of San Juan-Chama Project water in Heron Reservoir in lieu of delivery of this water to Abiquiu Reservoir. Utilizing the 2003 Agreement between Santa Fe and the Bureau of Reclamation for purchase of San Juan-Chama Project water, change the operation such that delivery would be taken at Heron Reservoir instead of Abiquiu Reservoir. Then determine the evaporation savings gained by this operation. The release schedule of this water remains unchanged. This alternative would not impact the firm yield of the San Juan-Chama Project.

**Legislative and Other Operational Authority**

It is clear that the delivery point for the San Juan-Chama contractors’ water is at the outlet of Heron Reservoir. This term is included in the SJC contracts. Further, pursuant to the SJC contracts, carryover storage of that water is not allowed. The contractors’ water must be evacuated from Heron by December 31st of each year. Currently, the Bureau of Reclamation has been granting waivers for extension of this contractual provision to March 31st of each year.

Heron was authorized under Public Law 87-483 which authorized the San Juan-Chama Project in 1962. Under that law, the Secretary of the Interior must comply with all applicable provisions of the Colorado River Compact, the Upper Colorado River Basin Compact, the Boulder Canyon Project Act, the Boulder Canyon Project Adjustment Act, the Colorado River Storage Project Act and the Treaty with the United Mexican States. In addition, all provisions of the Rio Grande Compact must be met.

Typically Reclamation projects are authorized to provide storage for water to be captured during the runoff season and used that same year for irrigation or other authorized purposes. This is consistent with the wording of Section 8 of P.L. 87-483. That section reads:

(d) The amount of water diverted in the Rio Grande Basin for uses served by the San Juan-Chama project shall be limited in any calendar year to the amount of imported water available to such uses from importation to and storage in the Rio Grande Basin in that year.

This section has been interpreted to mean that no carryover storage is authorized in Heron, but the interpretation has been the subject of differing opinions. If there were agreement to evaluate this alternative from a physical modeling standpoint, there would need to be a thorough analysis of the Heron authorizing legislation including all of the relevant Compact legislation that affects the SJC project.

Reclamation has negotiated temporary waivers with contractors that allow carryover in order to provide release rates on the Rio Chama to enhance the fishery between El Vado and Abiquiu Reservoirs during the winter and provide flexibility in managing flows. If a waiver has been obtained by a contractor, the contractor’s water must be released during late March and up until April 30th to a downstream reservoir where the contractor has storage space. Feasibility of modeling this alternative would involve limitations on storage in Heron that would not impair the firm yield of the project or the water rights of San Juan-Chama contractors. Funding may be needed to develop the required rules changes.

**Constraints / Issues**

The City believes that any modification to the “no carryover” provision in Heron authorizing legislation would lead to a revision of the City’s contract with the Bureau of Reclamation for storage of
water in Heron and they do not want to revise their storage contract. The recently adopted Public Law 108-447 (Jan. 7, 2005) may allay the City’s concerns. That law states:

Section 205. (a) Notwithstanding any other provision of law and hereafter, the Secretary of the Interior, acting through the Commissioner of the Bureau of Reclamation, may not obligate funds, and may not use discretion, if any, to restrict, reduce or reallocate any water stored in Heron Reservoir or delivered pursuant to San Juan-Chama Project contracts, including execution of said contracts facilitated by the Middle Rio Grande Project, to meet the requirements of the Endangered Species Act, unless such water is acquired or otherwise made available from a willing seller or lessor and the use is in compliance with the laws of the State of New Mexico, including but not limited to, permitting requirements.

The City of Santa Fe has expressed interest in evaluating this alternative because they are looking for alternate locations to store City of Santa Fe water. Further coordination with the City of Santa Fe on this issue is needed.

Increase Storage Opportunities At Heron Reservoir, Alternative 2.

Assuming the Program has acquired a certain amount of native water rights, capture native inflow to Heron up to the extent of these water rights, and maintain a Program pool by allowing for the carry-over of this storage from one year to the next if and when storage space is available. Storage could only be undertaken when the rights of downstream users are satisfied. This alternative would not impact the firm yield of the San Juan-Chama Project.
INTRODUCTION

The listing in 1994 of the Rio Grande silvery minnow as endangered under the Endangered Species Act and the drought conditions experienced in the middle Rio Grande valley during the first half of 1996 combined to underscore the need to address long-term water management options to meet water needs in the valley. The purpose of this paper is to outline alternative courses of action to satisfy these water needs that merit further investigation by agencies and entities which have a stake in water management for the valley.

The middle Rio Grande valley is hydrologically very complex and is home to substantial agricultural activity, urban development and the silvery minnow. Uncertainties exist in our understanding of the hydrologic connections between surface-water and ground-water systems in the valley principally due to a lack of data. There are also uncertainties regarding water needs over time for various purposes. Additionally, there are numerous incompatibilities between existing institutions as well as federal and state laws which affect water management in the valley and upstream reservoir operations for the valley.

Still, during the 1996 irrigation season, agencies and entities directly involved in water operations for the middle valley largely succeeded in satisfying the water needs of the silvery minnow and water users, including Middle Rio Grande Conservancy District (District) irrigators. This success was due to the District operating its system to allow native Rio Grande water to remain in the river undiverted for the minnow and the city of Albuquerque (City) and other entities making some of their San Juan-Chama Project water available to the District for use by irrigators at no cost to the water users in the valley. It is expected, however, that San Juan-Chama Project water owned by the City and these other entities may not be available in future years to augment surface-water supplies in the valley.

Without proactive water planning and related commitments to action, water management decisions may be made through litigation. Environmental organizations have sent Notices of intent to Sue, and others have contemplated legal action, regarding operation of the river system through the middle valley and related impacts to the silvery minnow. Government agencies with a stake in water management in the middle valley are now in the process of developing, plan for 1997 river operations for the silvery minnow and the District. Agencies and entities directly involved in water operations for the middle valley also share responsibilities in equitably meeting future water needs with the goal to satisfy water uses and the needs of the silvery minnow beyond 1997.
ACTIONS

To meet the needs of the silvery minnow, it is most desirable to take actions which will secure long-term, dependable amounts of water for the middle Rio Grande. In doing so, water users also need to be accommodated. No single action will by itself accomplish these goals.

However, the preparers of this paper believe that some combination of the following actions will be instrumental in meeting these goals. These alternative actions require further investigation and refinement to ensure that actions ultimately taken are responsive to these goals and to changing needs. Actions to be taken must be legal, economically feasible, politically acceptable and implementable in a timely manner. Successful implementation of any of these actions will require improved water measurement, monitoring and accountability. The following alternative actions are non-exclusive and no order of priority has been assigned to them.

1. **Acquisition of Water**: Acquisition of water from willing sellers to facilitate water supply management in the middle Rio Grande is an action that could be taken within existing laws. Modifications to existing laws and contracts might further facilitate various ways of implementing a water acquisition program which may involve elements of water-use forbearance agreements or water banking. While water could be acquired from water users, the District may need to be a party to agreements to allow such a program to be effective in satisfying needs of the water users and the silvery minnow. A water acquisition program may require sustained funding from federal and other sources, and it would require development of institutional and physical criteria for obtaining water in a timely manner.

2. **Conjunctive Ground-Water and Surface-Water Use**: The use of ground-water and surface-water supplies could be co-managed to contribute to meeting the needs of water users and the silvery minnow. During wet years, ground-water users such as the City might use a higher proportion of surface water for direct use or artificial ground-water recharge. During dry years, more ground water might be pumped in lieu of using surface water so that additional surface water may augment the total surface-water supply available for the silvery minnow and surface-water users such as the District. Another option is to strategically place shallow ground-water wells in the middle Rio Grande valley for use in times of severe surface-water shortages, thereby providing a supplemental source to the total water supply in years of low streamflow. This option could be expensive, but would provide a means to respond to emergency low-flow situations. These options would provide for a more comprehensive water use; however, institutional and water rights constraints need to be addressed to implement them.

3. **Upstream Water Management**: Changes to Rio Grande system water operations could increase the capability of storing native Rio Grande water upstream from the middle valley. Some reservoir and river operation options could require new authorizations, while other options could be accomplished under current authorities through changes to federal water control manuals. Possible options for consideration, in no order of priority, are: (1) storing Rio Grande water in vacant storage space in Heron Reservoir when space is available, as well as utilizing San Juan-Chama Project water; (2) transferring water from El Vado Reservoir to Abiquiu Reservoir; (3) increasing the storage capability in Abiquiu and Jemez Canyon Reservoirs; and (4) using Cochiti Lake for a re-regulation reservoir during the irrigation season. Aspects related to these options which would need to be addressed include: water supply. Native American water rights, effects on water management outside the middle valley, recreation, compliance with laws related to the environment, the Rio Grande Compact, and specific agency and project authorizations. There is also a need to annually prepare an operating plan for reservoirs and diversions of the Middle Rio Grande Project in consultation with stakeholders to specifically evaluate water management needs and opportunities for the middle valley.

4. **Water-Use Efficiency Increases**: Increased water-use efficiencies in the middle Rio Grande valley should contribute to an increase in the flexibility to manage the water supply. Options for action by which water-use efficiencies could be increased include improving off-stream water-delivery systems by such means as lining canals, improving on-farm irrigation practices, or improving water delivery
scheduling. Prior to taking action to increase efficiencies, the impacts of various options on the hydrology and the environment of the middle valley need to be assessed. Further, the disposition of water "saved" by these measures would need to be resolved in accordance with state and Federal water law and possibly by agreement with the District to allow water saving measures to effectively aid water managers in meeting the needs of the water users and the silvery minnow.

5. **Water Rights Administration:** Water rights in the middle Rio Grande valley are not adjudicated and much of the water uses in the valley are not metered. Metering surface-water and ground-water irrigation deliveries and drain flows would help clarify existing water uses and needs, quantify the available water supply, and identify water management options. Adjudicating water rights in the middle valley would, in conjunction with a metering program, allow for improved administration of water rights and improved water management. However, an adjudication may not be completed for the middle valley in the foreseeable future unless alternative dispute resolution procedures can be adopted by the state, water users and the court to carry the adjudication forward. Still, sustained funding from federal and other sources to meter and monitor flows throughout the valley is needed.

**RECOMMENDATIONS**

Agencies and entities directly involved in water operations for the middle Rio Grande valley should diligently and cooperatively investigate with the broader community of interests, the feasibility of implementing the actions described herein and develop a plan of action to serve as the basis for future river and reservoir operations to meet the needs of water users and the silvery minnow in the middle valley. Such a plan of action might include any combination of the alternative actions described herein which would lead to maximum improvements in water management for water users and the silvery minnow as a whole.

Attention should first be directed towards more immediately attainable actions such as upstream water management options which can be accomplished within existing authorities and the acquisition of water. Concurrently, existing institutional constraints to implementing potential actions should be examined and efforts should be initiated to make institutional changes as may be deemed appropriate to help accommodate both water users and the silvery minnow in the long-term. Where additional studies are deemed required to fully evaluate a potential action, the agencies and entities represented in the preparation of this paper should cooperate in securing the necessary resources to complete such studies promptly. These agencies and entities should also continue to dedicate staff to working on issues related to development and implementation of a plan of action to address future needs of both water users and the silvery minnow in the middle valley. To this end, the preparers of this paper seek confirmation from the leadership of their respective agencies or entities that the actions described herein should be pursued.
<table>
<thead>
<tr>
<th>Attachment</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-1</td>
<td>NEW MEXICO RIO GRANDE COMPACT DELIVERY AND CREDIT WATER</td>
<td>E-1</td>
</tr>
<tr>
<td>E-2</td>
<td>RIO GRANDE PROJECT USABLE WATER</td>
<td>E-6</td>
</tr>
<tr>
<td>E-3</td>
<td>COLORADO WATER</td>
<td>E-8</td>
</tr>
<tr>
<td>E-4</td>
<td>PROGRAM WATER ACQUISITION</td>
<td>E-10</td>
</tr>
<tr>
<td>E-5</td>
<td>MUNICIPAL AND INDUSTRIAL CONJUNCTIVE USE STRATEGIES</td>
<td>E-22</td>
</tr>
<tr>
<td>E-6</td>
<td>SUPPLEMENTING MRG FLOWS THROUGH IRRIGATION EFFICIENCY IMPROVEMENTS (DRAFT)</td>
<td>E-30</td>
</tr>
<tr>
<td>E-7</td>
<td>VOLUNTARY IRRIGATION FORBEARANCE IN THE MRGCD SERVICE AREA</td>
<td>E-36</td>
</tr>
<tr>
<td>E-8</td>
<td>NATIVE AMERICAN WATER</td>
<td>E-39</td>
</tr>
<tr>
<td>E-9</td>
<td>NEW MEXICO ACEQUIA WATER</td>
<td>E-40</td>
</tr>
<tr>
<td>E-10</td>
<td>WEATHER MODIFICATION – CLOUD SEEDING WATER</td>
<td>E-42</td>
</tr>
<tr>
<td>E-11</td>
<td>SUPPLEMENTING MIDDLE RIO GRANDE FLOWS THROUGH ACTIVE WATERSHED MANAGEMENT</td>
<td>E-46</td>
</tr>
<tr>
<td>E-12</td>
<td>STORAGE AND MANAGEMENT OF PROGRAM WATER</td>
<td>E-55</td>
</tr>
<tr>
<td>E-13</td>
<td>COCHITI LAKE WATER ISSUES</td>
<td>E-68</td>
</tr>
<tr>
<td>E-14</td>
<td>RESERVOIR EVAPORATION WATER</td>
<td>E-70</td>
</tr>
<tr>
<td>E-15</td>
<td>EVAPOTRANSPIRATION AND WATER SALVAGE</td>
<td>E-74</td>
</tr>
<tr>
<td>E-16</td>
<td>FLOODPLAIN LAKES AND FLOOD FLOW RETENTION BASINS</td>
<td>E-78</td>
</tr>
<tr>
<td>E-17</td>
<td>SUPPLEMENTING MIDDLE RIO GRANDE FLOWS THROUGH GROUNDWATER PUMPING</td>
<td>E-81</td>
</tr>
<tr>
<td>E-18</td>
<td>SUPPLEMENTING MIDDLE RIO GRANDE FLOWS THROUGH PUMPING FROM THE LOW FLOW CONVEYANCE CHANNEL (LFCC)</td>
<td>E-86</td>
</tr>
<tr>
<td>E-19</td>
<td>STUDY OF RECONFIGURATION FOR THE SAN ACACIA REACH</td>
<td>E-92</td>
</tr>
</tbody>
</table>
Attachment E-1

WATER ACQUISITION AND MANAGEMENT SUBCOMMITTEE POSITION PAPER:
NEW MEXICO RIO GRANDE COMPACT DELIVERY AND CREDIT WATER

1.0 INTRODUCTION AND BACKGROUND

The Rio Grande Compact was signed by the states of Colorado, New Mexico and Texas on March 18, 1938. The Compact was subsequently ratified by the legislature of each state, enacted as Public Act No. 96 by the 76th Congress, and signed into law by the President on May 31, 1939. The schedule of deliveries and responsibilities of each state under the Compact became effective January 1, 1940.

The Compact is administered by the Rio Grande Compact Commission, which consists of a Commissioner from each of the three signatory states, plus a Federal representative appointed by the President who acts as Chairman of the Commission without vote. The Commission holds regularly scheduled meetings each year in the spring. Additional special meetings are held as necessary. Any deviation from the terms of the Compact, including those that govern water operations, requires unanimous approval from all three state Commissioners.

The three states signed the Compact after a lengthy period of study and negotiation. The purpose of the Compact was to equitably apportion the uses of the waters of the Rio Grande among the three states based on how that apportionment existed in 1929, thereby allowing each state to develop its water resources at will, subject only to the delivery obligations set forth in the Compact. Prior to the Compact, the use of the waters of the Rio Grande had been a source of much controversy between the three states for the preceding four decades.

2.0 RIO GRANDE COMPACT

The Compact requires that the upper states of Colorado and New Mexico deliver a specified percentage of flow in the Rio Grande to the next lower state. These percentages are based on specified gaging stations and index schedules contained within the Compact. The percentage that New Mexico must deliver to Texas is based on the amount of annual runoff in the Rio Grande as measured at the Otowi gage, located on the Rio Grande a few miles south of Espanola. Pursuant to the Compact, adjustments to the gaged flow at Otowi are made to account for storage in upstream reservoirs and water diverted from the Colorado River basin into the Rio Grande basin in northern New Mexico by the San Juan-Chama Project. In dry years about 60 percent of the flow at Otowi must be delivered. In wet years, over 80 percent must be delivered. New Mexico’s apportionment of the native flow in the Rio Grande at Otowi is capped at 405,000 acre-feet per year (AFY) as shown in Figure 1 below. New Mexico’s deliveries are measured as the releases below Elephant Butte Dam plus the change in storage in the reservoir.

The Compact uses a system of debits and credits to account for annual over- or under- deliveries. In general, New Mexico may not under- deliver by more than 150,000 AF in any given year, nor accrue a debit of greater than 200,000 AF. The amount of credit that each state may accrue in any given year is capped at 150,000 AF. If Elephant Butte Reservoir fills up and overflows, a “spill” occurs. If a spill occurs when Colorado and New Mexico have accrued credits, these credits are reduced proportionally in an amount equal to the amount of the spill. If a spill occurs when Colorado and New Mexico have accrued debits, the accrued debit of the upstream states is cancelled. Spills have occurred in seven years since the advent of the Compact – 1942, 1985, 1986, 1987, 1988.
1994 and 1995 (see Figure 2 below). Annual credits or debits for Colorado and New Mexico are not computed during years in which a spill occurs.

Other provisions in the Compact impact the operations of reservoirs built after 1929 in New Mexico and after 1937 in Colorado. Article VII of the Compact prohibits storage of non-Indian native Rio Grande water in reservoirs upstream of Elephant Butte Reservoir whenever usable water in Rio Grande Project Storage in Elephant Butte and Caballo Reservoirs falls below 400,000 AF. In addition, when New Mexico has an accrued debit, it is required to store an amount of water equal to the extent of that accrued debit in post-1929 reservoirs.
3.0 **NEW MEXICO’S HISTORICAL COMPACT DELIVERIES**

New Mexico historically has had a difficult time complying with the Compact, as shown in Figure 3. It was not until the implementation of a deliberate management strategy in the 1950s, in partnership with the Federal government, based on the control of excessive natural depletions New Mexico began to turn the corner on long-term Compact compliance. That strategy has included control of excessive evapotranspiration by exotic riparian vegetation, construction and maintenance of drains to salvage water that otherwise would be lost to evapotranspiration, river channel maintenance, and construction and use of both temporary and permanent man-made channels to efficiently convey water downstream. These activities are essential, particularly in the reach between San Acacia and Elephant Butte Reservoir, to ensure that New Mexico continues to meet its Compact delivery obligations. Figure 4 shows the net annual change in New Mexico’s historical compliance with the Compact.

![Figure 3: New Mexico's Rio Grande Compact Cumulative Delivery Departure](image)

4.0 **PROGRAM USE OF COMPACT DELIVERY WATER**

Taking into account New Mexico’s Compact delivery obligations to Texas, the middle Rio Grande basin is fully appropriated. That means that there is no excess water available beyond that which is currently being depleted from the system. Any additional or new use of water in the basin must come from an existing use. Depletions associated with specified endangered species flow requirements below San Acacia are a new use on the system that must come from an existing use.
New Mexico Compact delivery water could be used to meet those flow requirements by storing that water during times when flows are in excess of that required to satisfy the diversion demands of downstream permitted water users. Essentially, such storage would occur during the snowmelt runoff period or during the winter months. That water would then be released in later months when there is insufficient flow to meet both the diversion demand of the permitted water users and the specified flow requirements of the endangered species.

Those specified flow requirements were partially met in 2001 and 2002 by New Mexico Compact delivery water released from the Middle Rio Grande Endangered Species Conservation Pool (Conservation Pool). The Conservation Pool was temporarily established by the State of New Mexico as a proposed settlement offer to on-going litigation under the Endangered Species Act (Cause No. 99-CIV-1320, styled *Minnow v. Keys*) filed in the United States District Court for the District of New Mexico in 1999. The goal of the state was to provide short-term compliance with the ESA with the hope that the Middle Rio Grande ESA Collaborative Program Workgroup would be able to formulate long-term solutions. In temporarily establishing the Conservation Pool, the state fully recognized the hydrologic realities and limitations on water supply in the middle Rio Grande and thus limited its term to three years (through 2003).

New Mexico Compact delivery water could be temporarily stored during the winter and snowmelt runoff period (when natural evapotranspiration demand is fully satisfied) for later release during low-flow periods (when natural evapotranspiration demand is not met), results in additional evapotranspiration depletions on the system. Since the middle Rio Grande basin is fully appropriated, those additional depletions on the system can only come from an existing use. Since no existing uses would be curtailed, the result of such a plan would be the eventual violation of the Compact by New Mexico.

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Thus, it is concluded that the sustained use of Compact delivery water to meet specified flow requirements for endangered species is not viable. In addition, the New Mexico Interstate Stream Commission will not consent to such a plan.

5.0 **PROGRAM USE OF ACCRUED COMPACT CREDIT WATER**

Under the Compact, New Mexico currently has an accrued credit of 155,700 acre-feet. That credit is physical wet water currently held in storage in Elephant Butte Reservoir that theoretically could be used in the short term to meet specified flow requirements for endangered species upstream in the middle Rio Grande. To make that water available for use in the middle Rio Grande would require either:

a) the consent by resolution of the Compact Commission to move that credit pool to upstream storage, by exchange, for subsequent release and depletion, or

b) relinquishment by New Mexico, and acceptance by Texas, of accrued credits pursuant to Article VII of the Compact.

Both options (a) and (b) are theoretically possible in the short term, but are clearly unsustainable in the mid- or long-term. While such a resolution as contemplated in option (a) is theoretically possible, it is highly unlikely given the current political climate and drought conditions of the basin (particularly in regards to basin-wide reservoir storage). In addition, the Compact contains no such provisions for performing such an exchange. Thus, the precise Compact accounting details necessary to accomplish that exchange are unclear, and represent a clear impediment to accomplishing such an action.

Both options have potential long-term detrimental ramifications. The history of New Mexico’s Compact compliance clearly shows that, as the framers of the Compact intended, that the purpose of such accrued credits is to offset debits over the long-term. Accrued credit water owned by the state of New Mexico must be managed to benefit the entire state, and, in particular, the citizens and water users of the middle Rio Grande valley. Mismanagement of such accrued credit could potentially result in rapid violation of the Compact by New Mexico. The Interstate Stream Commission has an obligation to determine how best to use that credit water and is extremely reluctant to enter into a shortsighted plan that would deplete that credit and subject the state to potential Compact violation and ensuing litigation in the US Supreme Court.

Thus, it is concluded that the use of accrued New Mexico Compact credits to meet specified flow requirements for endangered species for anything other than the immediate short-term is not viable.

6.0 **SUMMARY AND CONCLUSIONS**

1. The middle Rio Grande basin is fully appropriated.
2. Any new use of water, such as the depletions that result from specified endangered species flow requirements, must come from some current existing use.
3. The sustained, long-term use of Rio Grande Compact delivery water to meet specified flow requirements for endangered species would cause additional depletions on the system that would result in the eventual violation of the Compact by New Mexico, and is not a viable option.
4. The use of Rio Grande Compact accrued credits to meet specified flow requirements for endangered species is not considered to be a sustainable option.
Attachment E-2

WATER ACQUISITION AND MANAGEMENT SUBCOMMITTEE POSITION PAPER:
RIO GRANDE PROJECT USABLE WATER

1.0 INTRODUCTION AND BACKGROUND

The U.S. Bureau of Reclamation’s Rio Grande Project is located along the Rio Grande valley in southern New Mexico and northwest Texas. The Project supplies water for about 155,000 acres of irrigable lands in the Elephant Butte Irrigation District (EBID), located in the Rincon and Mesilla Valleys in New Mexico and the El Paso Water Improvement District No. 1 (EP No. 1), located in the El Paso Valley of far west Texas. The Secretary of the Interior authorized the Project in 1905 under the provisions of the 1902 Reclamation Act.

Storage for the Project is provided by Elephant Butte and Caballo Reservoirs in southern New Mexico, which have a total combined capacity in excess of 2,000,000 acre-feet. In accordance with the Rio Grande Compact, normal release from Project Storage under full-supply conditions is 790,000 acre-feet per year. By reuse of drain return flows, the normal release allows the full Project allocation of approximately 930,000 acre-feet per year to be delivered to the canal headings of EBID and EP No. 1, and to the heading of the Republic of Mexico’s Acequia Madre. Mexico receives 60,000 acre-feet of Project water per year, in accordance with 1906 and 1933 Treaty Conventions.

Drainage from EP No. 1 also provides a supplemental supply of water for 18,000 acres of irrigated lands in Hudspeth County south of El Paso. In recent years some Project water has been converted to municipal and industrial use for the City of El Paso.

2.0 RIO GRANDE COMPACT

All Rio Grande Project water operations at Elephant Butte and Caballo Reservoirs must be conducted in conformance with the Rio Grande Compact, which was signed by the states of Colorado, New Mexico and Texas on March 18, 1938. The Compact was subsequently ratified by the legislature of each state, enacted as Public Act No. 96 by the 76th Congress, and signed into law by the President on May 31, 1939. The schedule of deliveries and responsibilities of each state under the Compact became effective January 1, 1940.

Under the Compact, all water stored in Elephant Butte and Caballo Reservoirs is termed Project Storage. This includes credit water accrued by either New Mexico or Colorado by reason of deliveries in excess of required amounts, San Juan-Chama Project water stored in Elephant Butte pursuant to PL 97-140 and water available for release to downstream irrigation demand and to the Republic of Mexico (Rio Grande Project Usable Water).

3.0 PROJECT WATER RIGHTS

Rights to Project water have been the subject of on-going litigation since 1986 when EBID filed suit against the New Mexico State Engineer in state court and initiated a comprehensive adjudication of the Lower Rio Grande stream system. The case was removed to federal court by the City of El Paso and subsequently remanded back to state court. In 1997 the United States filed a complaint to quiet title to the rights of the Project in federal court. That complaint was dismissed and subsequently appealed to the Tenth Circuit Court of Appeals, which upheld the dismissal and remanded the case back to the state court adjudication. It will likely be several years before that adjudication is complete.
4.0 USE OF RIO GRANDE PROJECT WATER FOR SUPPLEMENTAL FLOWS

Use of Rio Grande Project Usable Water to provide Collaborative Program supplemental flows would face numerous impediments. There is the primary question of whether or not such a use would be legal under state and federal law, complicated by the lack of an adjudication of who owns what rights to what water. It would require the cooperation and agreement of numerous parties and would likely not survive a legal challenge.

To provide supplemental flows, water would need to be stored during spring runoff in either El Vado, Abiquiu, Cochiti or Jemez Canyon Reservoirs and labeled as Rio Grande Project Usable Water slated for release later in the summer during periods of lower flow. At a minimum, approval and cooperation would be required from the following parties:

- Rio Grande Compact Commission (consisting of the New Mexico State Engineer, Colorado State Engineer, and the Texas Commissioner)
- New Mexico Office of the State Engineer
- New Mexico Interstate Stream Commission
- U.S. Bureau of Reclamation
- U.S. Army Corps of Engineers
- Elephant Butte Irrigation District (EBID)
- El Paso Irrigation District (EP) No. 1
- City of El Paso
- Republic of Mexico
- U.S. Department of State
- Middle Rio Grande Conservancy District
- And, potentially, Hudspeth County Conservation and Reclamation District No. 1

Some of these parties, such as the Rio Grande Compact Commission, the New Mexico State Engineer, EBID, EP No. 1 and possibly the Bureau of Reclamation hold an unequivocal veto over any such proposal.

Complicating matters is the fact that 2003 will be the first year since the late 1970s that the Rio Grande Project will not have a full allocation for the irrigation season due to low storage levels in Elephant Butte and Caballo Reservoirs.

5.0 CONCLUSIONS

Due to the numerous parties involved, the complexity of Compact accounting, and various legal impediments (including international relations with the Republic of Mexico), compounded by a lack of available physical storage upstream of the MRG, the WAMS concludes that Rio Grande Project Usable Water would have no potentially viable role in addressing water needs for the ESA Collaborative Program.
Attachment E-3

WATER ACQUISITION AND MANAGEMENT SUBCOMMITTEE POSITION PAPER:
COLORADO WATER

1.0 INTRODUCTION AND BACKGROUND

Commencing with the first meeting of the Water Acquisition and Management Subcommittee (WAMS) on July 26, 2002, a listing of all potential sources of water that might provide supplemental flows to the middle valley was “brainstormed.” That list included the possibility of acquiring water from sources within the State of Colorado. Brief discussions at subsequent WAMS subcommittee meetings centered around the possibility of acquiring water from willing sellers within the Rio Grande basin in Colorado or possibly from the Closed Basin Project.

2.0 ASSESSMENT

The Rio Grande basin in Colorado is fully appropriated. All water within the basin is subject to the laws of the State of Colorado and the Rio Grande Compact. Any water that might be voluntarily “undiverted” by a Colorado water user would be, under Colorado state law, available for diversion by downstream users within Colorado. Furthermore, if that water were to cross the Colorado-New Mexico state line, it would at that point be part of Colorado’s delivery to New Mexico under the Compact. Also at that point, it would become public waters of the state of New Mexico. Such water would then be available for diversion and consumption by water users within the state of New Mexico above San Acacia.

The Closed Basin Project was authorized by PL 92-514 in 1972. The purposes of the project, in priority as listed in the authorizing legislation, are as follows:

- Assist Colorado in making annual deliveries under the Compact.
- Maintain the Alamosa National Wildlife Refuge and the Blanca Wildlife Habitat Area.
- Offset any accumulated deficit in water deliveries by Colorado under the Compact.
- Provide water for irrigation and other beneficial uses in Colorado.

Deliveries from the Closed Basin Project to the Rio Grande during the life of the Project have averaged about 25,000 acre-feet per year (AFY). This is equivalent to approximately 35 cubic feet per second (cfs). Deliveries to the Rio Grande for the last three years have averaged about 17,000 AFY, or 23 cfs. Deliveries have declined in recent years due to biofouling of the Project’s production wells. Operation of the Project is subject to numerous constraints contained within the authorizing legislation, including a limitation of the allowable drawdown of groundwater levels and water quality standards.

As with any potentially “undiverted” irrigation water in Colorado, all water delivered from the Closed Basin Project to the Colorado-New Mexico Stateline is also a part of Colorado’s delivery to New Mexico under the Compact. At the Stateline that water becomes public waters of the State of New Mexico and becomes available for diversion and consumption by water users within the state of New Mexico above San Acacia.

3.0 CONCLUSIONS

- The Rio Grande basin in Colorado is fully appropriated.
- Under Colorado law, any Colorado water potentially acquired by the Program would be available first for use by other Colorado water users; then, any potentially acquired water crossing the
Colorado-New Mexico Stateline would become part of Colorado’s delivery to New Mexico under the Compact.

- At the Stateline, any potentially acquired Colorado water would become public water of the State of New Mexico and, as such, this water would then be available for diversion and consumption by water users within the state of New Mexico above San Acacia.

- The WAMS concludes that acquiring water from Colorado and successfully delivering it to the Rio Grande below San Acacia appears to be impossible.

- Accordingly, the WAMS also concludes that no further discussion of the acquisition of water from sources within Colorado should be considered.

- Finally, the Interim Steering Committee, at its November 18, 2002 meeting, directed the WAMS subcommittee to discontinue investigation of seeking supplemental Program water from sources within the State of Colorado.
1.0 INTRODUCTION AND BACKGROUND

Achievement of the goals of the Middle Rio Grande (MRG) ESA Collaborative Program (Program) and advancement of the conservation and recovery of endangered species along the MRG valley likely requires that both short- and long-term water supply be acquired through the Program. This water supply acquired to meet the needs of the Program will need to include:

1. A flow component that would provide water to support river flows and river habitat under the applicable BO requirements and related Program activities.
2. A consumptive component that would include evaporation and transpiration losses associated with Program activities within the MRG valley.

To date, the needs of the Program have been met through the short-term acquisition of water, primarily from leasing of San Juan-Chama water, and agreements with the State of New Mexico. The development of a longer-term water supply to meet the needs of the Program is a major goal of the WAMS. Long-term or permanent acquisition of water to support both the flow and the consumptive requirements of the Program could include fee-simple acquisition of native Rio Grande water rights, acquisition of lands with appurtenant water rights, and/or long-term sublease of San-Juan Chama or other contracted water available from willing lessors. A long-term water supply could also be established through the implementation of a long-term, programmatic irrigation forbearance program with an annual target (in which, for instance, a number of irrigators agree to accept compensation in lieu of irrigating say once every five years, and this forbearance is rotated annually), if ongoing studies determine that such an approach is feasible. This position paper describes the short-term water acquisition strategy and activities that have been used thus far (through the 2003 season) to meet the goals of the Program, and also provides information and WAMS conclusions related to the need for long-term acquisition of water to support the needs of the Program.

2.0 HISTORY OF SHORT-TERM WATER ACQUISITION TO MEET PROGRAM NEEDS

As noted above, since 1996, the needs of the Program have been met through the short-term acquisition of water, primarily from leasing of San Juan Chama water, and agreements with the State of New Mexico. A summary accounting of the supplemental water program since 1996 is presented in Attachment I. Table A1 presents the quantities of San Juan-Chama water that have been leased from willing sellers by the US Bureau of Reclamation (Bureau), using Bureau or Program funds. Table A2 summarizes the amount of water that has been released to meet the needs of the Program during that year, based on the Bureau’s annual accounting reports of supplemental water to the Engineer Advisors (these reports began formally in 2001, previous years had less formal reporting). The majority of water released since 2000 for the Program purposes consists of Conservation Water Agreement water and Emergency Drought Water Management Agreement water made available by the State.

3.0 THE NEED FOR A LONGER-TERM WATER SUPPLY

As reported in the WAMS Position Paper “New Mexico Rio Grande Compact Delivery Water,” in an administrative sense, specified endangered species flow requirements impose a “new” use on the MRG water system. The storage of water during the winter and snowmelt runoff period (when natural
evapotranspiration demand is fully satisfied) for later release during low-flow periods (when natural evapotranspiration demand is not met), results in additional evapotranspiration depletions on the system. Also, as discussed in more detail below, additional depletions will likely occur as a result of planned habitat improvements, such as increased evaporation from wider, shallower reaches of river channel, low-velocity side-channels, and overbank areas. These depletions are “new” because they are not previously accounted for in New Mexico’s fully allocated water system. Therefore, these new depletions must be offset through retirement of other existing uses. In New Mexico’s water rights system, existing uses of are retired through purchase and subsequent non-exercise of their associated water rights or contracts.

The Program’s Draft Habitat Restoration Plan indicates that most habitat restoration actions that are likely to produce significant direct benefits to the MRG listed species will be accompanied by some increases in total evaporation and/or transpiration, i.e., basin depletions, unless offset by additional water salvage or other conservation efforts. For example, potential restoration projects often include altering habitat conditions for the listed species by actions that increase water surface areas and/or slow overall downstream conveyance rates. Without additional actions to offset these water losses, increased basin depletions would result. The magnitude of these depletions would depend on the extent of hydrologic alteration produced by the Project.

The Program includes the objective that net MRG basin depletions associated with Program actions produce no net increase in depletions in the basin. Therefore, an objective of the Subcommittee is to encourage and support, to the extent possible, projects intending to offset depletions caused by habitat restoration efforts and actions to supplement river flows intending to benefit the Basin’s listed species.

Also, the Subcommittee has established additional objectives to encourage and support, to the extent possible, projects intending to increase the understanding of factors affecting basin depletions (including irrigation efficiencies and riparian evapotranspiration rates) and those intending to decrease total depletions along the MRG basin (including actions that may be characterized as “water salvage projects”). Example projects would include those implemented to decrease total riparian evapotranspiration (e.g., replacing dense saltcedar growths with native grassland or mixed forest communities). Whenever increases in net depletions produced by habitat restoration or flow enhancement projects cannot be offset through these Program activities, the Subcommittee will work with the Program to secure the acquisition of water rights by the Program, through lease or purchase, to offset these increased depletions.

4.0 LONG-TERM WATER ACQUISITION OF NATIVE RIO GRANDE WATER RIGHTS - BACKGROUND

- Since 1846, when was it was claimed as a territory of the United States, water has been considered a public resource in New Mexico. The NM Water Code of 1907 confirmed earlier laws, including the Constitution of the State of New Mexico in stating, “all natural waters flowing in streams and watercourses, whether such be perennial or torrential, within the limits of the state of New Mexico, belong to the public and are subject to appropriation for beneficial uses.”
- The State Engineer is responsible for the general supervision of the state’s water resources, including their measurement, appropriation, and distribution.
- New Mexico, like most western states, follows the doctrine of prior appropriation (“first in time, first in right”) rather than riparian rights. That is, those who first use water beneficially have a higher priority to continue that use. These rights were codified by the New Mexico legislature in the 1907 for surface waters and in 1931 for groundwater basins.
- The MRG is not adjudicated. Therefore, the water rights in the valley have never been proven, quantified, or given priority dates. For this reason, the effective implementation of the prior appropriation system is not possible. In the absence of adjudication, the MRG Valley is not
administered according to the doctrine of prior appropriation, but rather through shortage sharing – holders of senior and junior water rights all get less water during water-short years (except Pueblo Prior and Paramount rights). In addition, responding to the recent drought conditions in New Mexico, general rules and regulations for administering Active Water Resource Management (AWRM) were finalized by the State Engineer on December 3, 2004. These statewide rules and regulations provide that, when necessary, junior water rights that would otherwise be curtailed would be able to temporarily acquire senior water rights from owners participating in the water rights marketplace in an expedited manner. These rules may also aid the Program in working with the State to acquire water to meet Program goals.

- Recent changes in the State law enacted by the NM legislature in 2005, authorized the Interstate Stream Commission (ISC) to establish a Strategic Water Reserve. This allows the ISC the option to purchase or lease surface and ground water from willing sellers or lessors, and to receive donated water or water rights or storage rights to develop a water reserve. But, at no time shall the use of this water or water rights result in an increase in net depletions in any if the State’s water basins. The Act also states that the ISC shall pay no more than the appraised market value to purchase or lease water or water rights and storage rights for the strategic water reserve. The ISC may accept money or grants from federal or other governmental entities or other persons to purchase or lease water or water rights for the strategic water reserve and to pay administrative costs. The ISC shall not acquire water or water rights that are served by or owned by an acequia or community ditch. This Strategic Water Reserve legislation could aid the Program in working with the State to acquire water to help meet Program goals. In addition, the City of Albuquerque, in an agreement with environmental groups, set aside 30,000 acre-feet of storage space for water for environmental preservation purposes within Abiquiu Reservoir. This storage space could become available to store water acquired to meet Program goals.

- A March 27, 1998 Opinion from the New Mexico Attorney General (Belin 1998) concluded “that there is nothing in the New Mexico Constitution, statutes, or case law that would preclude the State Engineer from approving an application to change the purpose of use of an existing water right to an instream purpose and conditioning that approval upon the installation of gauging devices to measure the instream flow beneficially used. However, since water distribution during water-short years follows the practice of shortage-sharing, river flows – even if they are supported by senior water rights – would have to share the shortage with irrigators using Junior water rights.

Note: A summary of concepts and definitions related to water rights in New Mexico is provided in Attachment II.

5.0 Administration of Water Rights in the Middle Rio Grande

According to personal communication with the Office of the State Engineer staff (Feb. 21, 2003) the only privately-held surface-water rights in the Middle Rio Grande Valley are pre-1907 rights. Many of these rights have not been validated at the Office of the State Engineer (OSE), since the OSE is only obligated to review applications to validate water rights in the event of a proposed sale or transfer of these rights. The OSE Water Rights Division is not obligated to validate water rights without an application for transfer of that water right. However, they can perform this validation with an application for a “temporary transfer” – which could be a lease. The OSE generally bases its decisions concerning the validity of a pre-1907 water right on the 1917 Irrigation and Drainage Survey. If the lands are irrigated in this survey, and there is no evidence of abandonment after that date, then the right is considered proven. If the lands were not irrigated in the 1917 survey, then proving of the water rights would require submission of other evidence of prior irrigation, such as a 1914 survey done in Bernalillo County, or records of irrigation on that particular piece of land. The 1917 survey showed irrigation of 48,800 acres.
Water rights associated with lands shown as alkali in that survey would be denied validation, unless the candidate shows other evidence of previous irrigation.

Under the New Mexico Conservancy Act of 1923, conservancy districts such as the Middle Rio Grande Conservancy District (MRGCD) are also authorized to hold water rights. The MRGCD presently operates under two OSE permits, 0620 and 1690, which include up to 42,482 acres of “newly reclaimed lands”, which were designated to be made irrigable based on drainage and land improvements associated with the creation of the District. The MRGCD rather than private landholders would hold any rights perfected under these permits for these lands. Presently, irrigation may be performed under the permitted rights associated with these acreages through leasing of water from the MRGCD through the District’s Water Bank. However, it should be noted that the MRGCD’s water bank, although authorized by the Conservancy Act, has not been sanctioned by the OSE, and the reclamation and beneficial use of these 42,482 acres have yet to be perfected through the submission of a Proof of Beneficial Use by the MRGCD to the OSE.

6.0 PURCHASE AND ADMINISTRATION OF SENIOR WATER RIGHTS FOR IN-STREAM FLOW

Based on discussions with the OSE staff (Feb. 21, 2003):

- The Program may only need to acquire water rights for its consumptive uses (e.g., ET, seepage, and conveyance losses) – not for the entire amount of water flowing down the river to meet Program Goals.
- If the Program acquires senior water rights, it should, according to OSE practice, receive for river flow for each acre of water rights purchased the 3.0 acre-feet per acre designated as the farm delivery requirement, with a right to consume 2.1 acre-feet per acre of that. The farm-delivery requirement of 3.0 acre-feet per acre is the amount of water transferred to a groundwater user who purchases a surface-water right. To date, it has not been the practice of the OSE to give diversion rights equal to the full amount that the MRGCD diverts for an acre to be irrigated, but they generally only transfer surface-water rights to groundwater rights, and in those cases the river diversion amount isn’t relevant. They also said that the OSE “allows the MRGCD to divert significantly higher than 3.0 acre-feet per acre, but it does not say that the MRGCD has a RIGHT to this water. The percentage of diversion that can be offset by return flow varies from purpose to purpose. The allowed consumptive irrigation requirement (CIR) of 2.1 acre-feet per acre is viewed as allowed river depletion.
- Under the present methods of administration, the management of water rights acquired by the Program to provide increased irrigation-season river flows would most easily be accomplished in the short run through the development of a cooperative agreement with the MRGCD for management of this water. This conserved water could potentially be stored in El Vado Reservoir in a designated pool, for release as the Program sees most beneficial for endangered species. The OSE would help administer such an agreement.

7.0 OTHER WATER-RIGHTS ACQUISITION ISSUES

- Without adjudication or other proof of water right, the Program needs to be very cautious in its potential use or purchase of water to ensure that the seller actually holds the rights to this water. Transfer of a water right to address short-term or long-term Program goals would require proof to OSE of cessation of the former beneficial uses for the water transferred to the Program.
- In the past couple of years, all new permits (for transfer of water) require the use of the “best conservation technology”. It is not clear how this would apply to the Program.
• Any environmental water rights purchase program will have to be competitive with other consumptive use demands. Right now, there are only two options for water right owners: keep irrigating or sell to developers, and once a water right is transferred to development, it may never again be available for purchase or lease. Individuals might agree to temporarily lease all or a portion of their water rights for environmental uses if they were assured by the OSE that doing so would not jeopardize the rights.

• The current price of native Rio Grande water rights along the MRG is approximately $6,000 per acre-foot.

8.0 SAN JUAN CHAMA PROJECT INFORMATION AND WATER AVAILABILITY

Another possible method for long-term water acquisition for the program is the long-term sublease of San Juan Chama water. Since 1996, the Bureau of Reclamation or the Program has subleased San-Juan Chama water from contract-holders on an annual basis in order to supplement Rio Grande flows to support endangered species. The Program could also consider longer-term leasing arrangements (such as 10 or 20 years) with contractors.

The following description of the San Juan-Chama project is excerpted from the Middle Rio Grande Water Supply Study, prepared by S. S. Papadopulos & Assoc. for the U.S. Army Corps of Engineers and the New Mexico Interstate Stream Commission, 2000:

Trans-mountain diversions of the San-Juan Chama Project were initiated in June 1971, to provide supplemental water supply to New Mexico entities contracting for this water. The US Bureau of Reclamation project, authorized by Public Law 87-483, diverts water from three tributaries of the San Juan River in Southwestern Colorado (the Navajo, Little Navajo, and Blanco rivers), and delivers it through a series of tunnels across the continental divide into northern New Mexico. Project deliveries are measured at the mouth of Azotea Tunnel, which discharges to Willow Creek, a tributary of the Rio Chama. Project water is stored in Heron Reservoir on Willow Creek, just above its confluence with the Chama. The total San Juan-Chama allocation, measured as released from Heron Reservoir, is 96,200 acre-feet per year, ...[all of which is presently contracted except for 2,990 acre-feet which has been reserved for the settlement of Indian water rights in the Taos area]. Included in this amount is 70,400 acre-feet per year contracted to entities within the Middle Rio Grande region, 5,605 acre-feet per year contracted to the city [and County] of Santa Fe and 5,000 acre-feet per year to maintain the recreation pool at Cochiti Lake, for a total contracted quantity for use between Otowi gage and Elephant Butte of 81,005 acre-feet per year. San Juan -Chama water delivered for use in the Middle Rio Grande regions is assessed a 2% conveyance loss between Heron Reservoir and Otowi gage, as approved by the Rio Grande Compact Commission in 1979.

The existing contracts for San Juan-Chama water, including the amount of water contracted and the expiration date of the contract, if applicable, are summarized in Attachment III to this document.

As long as the operation and maintenance of the San Juan-Chama Project complies with the Upper Colorado Basin Compact, the Rio Grande Compact, and there is water to transfer from the Upper Colorado Basin to the Rio Grande Basin, the USBR is under contract to deliver that water to contractors. However, some discretion on the delivery of that water has been clarified by recent court decisions (Judge Parker, September 2002, 10th Circuit Court of Appeals, April 2003). These decisions are currently on appeal.
9.0 CONCLUSION AND RECOMMENDATIONS

1. Since 1996, the Reclamation has subleased San-Juan Chama water from contract-holders on an annual basis in order to supplement Rio Grande flows to support endangered species. This program of short-term leasing will need to be continued until longer-term strategies are implemented. Reclamation has also acquired short-term water from the state of New Mexico, and the present agreement with the state will provide supplemental water through 2005. However, there is no indication that water will be available in the future through such agreements.

2. The Program should work with Reclamation to acquire a long-term water supply to offset the depletions associated with habitat improvements (such as increased evaporation from wider, shallower reaches of river channel, low-velocity side-channels, and overbank areas) and with increased in-stream flows during the warmer summer months, to the extent that these increases in depletions cannot be offset through Program water salvage projects. These depletions are considered “new” uses on the MRG water system, and so must be offset through the retirement of existing uses through the purchase of water rights or water contracts.

3. The Program should work with Reclamation to ensure long-term or permanent acquisition of water to support the goals of the Program, through some combination of acquisition of native Rio Grande water rights or lands with appurtenant water rights, long-term sublease of San-Juan Chama water or other water available by contract with willing lessors, or implementation of a long-term, programmatic irrigation forbearance program with an annual target (in which, for instance, a number of irrigators agree to accept compensation in lieu of irrigating say once every five years, and this forbearance is rotated annually), if ongoing studies determine that such an approach is feasible.

4. The amount of water that the program will be required to purchase to assure in-stream flows and near-stream habitats for the long-term conservation and recovery of the Rio Grande silvery minnow and the southwestern willow flycatcher will ultimately depend upon the success of the habitat restoration efforts, water salvage projects, voluntary irrigation forbearance programs, and water management efficiency improvements supported by the Program. The Program Management Subcommittee has determined that a comprehensive evaluation of the additional depletions associated with Program activities will need to be performed. The Depletions Subcommittee of the program is preparing a white paper on the state-of-knowledge related to the determination of depletions associated with activities or conditions on the river.

5. When the Program leases, buys, or otherwise acquires water for use to benefit Program goals, assurance must be obtained that the willing seller actually owns the water right being transferred and that the seller actually ends consumptive use of this water when he sells its associated right.

6. Administration of the dedication of water rights purchased by the program to in-stream flows and near-stream habitats will likely require, at least in the short-term, a cooperative agreement with the MRGCD.

7. In order to effectively manage the acquired water, it will be necessary for the Program, or one of its signatories, to secure the right to store and manage the acquired water in one or more upstream reservoirs.

4.0 BIBLIOGRAPHY

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NM Office of the State Engineer. 1999. Litigation and Adjudication Program. Water Information, Office of the State Engineer, Santa Fe, NM.  
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ATTACHMENT I:

Summary of Short-Term Water Acquisition

Table D-1.1: Summary of Rio Grande Supplemental Water Leasing Program: Leased San-Juan Chama Contract Water (acre-feet)

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<td>46,150</td>
<td>58,595</td>
<td>114,70</td>
<td>14,150</td>
<td>57,013</td>
<td>19,93</td>
<td>16,70</td>
<td>12,75</td>
<td></td>
<td>399,99</td>
</tr>
</tbody>
</table>

*Notes: P - Pending  D – Donated

ANNUAL AVERAGE 39,999
### Attachment II: Summary of Short-Term Water Acquisition

Table D-2.1: Summary of Rio Grande Supplemental Water Released since 1996 (acre-feet)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Leased San Juan-Chama Water</td>
<td>47,54</td>
<td>14,41</td>
<td>47,03</td>
<td>19,48</td>
<td>159,9</td>
<td>48,33</td>
<td></td>
<td></td>
<td></td>
<td>361,5</td>
<td>40,175</td>
</tr>
<tr>
<td>MRG ESA Conservation Pool</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>25,62</td>
<td>25,85</td>
<td>0</td>
<td>0</td>
<td>83,02</td>
<td>9,225</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>46,34</td>
<td>7,200</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>53,54</td>
<td>5,950</td>
</tr>
<tr>
<td>Annual Total</td>
<td>47,54</td>
<td>14,41</td>
<td>47,03</td>
<td>19,48</td>
<td>206,2</td>
<td>32,82</td>
<td>74,18</td>
<td>4</td>
<td>9</td>
<td>498,1</td>
<td>55,350</td>
</tr>
</tbody>
</table>
Attachment III
Water Rights Concepts and Definitions

- **Water Right:** a legal right to use, generally as proven through a diversion from a main water body and subsequent beneficial use for the diverted water. The right relates a specific quantity of water for a specified beneficial use or uses.

- **Beneficial Use:** This concept is not specifically defined in New Mexico water law. Generally, all uses including agricultural, commercial, industrial, and recreational are considered beneficial, excluding the willful waste of water. A March 27, 1998 Opinion from the New Mexico Attorney General (Belin 1998) concluded that in-stream flow can be considered a beneficial use (see Other Water Acquisition Issues).

- **Appropriation:** water set aside and put to beneficial use, associated with the date on which water was put to the beneficial use.

- **Waste:** any water diverted by man that is not put to beneficial use; NM law classifies the “willful waste of surface or groundwater to the detriment of another or the public” as a misdemeanor.

- **Prior Appropriation:** doctrine that enables the first person who diverts water and puts it to beneficial to become the highest-priority water-rights holder. Rights are determined by the date of initiation of the right: first users take precedence over users who come later—“first in time, first in right.”

- **Prior and Paramount Water Right:** The most Senior Water Rights in New Mexico, held by Native American Pueblos. A Prior and Paramount water right is defined as the right (a pueblo water right) that any pueblo “municipality,” with its origins tracing to a Spanish or Mexican pueblo grant, has to all water of non-navigable streams flowing through or by the pueblo to the extent necessary to serve its future growth (until the Pueblo Lands Act of 1924). Prior and Paramount water rights have also been granted to Middle Rio Grande Pueblos of Middle Rio Grande native water, even though the MRG is considered a navigable waterway.

- **Senior Water Right:** A (non-Pueblo) water right that has a higher priority than a Junior water right. In New Mexico, Senior Surface Water Rights are those initiated prior to 1907, the date of promulgation of the New Mexico Surface Water Code. These rights are considered Senior, and Vested (see below).

- **Vested Water Right:** Rights established before the 1907 Surface Water Code, or a groundwater right established prior to the state engineer’s declaration of an underground water basin. Vested water rights are transferable without restrictions.

- **Conditioned Water Right:** a water right granted under a condition that would prevent the right from adversely affecting flow of a stream or another water right.

- **Apportionment:** the diversion and distribution of water according to a plan.

- **Fully Appropriated:** the condition in which all available water has been reserved for existing water rights.

- **Adjudication:** a formal court proceeding that results in the determination of the validity and extent of water rights associated with an area. This involves two processes: (1) a hydrographic survey to identify, map, and report the ownership of water right within a particular stream system or groundwater basin; and (2) a legal proceeding through which the court orders how much water each user has right to divert and use for a specific beneficial purpose.

- **Consumptive irrigation requirement (CIR):** the amount of water that plants need over the entire growing season for transpiration and for building plant tissue, plus evaporation from the soil surface.
• **Depletion:** the amount of water consumptively used and therefore not returned to a surface or groundwater system.

• **Return flow:** water diverted for a use that finds its way back to its source of supply.
The USBR is under contract as part of the San Juan Chama Project to deliver project water to the following contractors:

**Municipal, domestic, and industrial purposes**
- City of Albuquerque (1963 – no expiration): 48,200 acre-feet
- Jicarilla Apache (1992 – no expiration): 6,500 acre-feet
- City of Santa Fe and Santa Fe County (1976 – Dec. 31, 2016): 5,605 acre-feet
- City of Española (1978 – Dec. 31, 2018): 1,000 acre-feet
- Town of Belen (1990 – no expiration): 500 acre-feet
- Town of Bernalillo (1988 – no expiration): 400 acre-feet
- Town of Red River (1990 – no expiration): 60 acre-feet
- San Juan Pueblo (2001 – no expiration): 2,000 acre-feet

**Irrigation:**
- Pojoaque Valley Irrigation District (1972 – no expiration): 1,030 acre-feet

**Recreation:**
- Corps - Cochiti Rec. Pool (1964 – no expiration): Up to 5,000 acre-feet

**Allocated, but uncontracted**
(water currently identified for future Indian water rights settlements and or use):
- Taos Area 2,990 acre-feet

**Total Allocation:** 96,200 acre-feet

Attachment E-5

WATER ACQUISITION AND MANAGEMENT SUBCOMMITTEE POSITION PAPER:
MUNICIPAL AND INDUSTRIAL CONJUNCTIVE USE STRATEGIES

1.0 INTRODUCTION

The ESA Collaborative Program (Program) is exploring options for maintaining flows in the Rio Grande for endangered species. Municipal conjunctive use has been proposed as an option that could be used to supplement river flows during periods of low flow. At this time, the City of Albuquerque (City) is the only municipality in the Middle Rio Grande that is a signatory to the Program; therefore, much of this paper is focused on City conjunctive use and its long-term water strategy. This paper will provide background on conjunctive use concepts in general, an overview of groundwater pumping in the basin and discuss potential of the City’s Water Resources Strategy, particularly the Albuquerque Drinking Water Project, to assist in maintaining river flows.

2.0 BACKGROUND

Groundwater and surface water in the middle Rio Grande are in hydrologic connection, but the precise nature this connection is uncertain. Impact of present and future pumping by the City of Albuquerque and other municipal and industrial water users directly affects the flow of the Rio Grande over time. While municipal and industrial water users must offset their pumping effects, New Mexico state water law does not require offset of stream effects from domestic well pumping.

Conjunctive use may be defined as the combination or integration of the management, administration and use of surface water and ground water that would:

- Minimize the undesirable effects of the use of each source of supply as used individually;
- Redistribute supplies to minimize differences between supply and demand;
- Increase water supply yield, water use efficiency and project cost effectiveness; and
- Achieve greater benefits than might be achieved under isolated management of individual sources of supply.

Middle Rio Grande water resource conjunctive use management methods might include reduction of diversion of surface water in exchange for the diversion of equal quantities of groundwater and actively storing surface water in underground water basins in wet years and withdrawing this water from the basin during periods of low surface water supply.

Physical components of conjunctive use of water supply could include:

- Surface water reservoirs
- Surface water diversion structures;
- Recharge wells/infiltration basins;
- Groundwater withdrawal wells;
- Surface water/ground water monitoring network.
Regulatory matters related to the administration of the conjunctive use of the water supply:

- Regulations to administer the storage of surface water in an underground water basin and the subsequent recovery of this water were promulgated in 2001;
- State water rights permitting conditions;
- Rio Grande Compact provides for a system of delivery credits and debits which could provide flexibility needed for implementation of conjunctive use management.

This paper is intended to examine the potential for the conjunctive use of the water supply of the Middle Rio Grande to supplement or maintain surface flow for the benefit of federally listed endangered species. The City Of Albuquerque is in the process of obtaining approval for its Drinking Water Project which is one example of a conjunctive use strategy for providing water to the City customers and curtailing diversions from the river during times of low flow so as not to impact downstream users or endangered species.

### 3.0 OVERVIEW OF GROUNDWATER PUMPING IN THE ALBUQUERQUE BASIN

At present, all municipal, industrial and domestic water supplies in the Middle Rio Grande come from groundwater pumping. Following is a table which reflects the major diversions of groundwater from the Albuquerque Basin. Because this information has not been consolidated for the last several years, some of the data represents different years, but it gives some idea of the existing and permitted pumping in the basin.

The City of Albuquerque pumps by far the largest quantify of groundwater from the Albuquerque Basin. The City pumps from approximately 90 wells in the metropolitan area.

It should be noted that the Current Pumping figure does not represent consumptive use, because return flows are not included in the table. Consumptive use is the difference between the water that is pumped and the water that is returned to the system through return flows, usually through treated effluent. Also, Permitted Diversion amounts do not indicate whether water rights are held by the permittee sufficient to offset the projected impact of the pumping and allow the entire permitted diversion amount to be pumped annually.

Because the Middle Rio Grande is a fully appropriated system, the State Engineer requires that offset water rights in the amount adequate to fully offset the pumping impacts on the Rio Grande be acquired by the permittee. The timing of when these effects reach the river and the timing of when the water rights must be transferred to the permit are subject to the terms of the various permits and the Middle Rio Grande Administrative Area Guidelines for Review of Water Right Applications (2000).

### 4.0 ALBUQUERQUE WATER RESOURCE MANAGEMENT STRATEGY

Following is a discussion of Albuquerque’s Water Resource Management Strategy, which includes the Drinking Water Project (DWP), conservation program, aquifer storage and re-use projects.

#### 4.1 City of Albuquerque Drinking Water Project (DWP)

Operations of the DWP will be subject to State Engineer conditions of approval included in Permit No. 4830 (currently pending) to ensure that the DWP is not operated to the detriment of valid existing water
### Albuquerque Basin estimated groundwater diversions in acre feet per year

<table>
<thead>
<tr>
<th>Type of Pumping or Name of Permittee</th>
<th>Permitted Diversions (^1) (AFY)</th>
<th>Current Pumping (AFY)</th>
<th>Year of current pumping estimate</th>
<th>Source of Data for Current Pumping Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic well pumpage</td>
<td>7,063</td>
<td>7,063</td>
<td>1990</td>
<td>USGS estimate(^2)</td>
</tr>
<tr>
<td>City of Albuquerque</td>
<td>155,000(^3)</td>
<td>107,860</td>
<td>2002</td>
<td>City of ABQ</td>
</tr>
<tr>
<td>Rio Rancho</td>
<td>26,416(^4)</td>
<td>10,744</td>
<td>2000</td>
<td>Shomaker Report(^5)</td>
</tr>
<tr>
<td>Los Lunas</td>
<td>2,250</td>
<td>2,178</td>
<td>2000</td>
<td>USGS estimate</td>
</tr>
<tr>
<td>Belen</td>
<td>4,190</td>
<td>1,473</td>
<td>1999</td>
<td>Shomaker Report</td>
</tr>
<tr>
<td>Bernalillo</td>
<td>1,174</td>
<td>1,170</td>
<td>1999</td>
<td>USGS estimate</td>
</tr>
<tr>
<td>Kirtland AFB</td>
<td>4,500</td>
<td>3,770</td>
<td>2000</td>
<td>Shomaker Report</td>
</tr>
<tr>
<td>PNM</td>
<td>6,720</td>
<td>427</td>
<td>1997</td>
<td>State Engineer records</td>
</tr>
<tr>
<td>Rio Grande Utilities (Valencia County)</td>
<td>10,800</td>
<td>1,246</td>
<td>1999</td>
<td>Shomaker Report</td>
</tr>
<tr>
<td>Sandia Peak Utility</td>
<td>1,010</td>
<td>828</td>
<td>1999</td>
<td>Shomaker Report</td>
</tr>
<tr>
<td>New Mexico Utilities</td>
<td>10,000</td>
<td>7,182</td>
<td>1999</td>
<td>Shomaker Report</td>
</tr>
<tr>
<td>National Utility Co.(Meadowlake, Valencia County)</td>
<td>1,920</td>
<td>183</td>
<td>1999</td>
<td>Shomaker Report</td>
</tr>
<tr>
<td>Intel</td>
<td>3,250</td>
<td>3,051</td>
<td>2000</td>
<td>Intel Report to SEO</td>
</tr>
<tr>
<td>UNM</td>
<td>2,685</td>
<td>2,271</td>
<td>1995</td>
<td>USGS estimate</td>
</tr>
<tr>
<td>All other tabulated permittees</td>
<td>14,206</td>
<td>*14,206</td>
<td>*</td>
<td>*Permitted diversion amount has been used for current pumping estimate</td>
</tr>
<tr>
<td></td>
<td><strong>225,768</strong></td>
<td><strong>163,652</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rights in the Rio Grande basin or of the “public welfare”, such as the State’s ability to meet Rio Grande Compact delivery requirements.

Through implementation of the DWP and re-use and water conservation, the City intends to:

- Reduce its pumping, which is anticipated to reduce the rate of drawdown of the aquifer and extend the useable life of the aquifer.
- Curtail surface diversions during low-flow periods to minimize effects on the river;

---

\(^1\) All Permitted Diversion data is from the “Documentation of the Administrative Groundwater Model for the Middle Rio Grande Basin (OSERG)” Barrol 9/01, unless otherwise noted.

\(^2\) “USGS estimate” refers to a personal communication between City and Doug McAda, USGS (9/03).

\(^3\) Increased diversion permit approved September 4, 2003.

\(^4\) Increased diversion permit approved August, 2003.

• During low flow periods, increase pumping, thereby supplementing the river with increased return flows below Albuquerque;

• Establish and manage a drought reserve in the Albuquerque basin aquifer for use in times of severe and prolonged drought;

• After development of ASR capability (aquifer storage and recovery), periodically recharge the Albuquerque basin aquifer during times when there is a surplus of treated surface water. (Note: given the capacity of the treatment facility, aquifer storage is likely to comprise a small fraction of the total diversion.)

4.2 Adaptive River Management – Annual Operations Plan

Under the DWP, the City will continue to work closely with those agencies having responsibility in managing the flows of the Rio Grande and Rio Chama. These include Reclamation, the U. S. Army Corps of Engineers (COE), the Office of the State Engineer (OSE), the Middle Rio Grande Conservancy District (MRGCD) and the U. S. Fish and Wildlife Service (Service).

The City, in consultation with the above agencies and with reference to the Upper Rio Grande Water Operations Model (URGWOM), intends to annually evaluate its surface water supply: snowpack, water available in reservoir storage, seasonal weather forecasts, and other factors particularly in the late-winter and early-spring periods leading up to the irrigation season (which begins in March). Preliminary decisions and action plans will be formulated for managing City’s SJC water, based on predicted supply. When the likelihood of low-flow or drought conditions is anticipated, the DWP may be curtailed or shut down entirely for several months. As the critical warm weather irrigation season approaches (usually beginning in late May or early June), flow forecasts and river management decisions will be updated and specific plans formulated for managing the City’s DWP release and diversion program for the coming year.

4.3 Past Pumping Effects

The City’s past pumping has lowered the water table in the aquifer inducing continued seepage of native Rio Grande water into the adjacent aquifer. The effects of this additional seepage will continue for the foreseeable future. When the DWP begins operation in 2006, the city will have stored water for the purpose of offsetting lingering effect of historical City pumping on the river. In accordance with the conditions on the City’s existing ground-water permits under RG-960 and the Guidelines for Review of Water Right Applications in the Middle Rio Grande Administrative Area, the City must offset both current and historical pumping effects. The City will meet these conditions by applying (crediting) vested and acquired native Rio Grande groundwater rights claimed by the Albuquerque, return flow from the Southside Wastewater Reclamation Plant, and releases of water previously borrowed by the MRGCD and the Bureau of Reclamation.

The estimated total water needed to offset the residual pumping effects, as calculated using the OSE interim model, for the period from 2006 to 2016 is about 91,000 aE-ft. The timing by which this offset water is released is subject to discretion. If discussions among the Interstate Stream Commission, the State Engineer Office, MRGCD and the Program are initiated to establish criteria for the release of this water, the City will work with the agencies to ensure that the water is released in a manner that is consistent with the needs of the river and the region.

Recent OSE Middle Rio Grande Administrative model runs show residual impacts of historic Albuquerque pumping will be about 9,500 acre-feet per year in the year 2060.

“2002 City of Albuquerque Drinking Water Project DEIS.” Note that it is difficult to reliably predict the future demand and hydrologic conditions in the Middle Rio Grande and that the actual Albuquerque water budget will be determined based on actual conditions, rather than the predicted values.
4.4 Hydrologic Effects and Operation of the DWP Diversion

First, it is appropriate to consider the hydrologic effects of the removal of the Albuquerque’s historic uses of San Juan-Chama Project water for the system. Albuquerque estimates that during the 1989-1998 period an average of 27,800 acre-feet of Albuquerque’s San Juan-Chama Project water flowed past the Albuquerque gage [41,600 acre-feet at the Otowi gage] each year. Once the DWP comes on line, the City intends to divert the bulk of its SJC water, and these “excess” flows will no longer be available at the Central Avenue Bridge.

Second, to provide for an objective evaluation of hydrologic effects of the DWP on the Rio Chama and Rio Grande through Albuquerque and downriver, it is necessary to specify specific values of flow, release, and diversion under a hypothetical operation of the DWP. The release-diversion scenarios described below are intended for that purpose, and represent a worst-case condition for evaluation under Permit Application No. 4830 (currently pending).

In most years, assuming a diversion point in the vicinity of Paseo del Norte, the project will be operated with a constant release of about 66 cubic feet per second (cfs) of City SJC water from Abiquiu Reservoir. After incurring conveyance losses between Abiquiu and Albuquerque, approximately 65 cfs of SJC water will reach the diversion facilities. There a constant diversion of 130 cfs will occur throughout the year provided flows are more than or equal to the ‘threshold flow’ of 200 cfs just above the diversion point. The 130-cfs DWP diversion will include 65 cfs of SJC water and 65 cfs of native water. The 65 cfs of SJC water will be consumptively used within the City’s Water Service Area. The 65 cfs of native water will, in effect, be returned to the river at the City’s Southside Wastewater Reclamation Plant (SWRP) outfall near the Rio Bravo Bridge.

4.5 DWP Curtailment Strategy

To ensure that DWP diversions do not dry up or otherwise adversely affect the riverine ecology between the diversion and return flow points, the City proposes to implement a curtailment strategy as described below.

For the full operation of the DWP under a constant release-diversion scenario, the flow at the Paseo del Norte diversion point must be at least 260 cfs based on the following:

- A diversion rate of 130 cfs comprised of 65 cfs of SJC water and 65 cfs of native water;

---

8 It is streamflow from the Rio Grande (that has been and is projected to be) depleted by the City of Albuquerque by its junior well pumping. It is water that will be owed in part to MRGCD (and the entities served by MRGCD works) and in part to Compact deliveries since those are parties whose senior water will be taken by the City’s junior pumping.

9 This is not to imply that the City’s SJC water has always been flowing uniformly downstream. A significant portion of this average was conveyed by the City to MRGCD who, in return, agreed to operate its diversions so as to maintain a minimum of 250 cfs between Central Avenue and Isleta. That agreement, executed in 1992, expired in 2001. Another 53,000 AF of water was delivered to Elephant Butte to replenish the recreation pool in the mid-1980s and the early 1990s. Additional quantities were leased to the Bureau of Reclamation for use in the Bureau’s Supplemental Water Program during the period from 1996 through 2000.
• A fishway bypass flow of 50 cfs on the west side of the river and 20 cfs at the outlet of the sluiceway on the east side of the river to provide for downstream movement of sediment and fish past the intake screens (for the surface diversion option); and

• A main channel flow of 60 cfs.

Thus, the total flow required to fully operate the DWP at 130 cfs is \( (130 + 60 + 50 + 20) = 260 \text{ cfs} \). When native flows at the diversion point fall below 195 cfs (total flow of 260 cfs including 65 cfs SJC in the river), the City will begin curtailing the quantity of the diversion by 1 cfs for each 1 cfs drop in native flow. However, the City would continue to release from upstream and divert at Albuquerque the full 65 cfs of SJC water. As native flow continues to drop, DWP diversions would be reduced accordingly. When native flow reaches 130 cfs above the diversion (assumed equivalent to about 165 cfs at the Albuquerque gage), DWP diversions and SJC releases will be cut off entirely. From the gage to the SWRP return flow point, minimum flows will be about 165 cfs, minus seepage and evapotranspiration losses plus any gains due to returns, thereafter increased by the amount of the return flow at the SWRP. The City, however, may determine during the development of the Annual Operations plan to shut down early and avoid this type of operation.

During periods of curtailment, the City will provide increasing amounts of water to the water service area from wells. During periods of complete shut down of river diversion, the water service area will be supplied entirely from wells.

4.6 **Aquifer Storage and Recovery**

Details of the City’s aquifer storage and recovery (ASR) operation, including pilot testing and an operating permit from OSE, have yet to be developed. However, a general ASR plan of operation is known. The new water treatment plant for the DWP will normally operate at an essentially constant rate of 84 mgd or 130 cfs, however, it will have the capacity to operate at 92 mgd or 142 cfs. Peak summer demands, which are considerably higher than the plant’s capacity, would be met with City well pumpage. During low-demand periods, typically October through March, the Plant would be producing sufficient water (more than demand) to allow the wells to be turned off. During this period, recharge would be accomplished by injection into City wells. The amounts of water involved, number of recharge wells, and other aspects of the ASR program await development over the next few years.

4.7 **Conservation and Re-use projects**

As part of development of the City of Albuquerque’s adoption of the Water Resource Management Strategy, the City adopted a water conservation goal of reducing its 1995 use by 30% by year 2004. This translates into a reduction from 250 gallons per capita per day (gpcd) to 175 gpcd. As of late 2002, the City had reduced overall use by about 26%. Total production in 2002 was more than two billion gallons less that in 1996. These water savings were realized even as the City added more than 16,000 new water accounts to its system and despite the fact that rainfall has been below average for the past 5 years. Current (2002) residential use averages approximately 138 gpcd. In May 2003, the Mayor announced an increase in the City’s water conservation goal to 40%. This reduction is designed to take place from 2005 to 2014. This would take per capita usage to 150 gallons per capita per day (gpcd).

The City of Albuquerque has constructed several re-use projects and is currently developing a wastewater treatment project. Altogether these projects will reclaim about 7,000 acre feet of water to be used for non-potable purposes. First, the City is re-cycling wastewater from several industrial customers in the North I-25 area. The water is blended with surface water from the subsurface diversion structure, recently constructed south of Alameda Bridge. The water will be used to irrigate the Balloon Fiesta Park, new soccer fields and eventually the Journal Center landscaping and all major public landscaped areas north of Montgomery Blvd. The City is designing a Southside Municipal Effluent Recycling project proposed to take treated wastewater from the sewage treatment plant and clean industrial wastewater to be recycled.
and sent through a special pipeline to the UNM Sports Complex, golf courses and parks in the southeast heights.

5.0 CITY OF RIO RANCHO

The City of Rio Rancho pumps about 3.5 billion gallons (approximately 10,500 aE-ft) of water each year, which has remained fairly constant since 1997, despite a 17% increase in the number of accounts. The Rio Rancho Utilities Department serves 22,000 accounts. Current use is about 181 gpcd. Rio Rancho’s gpcd goal is 150. The fastest growing City in New Mexico, Rio Rancho grew from 10,000 in 1980 to 52,000 in 2000; by 2040, the population is likely to reach more than 150,000. Rio Rancho currently has permits to pump 26,416 acre-feet per year. In addition to purchasing water rights to offset effects of pumping, the City has adopted a Water Reuse Strategy to maximize beneficial use of current supplies through reclaiming highly treated wastewater for nonpotable uses and to augment and replenish the City’s groundwater supply through aquifer recharge by 2008.

6.0 MUNICIPAL FLOOD CONTROL AUTHORITIES

Rainfall events in urban watersheds produce variable and unpredictable quantities of stormwater. Stormwater in the combined average amount of approximately 10,000 acre-feet annually is discharged through Sandoval County and Albuquerque Metropolitan Arroyo Flood Control Authority channels to the Rio Grande. Under the federal Clean Water Act, a TMDL (Total Daily Maximum Load) has been determined for fecal coliform bacteria in stormwater discharges. The Flood Control Authorities (FCA) are considering alternative capital improvements to comply with the TMDL. Projects under consideration include treatment of stormwater and possible infiltration of stormwater to the aquifer. While a conjunctive use scheme with stormwater is speculative, it may receive investigation from the FCAs.

7.0 CONCLUSIONS

- Albuquerque Basin groundwater pumping impacts the flows of the Rio Grande.
- Municipalities are required to own or lease water rights to offset their pumping effects.
- In 2006, the City of Albuquerque’s Drinking Water Project (DWP) is scheduled to begin directly using imported San Juan-Chama water in order to reduce its reliance on groundwater pumping. The City’s DWP permit from the OSE will contain conditions designed to prevent increased depletions below the Southside Wastewater Reclamation Plant (SWRP).
- After the City’s DWP is implemented, there may be an opportunity to consult with the OSE/ISC to time the release of offset water to accommodate Program flow requirements along with MRGCD and Compact requirements.
- When DWP surface water diversions are curtailed and groundwater pumping resumes, City return flows will provide a water to the river downstream of the Southside Water Reclamation Plant (SWRP).
- During the 1989-1998 period an average of 27,800 acre-feet of Albuquerque’s San Juan-Chama Project water flowed past the Albuquerque gage. After the DWP is implemented, most of this water will no longer be available.

Estimate based on USGS “Water Resources Data-New Mexico” values for AMAFCA North Floodway, doubled to account for SCFCA for which no data are reported. Much of this water is not capturable.
• A primary goal of the City’s DWP curtailment strategy is ensuring that operations of the project do not adversely impact the silvery minnow habitat in the Albuquerque reach during times of low flow.

• City water conservation and reuse efforts are intended help slow the increase of the City’s effects on the river, while municipal population continues to increase.

• The City and other entities will investigate aquifer storage and recovery to help diminish pumping effects on the Rio Grande.

• Data collection and research into the groundwater-surface water interaction should be continued.
1.0 INTRODUCTION

The Middle Rio Grande (MRG) Endangered Species Act (ESA) Collaborative Program (Program) is exploring options for enhancing flows in the middle Rio Grande valley for endangered species. This paper discusses potential benefits to the listed species that might result from irrigation efficiency improvements, including both off-farm (conveyance) and on-farm efficiencies for surface-water irrigation systems within the MRG. Between Otowi Gage and Elephant Butte Reservoir, irrigation is mainly under the jurisdiction of the Middle Rio Grande Conservancy District (MRGCD).

The purpose of this paper is to consider whether potential improvements in irrigation efficiency would benefit the ESA Collaborative Program (Program) by increasing flows in the MRG for the benefit of endangered species. This paper includes an explanation of irrigation efficiency as it relates to MRGCD operations. It also includes a discussion of potential positive and negative effects that might accompany efficiency improvements.

2.0 BACKGROUND

2.1 Irrigation Efficiency

To understand the potential benefits of irrigation efficiency within the MRG, it is necessary to define the term and understand MRGCD operations. This paper considers both off-farm and on-farm irrigation efficiency. The off-farm (conveyance) efficiency of an irrigation system is defined as the quantity of water delivered to farms divided by the water supply to that system diverted from the main source. In the MRGCD, the source is the Rio Grande. Irrigation efficiency is not a reflection of the consumptive use within the irrigation system, and improving efficiency is not equivalent to cutting consumptive use. Improving irrigation system conveyance efficiency could simply allow more of the water that is moving down the valley to do so in the river, rather than in the canals of the irrigation system or in the shallow groundwater system.

Improvements in off-farm irrigation efficiency might come from improvements in system operations, or from physical improvements to the irrigation system infrastructure, including lining of canals, installation of additional check structures, automating of water control structures, and other structural changes to the conveyance system. Both physical and operational improvements have some potential to benefit the Program, as well benefit irrigators, through improvements to the equitable distribution of water and the length of the irrigation season when water is in short supply. However, any changes that result in less water in the irrigation water conveyance canals may also have negative consequences, potentially including reduced aquifer recharge and, in turn, less water available to wildlife habitat along the canals and diminished recreational and quality-of-life amenities associated with the canal system.

Similarly, on-farm efficiency is the quantity of water consumed on a farm divided by the amount of water delivered to that farm. Improvements in on-farm efficiencies do not significantly change the consumptive requirements of crops or their productivities, except possibly through incidental improvements in farming practices. Instead, improvement in on-farm efficiency decreases the amount of water required at the farm turnout to irrigate the crop. Examples of improvements to on-farm efficiencies include improvements that can decrease the time required to deliver the needed water to the farm through the farm turnout, or the hydraulic head required in the main canal to allow water delivery. On-farm improvements often lead
directly to improvements in off-farm efficiency. Both categories of irrigation efficiency have potential benefits to the Program, so both are considered in this paper. Irrigation efficiencies might be achieved through improved water delivery operations, physical improvements to the conveyance system, improved farm practices, or a combination thereof.

It is important to recognize that the water diverted by an irrigation system includes water that is consumed on farm and during conveyance through open water evaporation and riparian evapotranspiration as well as water that is used for conveyance but not consumed. It is the non-consumed water that is the primary topic of this paper, since the Program is exploring ways to make more of this water available to support endangered species habitat along the MRG. Water could potentially be made available to support river flows and endangered species habitat through carefully managed conveyance efficiency improvements, or on-farm efficiency improvements in the irrigated acres served by this system. Such improvements are unlikely to create additional water that can be consumed elsewhere. Such non-consumptive conserved water may be made available to support flows, but cannot be diverted and consumed by some other use on route.

2.2 MRGCD Past and Present Diversions

Most definitions of irrigation efficiency do not account for the fact that in a system such as the one in the MRG, water that is diverted, used for conveyance, and returned to the source may be diverted again farther downstream. That re-diverted water may be either consumed or again returned to the source. This “recycling” is an essential fact of MRGCD operations and it tends to encourage the belief that that there is more water within the system than actually exists.

The return and re-use of water gives rise to what is perhaps the most controversial subject concerning the MRGCD. For many years, MRGCD reported the sum of diversions at its four diversion structures. That number has historically been very large (approximately 600,000 acre-feet per year [AF/year]) relative to the acreage irrigated. As a result, MRGCD appeared to be a very inefficient irrigation system. The number often reported in past years was a sum of the amount of water diverted at MRGCD’s four points, i.e., it was a "gross" diversion amount. It did not account for rediersion of water at the 3 downstream structures. In theory, 500 cubic feet per second (cfs) released from Cochiti reservoir could be diverted and fully returned for reuse at the three downstream diversions, resulting in a "gross" diversion of 2,000 cfs, with 500 cfs arriving at Elephant Butte (ignoring carriage losses and other factors). For example, the water supply for the Socorro Division of the MRGCD consists primarily of water originally diverted upstream at the Isleta Diversion Dam and subsequently carried downstream to Socorro in the conveyance system, with return flows also being conveyed downstream in the river channel. Past accounting based on the use of gross diversions incorrectly characterizes both the complex workings of MRGCD diversions and the efficiency of the MRGCD’s irrigation operations.

Each diversion downstream from Cochiti derives a significant portion of its supply from the upstream diversion. The term “net diversions” has been proposed as a method of accounting for this rediersion of water. The “net diversion” is calculated as the difference between the total “gross” diversions into the District and the total return flows made to the river from the irrigation system. Although return flows were not gaged until recently, occasional measurements of the return flows downstream from MRGCD diversions at Cochiti Dam and Angostura diversion show that the net diversion amount is unlikely to have exceeded approximately 350,000 AF.

Neither gross diversion nor net diversion fully represents MRGCD’s complex operations or the impact of the District on the River. Gross diversions present diversion numbers that give an artificially high impression of water use by the District, and may be higher than the total surface water in the valley, through recounting of the same water. However, irrigation efficiency improvements that redistribute water from the irrigation system into the river do result in changes in the magnitude of gross diversions, and therefore the concept of gross diversions can be used to evaluate the effect of efficiency
improvements. Net diversion values, on the other hand, more closely reflect the total water diverted, but may not change significantly in response to efficiency improvements. For example, if 500 cfs is flowing in the river, the net diversion would appear the same whether all 500 were diverted and 400 were returned at the bottom of the division, or if only 100 were diverted, and not returned – although in the first case, the river would be dry between the diversion and return points, and in the second case, the river would be flowing at 400 cfs between the two points.

MRGCD gross diversions have been declining steadily since 2000 (as have return flows), due primarily to the expansion of measurement of both diversions and return flows, along with a comprehensive re-evaluation and modification of operational practices necessitated, in part, by reduced water supplies. Funding for these efficiency improvements was provided by the New Mexico Legislature through the Interstate Stream Commission (ISC) and the Office of the State Engineer (OSE).

Gross diversions were reduced to 492,000 AF in 2001 and to 369,000 AF in 2002. Gross diversions in 2003 are currently projected to total slightly more than 300,000 AF. Both the 2002 and 2003 irrigation seasons were shortened by extended drought conditions. If those two seasons had been of the normal duration, diversions likely would have been greater, but perhaps only slightly. An analysis of diversions from March through August during the last eight irrigation seasons (i.e., 1995-2002) revealed that MRGCD gross diversions over that period declined 40% (based on MRGCD gage data, 12 August 2003). Net diversions have likely been reduced over the same period, although unmeasured return flows and the inherent difficulty of accounting for seepage to the drains from the river make that estimate less reliable.

Much of this improvement in efficiency has been accomplished through simple operational changes. An odd paradox of MRGCD diversions in the past was that the wetter the year, the larger the diversions. This generally happened because it was easier for conveyance system operators, and more convenient for irrigators, to leave canals running full when there was ample water in the river. One result of these operations was reduced threat of damage due to flooding from high river flows. Another common cause of large gross diversions was the manual operation of diversion dams, e.g., opening the intake gates wider as the river dropped causing large amounts of water to enter the conveyance system canals during rainy period when there was little demand for irrigation. Automation of Isleta diversion last year and the collection of return flow data the past few seasons has clearly demonstrated how such operations contributed to large "gross" diversion numbers.

2.3 MRGCD Demand and Water Conveyance Operations

MRGCD demand is not equivalent to consumptive use in the irrigation system. Rather, it is the discharge (i.e., flow) entering the MRG (from the Cochiti Reservoir outlet works) sufficient to allow the desired diversion of water at Cochiti, Angostura, and Isleta diversion dams. MRGCD demand also includes non-agricultural consumption from riparian vegetation and other uses between Cochiti and Isleta dams, and return flows from upstream divisions within the MRG. From the standpoint of irrigation demand, all irrigation water required by MRGCD downstream of Isleta Diversion Dam can be diverted there; that is, operation of the San Acacia Diversion Dam is not essential to maintain irrigation downstream of that diversion. Such operation would allow for easier monitoring of the downstream irrigation demand.

The MRGCD operates by storing native water in El Vado Reservoir (on the Rio Chama), and then releasing that water according to the irrigation demand in its system over the course of the irrigation season (subject to the constraints of the Rio Grande Compact). Most water is stored at El Vado during May and June, when snowmelt normally swells the Rio Grande and its tributaries. During the spring runoff period, the flow of the Rio Grande usually exceeds MRGCD demand. At most other times of the year, MRGCD demand is greater than the naturally occurring flow of the river, and varying amounts of supplemental irrigation water is released from El Vado. That volume of supplemental irrigation water would include the amount expected to be lost in conveyance between El Vado Reservoir and Cochiti.
Reservoir. If efficiency improvements lead to a decreased MRGCD demand, less water will be released from El Vado to meet that demand. The saved water will extend the MRGCD irrigation season, or remain in El Vado for use during subsequent irrigation seasons (subject to Rio Grande Compact constraints).

2.4 Administrative Framework

Water rights in the MRG are not adjudicated. However, the OSE has operated since the 1950’s under the assumption that the surface waters of the MRG are fully appropriated. That is, the sum of demands represented by permitted or claimed rights exceeds the supply. The available water supply has been fully divided for beneficial uses, but the rights of the individual users to that water have not been quantified. This circumstance is further complicated by the water rights of the six MRG Pueblos. These rights are as yet unquantified, they include rights that are the most senior rights in the system, and are rights that are subject to Federal rather than State regulation.

3.0 DISCUSSION

3.1 Efficiency Improvements as a Source of Water for the Program

The Program has expressed a desire to make available additional water, as a result of irrigation efficiency improvements, to augment river flows for endangered species. Although it may seem that any increase in irrigation efficiency should translate to more water remaining in the river, careful consideration reveals that “saved water” is water that passes through the water conveyance system unused, before being discharged downstream to the Rio Grande or the Low Flow Conveyance Channel. Due to the divert/return/divert practice along the MRG, the potential availability of additional water can only be determined by considering net diversions by MRGCD. At most times of the year, increases in efficiency would most likely only reduce the water volume discharged from El Vado Reservoir, thereby increasing the potential water supply available for future MRGCD demands. Only when the natural river flow is in excess of MRGCD demand would efficiency improvements likely provide direct benefits to endangered species.

Potentials may exist for the Program and the MRGCD to negotiate an agreement that makes some amount of stored water available for Program use in exchange for funding efficiency improvements. But such arrangement would have to include the consent of MRGCD irrigators and other users.

3.2 Location within the District

The potential benefit to the Program of efficiency improvements is generally higher in the more downstream portions of the District. The least direct benefit to the Program would be gained through efficiency improvements in the upper two divisions, Cochiti and Albuquerque. This is because the water required in the downstream divisions must be carried through the upstream divisions, and therefore, when the district is operating on releases from storage in El Vado reservoir, there is still an excess of carriage water in the upstream divisions. The river is generally wet as it flows through these upstream reaches, since it contains the water destined for the downstream divisions, and therefore a change in the distribution of water in the valley in these reaches would not produce significant benefit to in-stream habitat.

Decreases in diversion demand in the downstream divisions, Belen and Socorro, translate more directly into decreases in District demand, since there is not an excess of carriage water in these reaches. For the same reason, these are also the reaches where the most summer drying occurs. However, they are also the divisions that are more efficient already.
3.3 Increasing Storage to Extend MRGCD Operations

Improvements in MRGCD efficiency could reduce the required irrigation diversions in the MRG, particularly in the Cochiti and Albuquerque Divisions. Most of the flow targets defined in the 2003 Biological Opinion tend to be met more easily when MRGCD is operating, especially during Article VII Compact limitations on upstream storage of non-Indian native Rio Grande water. Therefore, any efficiency improvements that help MRGCD operate for a longer period of time on a limited volume of water in upstream storage might benefit meeting Program goals when there are Rio Grande Compact storage restrictions at El Vado. More simply, when the MRGCD operates, Program water needs lessen. When MRGCD operations cease, Program water supply requirements substantially increase.

During years of Article VII Compact restrictions, when the District is operating on native Rio Grande flows, increases in efficiency can benefit the program, through decrease in the proportion of native flow that is required to make MRGCD diversion demands. Any time that MRGCD demand is met with less than the full native flow of the river, the remaining portion will remain in the river as in-stream flow.

3.4 Increased Runoff Peak Discharge

Another potential benefit to the Program from MRGCD efficiency would occur if MRGCD increased its carryover storage from year to year. By releasing less supplemental water in a season, MRGCD would have more water in storage the following spring. Since EL Vado is not a large reservoir, relative to the expected volume of spring runoff, any extra water already in storage would cause the reservoir to spill earlier during the typical spring filling cycle. This could result in higher discharge volumes and higher peak flows in the Middle Rio Grande downstream of Cochiti Lake, until the limits of channel capacity was reached. Both of these results can aid in meeting some Program goals, but may not benefit in providing supplemental river flow during the summer.

4.0 CONCLUSIONS

- This paper discusses the possibility of obtaining higher river flows, and other benefits, through irrigation efficiency improvements, including both off-farm and on-farm efficiencies in the surface-water irrigation system in the MRG.
- Between Otowi Gage and Elephant Butte Reservoir, the reach upon which this paper is focused, this irrigation is mainly under the jurisdiction of the six Middle Rio Grande pueblos, MRGCD and some acequias and community ditch systems.
- The MRGCD serves Pueblo and non-Indian lands, community ditch associations, independent acequias, NM Game and Fish lands, the Bosque del Apache National Wildlife Refuge, and urban lands. The competing demands of these different entities increase the complexity inherent in operation of the district by imposing additional constraints on water deliveries.
- Present estimates of the irrigated area of the MRGCD vary between 53,000 and 73,000 acres. The district’s gross diversions averaged approximately 600,000 acre-feet throughout the 1990s, but have been reduced to slightly more than 300,000 acre-feet (in the 2003 irrigation season), mainly through operational improvements.
- MRGCD is committed to improving the efficiency of the irrigation system for the benefit of its irrigators, and to increase its operational flexibility under the constraints of the Rio Grande Compact. Improvements have already been made and more are planned.
- Irrigation system efficiency improvements in the MRGCD may not directly produce additional water for the Program. That is, if water is conserved by such improvements, MRGCD has the option (except in years of Article VII restrictions under the Rio Grande Compact) of holding that...
water in upstream storage. The potential benefits under such an option have not been fully assessed by either the WAMS or MRGCD.

- Irrigation system efficiency improvements could provide indirect benefits to the Program, including:
  - Reduction in MRGCD demand, which could extend the MRGCD irrigation season in water-short years, thereby potentially reducing the amount of supplemental water that the Program would need to deliver to support the BO and Program goals;
  - Increasing MRGCD carryover storage at El Vado could produce larger spring runoff volume and peak discharges (within the constraints of channel capacity though the Albuquerque Reach), could achieve many of the Program’s long-term habitat restoration goals, and could decrease the need for Program water;
  - Increasing MRGCD efficiency to reduce evaporation from the floodway, fields, or canal surfaces would improve the State’s ability to meet Rio Grande Compact obligations and potentially benefit the Program through increased reservoir operational flexibility.
  - When Article VII restrictions of the Rio Grande Compact, which restrict storage of non-Indian native Rio Grande water in reservoirs upstream of Elephant Butte, are in effect, improvements in irrigation efficiency could allow a greater portion of native Rio Grande flows to flow in the river.

- Irrigation system efficiency improvement could provide direct benefits to the Program through a negotiated agreement that would provide some amount of stored water for use by the Program in exchange for funding efficiency improvements.

- The Program should continue to support projects to study and implement irrigation efficiency improvements, and to evaluate whether and/or how these actions may help meet Program goals.
Attachment E-7

WATER ACQUISITION AND MANAGEMENT SUBCOMMITTEE POSITION PAPER:
VOLUNTARY IRRIGATION FORBEARANCE IN THE MRGCD SERVICE AREA

1.0 INTRODUCTION AND BACKGROUND

The Middle Rio Grande (MRG) Endangered Species Act (ESA) Collaborative Program (Program) recognizes the necessity of acquiring water to supplement stream flows in the Rio Grande to assist in the recovery of the Rio Grande silvery minnow and other species, and to offset any increased depletions of the river that may result from projects undertaken by the Program to restore endangered species habitat. In this document, the possibility of using a voluntary irrigation forbearance program to support these goals is examined.

1.1 Introduction to the Forbearance Concept

- Irrigation forbearance is the commitment by a practicing irrigator to “forbear” the use of water for a period of time, either by leaving previously irrigated land fallow or simply not irrigating, and legally reassigning the water allocated for use on that land to other uses. In the MRG valley, where there has been no water-rights adjudication, forbearance would be of a right to divert and consume water, based on a history of such diversion and consumption.

- Participants could agree to forbear for a single season, multiple seasons, or at regular intervals (such as once every 5 years) for some period into the future.

- The water secured through the Program could be stored in an upstream reservoir and subsequently be released following an agreed-upon schedule to benefit endangered species, using procedures similar to those followed by irrigators.

1.2 Potential for Implementation of a Voluntary Irrigation Forbearance Program in the MRG Valley

- The Middle Rio Grande Conservancy District (MRGCD) is a major water user that serves approximately 11,000 irrigators along the MRG. Therefore, it is a potential source of flexibility to aid in attaining water supply goals for the ESA Program.

- With the support of the WAMS, MRGCD has initiated a forbearance feasibility study within its system. The results of this feasibility study will be used by the MRGCD and the Program to determine what, if any, additional steps need to be taken to pursue a forbearance program for the middle Rio Grande. The MRGCD has expressed willingness to seek input from the WAMS in designing and completing this study.

1.3 Legal, Political, and Technical Requirements

In practice, a forbearance program involving the MRGCD will be quite complex and involve a number of political, legal, and technical requirements, including the following.

- Any water to be acquired through forbearance in the MRGCD service area should be on a voluntary basis.

- Operation of any forbearance program should protect against any forfeiture or impairment of water rights, either of the forbearer or other water-rights holders.

- Voluntary irrigation forbearance would be most feasible during years of full District irrigation supply, and for which there are no Rio Compact restrictions on upstream storage. Voluntary
irrigation forbearance during years of less than a full irrigation supply may be feasible, but would involve significantly more technical and administrative challenges.

- The Collaborative Program, acting through one or more Program Signatories, would need the ability to store any water obtained through voluntary forbearance in upstream reservoirs and manage the storage and release of that water, including carry-over to future years.
- Only currently irrigated lands can be considered for a forbearance program. Specific criteria would need to be established to determine which irrigated lands are eligible.
- The compliance of participants would need to be monitored.
- Participation by MRGCD in any voluntary forbearance program would require approval in advance by MRGCD Board of Directors. If participation in a voluntary forbearance program would potentially affect Pueblo lands or water, approval by the appropriate governing entity of each potentially affected Pueblo would also be required.
- Any voluntary forbearance program would need to be implemented in a way that would minimize operational impacts on the MRGCD. Specifically, such a program could not adversely impact the ability of the MRGCD to deliver water to irrigators who are not participating in voluntary forbearance.

2.0 ISSUES REQUIRING FURTHER RESOLUTION

A number of outstanding issues still need to be resolved before a forbearance program can be effectively implemented:

- Determination of the quantity of water required for the forbearance program and the quantity of additional flow in the river that could reasonably be provided by forbearance toward meeting Program goals.
- Protection of priority users in the absence of a water-rights adjudication,
- Resolution of the role of the Office of the State Engineer in approving forbearance transactions.
- Determination of whether water resulting from a potential voluntary forbearance program should be stored in a new water bank or conservation pool created for Program purposes, or in the existing MRGCD water bank.
- Determination of criteria and process for implementing forbearance:
  - How would an irrigator prove eligibility to participate in a voluntary forbearance program?
  - How, when, and to whom would payments be made?
  - How much water and how much money would be conveyed for forbearance during a year that does not turn out to be a full-supply year?
- Determination of which areas of the District have the most potential for an effective forbearance program. For example, to what degree does the presence of Pueblos in the Albuquerque and Belen Divisions constrain forbearance opportunities? Which areas already have a practicing rotational water delivery system to facilitate implementation of the forbearance program?
- Determination of whether any active irrigators / water-rights holders may be willing to forbear
  - Who are they?
  - Where are their fields located?
  - How often are these irrigators willing to commit water?
  - What would they like in exchange for their forbearance?
  - How much water could they, cumulatively, be willing to commit to the program?
• Determination of what compensation the Program would provide to the MRGCD, for the increased management and operational expenses it would incur as a result of a forbearance program.

3.0 CONCLUSIONS

• Institutionalizing a method for acquiring supplemental water is a goal for the ESA Collaborative Program working though the Water Acquisition and Management Subcommittee. Voluntary irrigation forbearance may be a mechanism for the Program to acquire water to help meet Program goals.

• The Program should acquire a scientifically sound understanding of the flow regime required to support the listed species in order to determine the amount of supplemental water required by the Program.

• The MRGCD has initiated a study, with input from the WAMS, on the technical feasibility of forbearance in non-Pueblo portions of the District’s system, upon which a forbearance program could be designed. If technical feasibility is established through the MRGCD study, an assessment of the willingness of individual irrigators to participate in the forbearance program should then be conducted,

• The voluntary forbearance program should be entirely voluntary and it must carefully protect the water rights of participants from forfeiture or impairment.

• The voluntary forbearance program must protect the ability of the MRGCD to deliver water to its irrigators who are not forbearing.

• Ultimately, the Program and the MRGCD will need to work together closely to identify and implement collaborative approaches to help attain Program goals for the near- and long-term benefit of listed species.
Attachment E-8

WATER ACQUISITION AND MANAGEMENT SUBCOMMITTEE BACKGROUND PAPER: NATIVE AMERICAN WATER

1.0 SUMMARY AND CONCLUSIONS

- Seven Pueblos are located along the mainstem of the Rio Grande. Three Pueblos have lands along the Rio Jemez. Six Pueblos are included within the MRGCD service area. Also, the Jicarilla Apache and the San Juan Pueblo hold leases for San Juan-Chama Project water. Therefore, consideration of potential water sources to aid meeting the goals of the Program would be incomplete without consideration of the potential role of Native American water holders.

- The Pueblos’ water rights are not subject to State law or governed by State administration. The inherent sovereign authority of the Pueblos over their water resources must be respected in regional water planning efforts.

- Pueblos hold the senior-most water rights along the Rio Grande.

- While Native Americans hold claim to a diversity of classes of water uses, it is their Prior and Paramount (P&P) water rights that are most commonly the focus of discussion. In 1928 Congress authorized Interior to contract with the MRGCD to provide conservation, irrigation, drainage, and flood control for the MRG Pueblo lands.

- Within the MRG Valley, the Pueblos hold Congressionally recognized P&P water rights.

- Reclamation maintains a storage pool in El Vado Reservoir for P&P water. Releases of this water are called for by the six MRG Pueblos, working with Reclamation and the Bureau of Indian Affairs. P&P for all of the six MRG Pueblos is managed as a single pool – the storage capacity of the individual Pueblos are not differentiated.

- There will be great difficulties associated with any attempt to institute a voluntary forbearance program on Pueblo lands. Forbearance at any Pueblo would involve complex political, cultural, and technical issues that could only be addressed by that Pueblo’s government.
Attachment E-9

WATER ACQUISITION AND MANAGEMENT SUBCOMMITTEE BACKGROUND PAPER:
NEW MEXICO ACEQUIA WATER

1.0 INTRODUCTION AND BACKGROUND

An acequia is a community irrigation ditch and, in New Mexico, an acequia refers to a centuries-old system of communal management of water and to the community of farmers that cooperatively maintain the ditch and distribute irrigation water.

Acequias are local units of government, political subdivisions of the state. As a political organization, an acequia, or a community ditch, is a public entity that functions to allocate and distribute irrigation water to the landowners who are its members.

An acequia or ditch typically include a diversion dam and headgate, a main ditch channel commonly called the acequia madre, lateral ditches leading from the main channel to irrigate individual parcels of land, and a wasteway channel that returns surplus water from the acequia or ditch system back to the stream. Occasionally, the works include a storage reservoir or transbasin ditch. The diversion structures commonly are built of readily available materials, such as timber, brush, and rocks, or consist of concrete and masonry. The channels are usually unlined, open and operate by gravity flow.

The community acequia or ditch association is composed of all owners of the lands irrigated by a ditch. Landowners are assessed dues by the acequia association for the operation and maintenance of, and improvements to the ditch system. Three commissioners and a mayordomo, elected by association members, manage the allocation and distribution of irrigation water, and all members participate in acequia maintenance.

2.0 ACEQUIA NUMBERS

- An estimated 1,000 acequias exist in NM, which hold a significant portion of senior water rights (http://www.nmacequias.org/page7.html).
- Approximately 680 acequias/ditches exist in north-central NM, within the upper Rio Grande watershed, distributed among about 40 acequia/ditch associations and individual tributaries (NMOSE database records).
- Small tributaries have as few as four individual ditches to as many as 21 ditches on the Rio Chama, 34 on the Red River, 36 on the Rio Jemez, 52 on the Santa Fe River, 91 on the Rio Tusas (NMOSE database records).

3.0 WATER RIGHTS

- Most acequias have not been adjudicated. (Indeed, the NM Acequia Association in 2000 objects to the process of adjudication as being unnecessarily costly, adversarial, etc.)
- Acequias generally lack explicit statutory authority to control water rights that are part of their system making them among the most vulnerable water rights to water transfers.
- Acequias operate to share shortages as opposed to water rights administration.
4.0 POSITION FROM THE NM ACEQUIA ASSOCIATION ON USES OF RIO GRANDE WATER FOR PURPOSES SIMILAR TO THOSE REQUIRED FOR THE MRG ESA COLLABORATIVE PROGRAM NEEDS


> While we value and work towards the existence of living, healthy rivers, and we are indeed dependent upon their viability for irrigation, livestock, and domestic uses, we oppose attempts to establish instream flow rights through legislation or litigation. Any attempt to do so will place historically new demands upon acequia rights to meet recreational and habitat needs. We are opposed to the commodification of water a resource that has always been managed as a community. By promoting the creation of an instream flow water rights and market mechanisms to acquire water rights, instream flow proponents have become a competing interest along with cities, industry, and developers whose increasing demand threatens acequia viability. We oppose any attempt to sever water rights from the lands to which they have been tied for hundreds of years. Such action would threaten both the economic viability of acequia communities dependent upon these rights for agriculture and the ability of the acequia to function efficiently. Use of the Endangered Species Act through the federal government to impose minimum stream flows goes against state primacy in water law and protections of acequia water rights by the Treaty of Guadalupe Hidalgo.

5.0 CONCLUSION AND RECOMMENDATIONS

- Acquiring acequia water for Program use would require the consent of the individual irrigators willing to forebear, other irrigators along that ditch or acequia, as well as those downstream with senior rights.
- It is likely that the volumes of water available for acquisition would be small (in the range of a few or a few 10s acre feet per year for each agreement).
- With the limited exceptions where the water rights have been adjudicated, legal ownership of most acequia/ditch water is unsettled. This exception includes the Rio de Chama below Abiquiu Dam, which includes operations of the Rio de Chama Acequia Association.
- During low-flow years, downstream irrigators with senior rights (including Middle Rio Grande Conservancy District) apparently could legally divert any native water acquired by the program from individual acequia irrigators or acequia groups. (Acequias essentially have run-of-river diversion rights.)
- In general, acequia water does not appear to be a reliable source of significant water volumes for the Program. It is presently beyond the means of the Program to contact individual irrigators to determine the extent of interest in leasing water to the Program.
- Any direct offers of acequia water for Program use from forbearing individuals or groups of irrigators should be evaluated on assurances of legal ownership and dependability of the water reaching areas designated for Program uses.
Attachment E-10

WATER ACQUISITION AND MANAGEMENT SUBCOMMITTEE BACKGROUND PAPER:
WEATHER MODIFICATION – CLOUD SEEDING WATER

1.0 INTRODUCTION

- Cloud seeding is also termed weather modification.
- The fundamental technology development started in the 1940s.
- Today, the technology is applied most commonly and, apparently, most successfully to reduce cold fogs at airports using, predominately, dry ice dropped through or compressed gases released into the fog.
- The second most common use is treatment of winter clouds rising over mountains to increase snowfall (commonly estimated to increase snowfall by 10 to 15%).
- The third generally recognized approach is the seeding of summer clouds to reduce hail damage and, secondarily, increase local precipitation.
- Cloud seeding of summer clouds over flatter terrains to increase precipitation appears to be least reliable.
- Cloud seeding is commonly portrayed as not reducing downwind precipitation volumes, ostensibly because the amount of water typically removed by cloud seeding is, at most, only 10% of the cloud water available before seeding. (The question of whether multiple, sequential seeding operations could produce a downwind decrease in precipitation is not commonly addressed.)
- Chemicals used in cloud seeding, especially silver iodide, is reported to produce no significant adverse environmental impacts or to accumulate above background concentrations in seeding areas (very dilute in-cloud concentrations result from seeding).

2.0 EXAMPLE CONTEMPORARY CLOUD SEEDING PROGRAMS

- At least ten states have active (aggressive) cloud seeding programs for precipitation enhancement and/or hail suppression.
- For the Winter of 2002-2003, Denver is proposing to contract $700,000 for Year 1 of an ongoing cloud-seeding program, adding 41 new ground-based generators to augment snowpack and streamflow around reservoirs. Denver Water estimates that 35,000 to 50,000 AFY can be generated at a cost of $12-23/AF.
- In October 2002, Colorado public hearings were listed for 12 cloud-seeding permits to augment snowpack, suppress hail, and augment precipitation.
- In 2002, Texas had 11 listed weather modification projects covering 52 million acres.
- In 1994, $645,000 was spent on cloud seeding in Tasmania, which was estimated to produce 55 mm (2.2 in) of rain over 6 months, at a benefit cost ratio of 13:1.
- In a 1997 report, Nevada estimated that augmented water produced by cloud seeding varied from 35,000 to 60,000 AFY for 10 years of seeding; estimates of percent increases in total water yield varied between 4 and 10% per year, with the greatest production in drought years; costs ranged from $8 to $15/AF.
• In a 2000 report, Utah estimated an annual increase in runoff of 249,600 AF due to its cloud seeding program, an average increase of 13% at an average cost of $1.20 /AF.

• North Dakota reports that for that state cloud seeding, particularly for hail suppression, results in a 45% reduction in crop loss (worth $34.4M), a 15% increase in rainfall (worth $52.5M) for a $3.2M investment in cloud seeding, offset by $5.1M increase in taxes.

3.0 A CONSERVATIVE VIEW

Position on the potential of cloud seed from William R. Cotton, [http://rams.atmos.colostate.edu/gkss.html](http://rams.atmos.colostate.edu/gkss.html)

• [The most compressive review of the scientific literature on cloud-seeding apparently available on the Internet and one pointed to by several other web sites.]

• “Often the decision to apply cloud seeding technology to a particular country or state is a prescription of a political placebo or a decision that it is better to do something than to sit idly by and do nothing as reservoirs dry up and crops wither and die due to the absence of water.”

• “... there are only a few limited examples of where cloud seeding has been scientifically [i.e., statistically] shown to be effective in enhancing rainfall.”

• “The window of opportunity for cloud seeding appears to be limited to:
  o “clouds which are relatively cold-base and continental;
  o “clouds having top temperatures in the range of –10 to –25 C;
  o “a time scale limited to the availability of significant supercooled water before depletion entrainment and natural precipitation processes.”

• “[... the success of cloud seeding experiment or operation, therefore, requires a cloud forecasting skill that is far greater than is currently in use.”

• In a 2002 article in the Colorado State Collegian he is quoted as, “The increase [in cloud seeding rainfall augmentation] could be between 5 to 10%. “[Cloud seeding] may increase precipitation, but it is very modest. It’s not going to be a drought breaker.” [Note similarity to estimated runoff benefit of 4-10% from cloud seeding presented in the 1997 Nevada report]

4.0 JEMEZ Y SANGRE WATER PLAN 2002 ALTERNATIVES ASSESSMENT

From [http://www.dbstephens.com/project_plans/AppendixF.pdf](http://www.dbstephens.com/project_plans/AppendixF.pdf) (accessed 1-22-04)

• Recognized that disagreement exists in the scientific community on cloud seeding benefits.

• Noted that scientific societies have guardedly optimistic policy statements on the benefits from cloud seeding.

• Report recommendations:
  o Form partnerships with local entities to conduct a pilot program
  o Share costs with NMISC
  o Establish a public information/education program
  o Review recent experiments by NMISC in the Pecos Valley and elsewhere
  o Model predicted runoff distributions and potential volumes

• 3,000 to 6,000 AFY may result from cloud seeding in the Jemez y Sangre Project area.
5.0 NMISC AND CLOUD SEEDING IN NM

- State of New Mexico has provided, on average, approximately $100,000 per year for the past 5 years to support a cloud seeding demonstration project in eastern NM. Funding for this activity was administered through a Joint Powers Agreement between the NMISC and local NM Soil and Water Conservation Districts. The west Texas underground conservation districts in conjunction with the NM Soil and Water Conservation Districts conducted the cloud seeding operations.

- Over the last two years, NMISC has taken a greater interest in the administration of the cloud seeding activities and as a result, reporting and assessment activities have increased, and better weather data is being compiled. Better methods are being implemented to allow calibration of radar to estimate precipitation volume.

- At this time, the question of whether cloud seeding produces or does not produce new water in NM lacks adequate data for a scientific/statistical evaluation.

- NMISC have contracted with both Dr. Conrad Keyes and additional support from Dr. Bill Woodley to aid the ISC in the assessment of these and future funded efforts in NM.

- The Llano Estacado Weather Modification Association with assistance from the NMISC is prepared “Proposal for Eastern New Mexico Precipitation Enhancement Program, January 2002” that request legislative/Water Trust Board funding of approximately $1M per year for the next five years in support of a “expanded, State Managed Cloud Seeding Program.”
  - The annual total dollar amount may be larger than that, if the State is successful in tapping into BOR matching funding.
  - This bulk of program will include a summer cloud seeding program using aircraft based out of Roswell. The program will include the purchase of perhaps two used aircraft the first year, and perhaps a fleet of 4 or 5 aircraft by the end of the first five years. The program will include a statistical/scientific based seeding program with the intent of developing a data set to allow an adequate assessment of the success of the seeding program in reducing irrigation demands.
  - About 10-15% of the budget will be devoted to conducting a winter demonstration, ground-based seeding program, first, in the upper Pecos Watershed for 2 years, then in the Sacramento Mountains for 2 years. The goal of this seeding would be to increase snowpack, surface yield, and base flow.
  - No seeding has been planned in the Rio Grande watershed.

6.0 ADDITIONAL OBSERVATIONS:

- NCAR scientist seeded clouds in Mexico during a 3-year randomized experiment ended in 2000 that showed that rainfall from seeded clouds statistically lasted longer, the rainfall area was larger, and total precipitation was greater (sometime even double) than output from similar non-seeded clouds.

- Important to recognize the high degree of difficulty in designing a statistically rigorous, adequately replicated and randomized weather modification experiment, lacking a precipitation area bias or confounding factors (“standard clouds” don’t exist).

- Science/statistics is best equipped to disprove rather than prove relationships exist (i.e., use of “null hypothesis”).

- Ultimately, the final basis for determining for or against cloud-seeding benefits will likely be based on a “weight-of-evidence support” producing deductive conclusions, rather that statistically based inductive conclusions.
7.0 CONCLUSION AND RECOMMENDATIONS

- The Collaborative Program should establish a Program priority to update the findings of the NMISC seeding program, both in terms of success in reducing potential irrigation demands by seeding and increasing spring runoff production from seeding.

- The Collaborative Program should establish a Program priority to provide a cost-share expansion of the NMISC winter seeding pilot program into the upper Rio Grande watershed, south of the CO-NM Stateline, to assess the potentials for cloud seeding to increasing snowpack and Spring runoff potentials. The WAMS suggests that ground-based seeding to enhance snow pack water volumes may be the most cost-effective method to increase stream flow and a useful 3- to 5-year pilot program in north central NM could likely be undertaken at a cost of $150,000 to $250,000 per year.

- Proposals developed in response to any such RFP for clouding seeding pilot study should include provisions for matching funding, to augment the Programs support, from ski areas in the upper Rio Grande watershed of New Mexico, who are likely to also benefit from such a program.
Attachment E-11

Water Acquisition and Management Subcommittee Position Paper:
Supplementing Middle Rio Grande flows through Active Watershed Management

1.0 INTRODUCTION

The Middle Rio Grande (MRG) Endangered Species Act Collaborative Program (Program) is exploring options for increasing flows in the MRG for endangered species. This paper discusses the possibility of obtaining higher, augmented river flows through active upland watershed management. Augmented river flows by riparian vegetation or invasive species management is the topic of other Program position papers and is not discussed herein.

Prolonged drought has led to increased concern over water yield and fire danger. Manipulating upland watersheds for multiple purposes, including reducing fire threat from insect- and drought-devastated forests, can increase overall water yield and improving water quality. When active watershed management is combined with cloud seeding to further increase total precipitation, the opportunities for increased water yield at a reasonable cost per acre become potentially attractive (Baker and Ffolliott, 2000). Current administrative and legal frameworks do not clearly permit those investing in watershed management to take direct benefit of the increased water yield.

Recent changes in the State law, however, enacted by the NM legislature in 2005, authorized the Interstate Stream Commission (ISC) to establish a Strategic Water Reserve. This allows the ISC the option to purchase or lease surface and ground water from willing sellers or lessors, and to receive donated water or water rights or storage rights to develop a water reserve. But, at no time shall the use of this water or water rights result in an increase in net depletions in any if the State’s water basins. The Act also states that the ISC shall pay no more than the appraised market value to purchase or lease water or water rights and storage rights for the strategic water reserve. The ISC may accept money or grants from federal or other governmental entities or other persons to purchase or lease water or water rights for the strategic water reserve and to pay administrative costs. The ISC shall not acquire water or water rights that are served by or owned by an acequia or community ditch. This Strategic Water Reserve legislation could aid the Program in working with the State to acquire water to help meet Program goals. In addition, the City of Albuquerque, in an agreement with environmental groups, set aside 30,000 acre-feet of storage space for water for environmental preservation purposes within Abiquiu Reservoir. This storage space could become available to store water acquired to meet Program goals. This position paper explores active watershed management alternatives that could result in wet water benefits to the MRG through increased wet water flows and paper water rights that, when managed on behalf of the Program, could benefit MRG endangered species.

In the Rocky Mountains, there is a long history of manipulating watershed vegetation with resultant increases in watershed yield. However, the uncertainty in defining absolute year-to-year water yield rests in understanding complex and interrelated hydrologic, biogeochemical, geomorphic, and ecosystem interactions. While increased water yields are well documented (Megahan and Hornbeck, 2000), attention must be paid to potential unintended consequences of any Program-funded activities. Best management practices (BMPs) are already established by the timber industry to minimize many of the undesirable effects of watershed management including erosion and sediment management associated with land disturbance. Long-term and paired watershed monitoring should be required for any watershed manipulation activities funded by the Program to ensure that increased water yields do not result in adverse impacts on species caused by erosion, sediment, or water quality impediments.

Between the Colorado/New Mexico state line and the Otowi Gage, sub-alpine and alpine upland areas contribute snowmelt runoff to the Rio Grande system. Collaborative watershed management activities in
the Rio Grande headwaters areas of southern Colorado have potential to increase overall water supply flowing to New Mexico across the Colorado/New Mexico state line. In New Mexico, upper elevation spruce/aspen forests and middle elevation mixed conifer forests offer the greatest potentials for increased water yield. Federal and state lands comprising upland watersheds surrounding the Heron, El Vado, Abiquiu, and Cochiti Reservoirs are also potential targets for active watershed management with downstream reservoirs potentially available to store increased water yields.

4.0 BACKGROUND

Water yield from a watershed receiving average input precipitation will yield an average output streamflow. The difference between input precipitation and output streamflow is typically a function of evapotranspiration by vegetation growing in the watershed. If one can decrease the amount of water used by vegetation, more water should be available for streamflow or infiltration. In arid areas, as much as 90 percent of the precipitation is lost to evapotranspiration. Therefore, upland watershed management could provide increased water yield by replacing deep-rooted or high water using plants with shallow-rooted, lower water using plants. Techniques used to reduce evapotranspiration include: decreasing stand density to reduce transpiration and interception; type conversion where in dominant vegetative cover is changed to another that uses less water; creating forest openings to accumulate, redistribute and concentrate snow in order to reduce evaporation, increase snowmelt efficiency, and enhance streamflow contributions; and establishing trees, shrubs, or fences to pile snow into drifts thereby reducing evaporative losses.

While increased water yield has been observed following catastrophic fires, the ancillary undesirable consequences of increased sedimentation, erosion, flash flooding and their impacts on water quality, following such fires preclude the use of fire as a watershed management tool (Farnes, et. al., 1989; Kunze and Stednick, 2003, Neary et. al., 2000).

Surrounding states are evaluating the potential for watershed management in increasing water yield and overall water supply. The costs for watershed thinning are often less, on a per-acre-foot basis, than imported water. Watershed management also offers synergistic benefits with fire reduction and cloud seeding programs. The value of watershed thinning was recognized early on – in 1983, the Denver Water Board estimated the value of incremental yields at $112 per acre-foot. Assuming an annual inflation rate of 3%, in today’s dollars, that estimate would be about $210 per acre-foot. California (Turner, K.M, 1994), Texas (Texas State Soil and Water Conservation Board, 2002), Arizona, and Colorado are all evaluating and/or implementing watershed thinning projects in an attempt to increase water yields. It has been estimated that the surface water supply in the Colorado River Basin could be increased by as much as 33% if vegetation and snow on 16% of the basin were manipulated solely to increase water yield (Hibbert, 1979). Texas is evaluating woody vegetation and brush management in an attempt to increase watershed yields in the Edwards Plateau (Wu et. al., 2001; Walker et. al., 2000).

New Mexico has also made forays into recommending and implementing active watershed management for improved water yield.

- Section C.8 of the New Mexico 2003 State Water Plan addresses state support for watershed restoration projects with a high potential to increase the water supply or improve the quality of water. However, the Plan does not provide specific implementation strategies to support or enhance these activities (State of New Mexico, 2003).

- The Governor’s Blue Ribbon Task Force on “Stewardship of New Mexico’s Water” supports water-related funding for watershed restoration and management, recommending that the State aggressively pursue such activities to: improve forest health; prevent catastrophic fires; increase water yield; and improve water quality (State of New Mexico, 2002).
Attachment E - MRG ESA Collaborative Program Water Plan

• The Middle Rio Grande Water Assembly (MRGWA) evaluated watershed management as “Alternative 66: Watershed Plans”. They emphasized the formation of local watershed groups coordinated by state, Tribal or Federal entities and estimated an average cost of $150 per acre foot of increased water over a 20-year timeframe. A legal analysis was also provided exploring pertinent Federal and state laws and provided a statement on Rio Grande Compact implications (MRGWA, 2003).

• The Jemez y Sangre Planning Council evaluated watershed management in their Regional Water Plan (Jemez y Sangre, 2002). They considered opportunities for forest, woodland and riparian systems management for increased water yield and evaluated the legal and administrative implications for implementation in New Mexico.

• Santa Fe is aggressively thinning woody vegetation in the steep terrain of the Santa Fe watershed at a cost of approximately $1,000 per acre (MacDonald, 2002). These costs did not include costs for slash management or reseeding with grasses. The goal of this thinning project is water quality protection in the event of a large crown fire. This program is participating in a paired basin study – attempts to quantify water yield will be made over the course of the thinning program (Carpenter, 2003 personal communication).

• The Rio Penasco Watershed Restoration Project is exploring a community-based watershed restoration project performed in conjunction with the USDA-Forest Service, U.S. Bureau of Land Management, Mescalero Apache Tribe, NM State Forest Service, Village of Cloudcroft, and other local partners. The goals of this project are to reduce catastrophic fire danger; restore ecological integrity and biodiversity; improve water supply and water quality; and create a sustainable economy based on diverse forest products and values. Actions include: thinning of small-diameter trees; reducing stand density with commercial timber sales; erosion management; providing slash disposal areas; and allowing for additional prescribed burns and pre-commercial thinning. Long-term restoration activities include: fuels reduction (Cloudcroft Estate); water quality improvement projects; and commercial small-diameter tree projects (Mescalero Mill). Other activities supported include community-based partnership workshops, educational outreach; and other public outreach activities (Doppelt et. al., 2002).

• The ZeroNet Water-Energy Initiative, a joint initiative between Los Alamos National Laboratory, the Electric Power Research Institute, and Public Service Company of New Mexico is also trying to quantify the costs and benefits of comprehensive pinon-juniper and upland forest vegetation management for increased water yield and biomass-based electricity generation (ZeroNet Water-Energy Initiative, 2003).

5.0 WATERSHED MANAGEMENT:

From a hydrologic perspective, watershed management refers to managing the balance between inflow of water as precipitation and outflow of water as evapotranspiration, groundwater discharge, and streamflow. The basic water balance equation is as follows (Fetter, 1980):

\[
\text{Inflow} = \text{Outflow} + \text{Changes in Storage}
\]

When written in terms of watershed processes, the equation becomes the following.

\[
P = (\text{ET} + \text{SF} + \text{GWD}) + (\text{SMC} + \text{GWS})
\]

Where:

\[
\begin{align*}
P & = \text{Precipitation (gain) = inflow} \\
\text{ET} & = \text{Evapotranspiration (loss) = outflow} \\
\text{SF} & = \text{Streamflow (loss) = outflow} \\
\text{GWD} & = \text{Groundwater discharge (loss) = outflow (subsurface baseflow)}
\end{align*}
\]
SMC = Soil moisture content (gain or loss) = change in storage  
GWS = Groundwater storage (gain or loss) = change in storage  

Active watershed management is often performed for reasons other than increasing water yield – reduction in fuel load to reduce the magnitude and frequency of wildfires; forest health; insect infestation management, and improving forest health/drought resistance. However, the potential water yields versus the cost of watershed management justify examining watershed management as an alternative source of reasonably priced water. Watershed management for increased water yield becomes even more cost-effective where synergistic benefits can be achieved – e.g., fuel reduction with enhanced water yield and/or performed in conjunction with cloud seeding to enhance total precipitation.

Clear cutting and vegetation conversion are the two techniques most commonly cited for water yield; however, even limited vegetation thinning can provide significant (2-5% increases) in water yield (Baker and Ffolliott, 2000). The cheapest water (based on costs to produce) are typically associated with commercial forestry activities, where timber yields can pay for part of the treatment cost. Thinning combined with cloud seeding can further increases total precipitation in the watershed and the overall magnitude of water yielded to streamflow and aquifer recharge.

Typical vegetation manipulation at the watershed scale involves removing woody vegetation to provide increased streamflow or infiltration. However, unintended consequences must also be managed – e.g., cheat grass invasion, compaction from increased grazing, and soil erosion in water-stressed systems. Sub-alpine spruce, aspen, and mixed conifer forest zones have the greatest water yield potentials. However, even ponderosa, pinon-juniper and lowland vegetation management programs have shown increased water yields. The duration of increased yields ranges from 15 to 45 years (Troendle and Nankervis, 2000).

Early water balance studies were performed on two paired watersheds at Wagon Wheel Gap on the headwaters of the Rio Grande in southwestern Colorado (Bates and Henry, 1928). Streamflow was measured from 1911 to 1919, then one watershed was clearcut. Of 530 mm annual precipitation falling on these watersheds, about 150 mm was returned as streamflow, with an estimated 380 mm lost to evapotranspiration. Following clearcutting, water yield, as measured by streamflow, increased an average of about 25 mm. Reduced overstory transpiration was offset by increased understory transpiration and ground evaporation.

Studies performed in the Fraser Experimental Forest in north-central Colorado also demonstrated the potential for increased water yield associated with timber harvesting and weather modification (Leaf, 1975). Later studies in this area (Alexander, et. al, 1987, Troendle, et. al., 1987) indicated good potential for increasing water yield in sub-alpine forests by creating forest openings to reduce snow redistribution and transpiration with attendant water yield increases of 25 to 75 mm. The authors recommend patch cuts to create forest openings, rather than clear cutting. Patch cuts are considered ecologically sound and help maintain ecosystem diversity. Harvest procedures recommended for lodgepole pine forests include path cuts of 5 to 8 tree heights in diameter exposing about 1/3 of the area, with cuts made at 30-year intervals over a planning period of 120 years. Periodic thinning is proposed in regenerating stands. Spruce fir forests have similar recommendations, except that patch cuts are made at 50-year intervals.

Work done on mixed conifer forests at Workman Creek on the Sierra Ancha Experimental Forest in central Arizona demonstrated that increases in streamflow could be obtained by replacing trees with grass cover or by greatly reducing overstory densities (Baker, 1999). Results indicate that treatment of mixed conifer forests can result in water yield increases that remain consistent for 13 years or more. Treatments included both moist and dry-site clearcuts and single-tree selection. Minor changes were observed in sediment yields, but significantly less than sediment mobilization resulting from wildfire thinning. Patch thinning estimated an average 40 mm increase where 33% of the area is cleared on sites where
streamflow normally averages 100 to 125 mm. Increases in water yield of 75 to 100 mm were possible where clearcutting was used.

Ponderosa forests were examined in pilot watersheds at the Beaver Creek Watershed (Brown et al, 1974 and Baker and Ffolliott, 1998, Gary 1975). Ponderosa forest water yield is less than that obtained from other commercial forest types. Short-term (3 to 10-year) increases of 25 to 75 mm are expected from clearcutting ponderosa pine. Long-term increase of 2 to 25 mm is more realistic using a 33% patch clearing technology. No meaningful increases in total sediment production occurred with patch treatments; clear-cutting increased sediment by about 170 kg/ha (Brown, et. al., 1974). An average water yield of 30% remained stable for 20 years after treatment, with the initial increase attributed to reduced evapotranspiration and increased snow accumulation in forest openings (Alexander, 1987).

Additional information is available for lowland vegetation management; however the land management obstacles for the patchwork of land ownership within the MRG valley at lower elevations renders active watershed management more impractical at these elevations.

Given widely documented increases in annual water yield resulting from active watershed management, what is the nature of the enhanced hydrograph? Both increased peak and flood flows have been observed following thinning. Peak flows are the maximum flows resulting from a runoff event. Flood flows are peakflows that exceed channel capacity as defined by bankfull levels. With forest thinning, it was generally found that most increases in water yield occur at low flow levels – as augmented baseflow or delayed flow resulting from improved infiltration and groundwater recharge. Peak flow yield increases tended to occur primarily during the growing season. Flood flows were also increased due to larger overland flow rather than channel flow – these were evidenced as increased snowmelt and earlier ascending limbs on the spring flood hydrograph (Harr, 1979 and Troendle, et. al, 1988).

Surface erosions was found to be largely confined to areas of severe disturbance and compaction – primarily limited to skid trails, log landings, and roads (Megahan and Kidd, 1972). Disturbance can be limited by employing BMPs standard in the timber industry. Sedimentation is complementary to erosion – increased sedimentation can cause problems for fisheries because high concentrations of suspended sediments can damage the gills of aquatic insects and fish. Bedload sediments can interfere with fish spawning and rearing success. Fine organic and clay-sized lithic sediments can be vectors for downstream transport of sorbed pollutants such as pesticides, organic chemicals, radionuclides, or heavy metals. Sediment impacts are typically observed in the first five years of landscape alteration and will require long-term monitoring. Sediment impacts from patch cuts are much less than clear-cut areas. Implementation of BMPs is essential to protect water quality and minimize unintended consequences of increasing water yield by forest thinning.

6.0 ADMINISTRATIVE ISSUES:

6.1 Watershed Management Authorities

The United States provides various authorities for the establishment and management of national forests. Implementation and oversight for various aspects of watershed health are divided among federal land, resource and water management agencies. Primary agencies offering watershed management funding support include the U.S. Department of Agriculture (USDA) – Forest Service (USFS), the USDA-Natural Resource Conservation Service (NRCS), and the Environmental Protection Agency (EPA). Of the agencies with primary responsibility in watershed management, only the USFS is a current Program signatory.

Sample federal authorities are cited below.
• The Organic Act of 1879 (16 USCA 475) states that “No national forest shall be established, except to improve and protect the forest within the boundaries, or for the purpose of securing favorable conditions of waterflows”.

• The 1911 Weeks Law further reinforced this concept by stating that “The Secretary of Agriculture is authorized and directed to examine, locate, and recommend for purchase such forest, cutover or denuded lands within the watersheds of navigable streams as in his judgment may be necessary to the regulation of the flow of navigable streams or for the production of timber.”

Other important acts for managing watersheds include: Multiple Use Sustained Yield Act, the Forest and Rangeland Renewable Resources Planning Act, and the National Forest Management Act (NMFA) all including protection of soil and water resources. Additional legislation with watershed protection themes includes: Watershed Protection and Flood Prevention Act, the Federal Water Pollution Act, the Clean Water Act (CWA), the National Environmental Policy Act (NEPA), and the National Historic Preservation Act (NHPA) (Jemez y Sangre 2002 and MRGWA, 2003). For example, the Multiple Use Sustained Yield Act of 1960 provided that national forests “shall be administered for watershed purposes”. However, the NMFA limits the methods and locations of logging and road building; the ESA may limit any actions in designated critical habitats for threatened or endangered species; the CWA may limit the amount of sediment; and the NHPA may limit land disturbance near sites of religious, cultural or historical significance.

While the USDA-FS, USDA-NRCS, and the EPA are the lead agencies with active watershed management programs, a myriad of other federal agencies are involved with aspects of watersheds including: the Bureau of Land Management (BLM), the U.S. Army Corps of Engineers (Corps), the Bureau of Reclamation (Reclamation), and the Fish and Wildlife Service (FWS). Some of these agencies are Program signatories and could assist in leveraging Federal funding for implementation. The Catalog of Federal Domestic Assistance lists at least 29 federal funding sources for watershed-related activities (General Services Administration, 2003).

The State of New Mexico has equivalent resource and management agencies (State of New Mexico – Forestry Division, New Mexico Interstate Stream Commission (NMISC), New Mexico Office of the State Engineer (OSE), New Mexico Environment Department (NMED), New Mexico Department of Game and Fish, New Mexico Department of Agriculture, etc.), some of whom are also signatories to the Program. The ISC regulates surface waters of the state subject to interstate and international agreements. The OSE has authority over the appropriation of surface waters and groundwaters of the state. The New Mexico Water Trust Board has indicated its willingness to fund watershed restoration projects that stand to increase available water supply (State of New Mexico, 2002). Thus, sources of state funding for watershed improvements yielding wet water are also available and could be used to show in-kind contributions and better leverage federal investments.

6.2 Operational Authorities

If active watershed management can increase water supply, reservoir storage is recommended to best leverage the wet water resource to meet multi-year and year-round species water demands. Operational authorities associated with the storage and management of waters related to the Program are discussed in the WAMS position paper, “Storage and Management of Program Water”. Alternatively, benefits to MRG species and habitat may also be realized without storage, by letting a larger water pulse move downriver through riparian habitat.

New Mexico water law asserts a legal right to waterflows derived from lands within the state. Any additional water created by active watershed management would become part of the public water supply and be subject to the prior appropriation system. If thinning and management produced excess water, the Program might secure that water under existing law by filing an application to appropriate with the OSE.
However, the priority of this appropriation would be junior to the rights of more senior water rights holders who would retain the first right to divert any additional supplies.

7.0 CONCLUSIONS

- The Program should explore opportunities for increased or enhanced river flows through active watershed management. Can wet water supplies be increased sufficiently to benefit endangered species in the MRG?
- Watershed management alone has the potential to increase watershed yield ranging from 5 to 25 percent. When performed in conjunction with cloud seeding (the topic of a separate position paper), the potential water yield may increase by an additional 5 to 15 percent.
- The cost of water gained through active watershed management appears attractive when compared to the cost of other water sources. However, well-documented costs for NEPA compliance, environmental permitting, and paired watershed monitoring were not available and further economic analysis should be undertaken to evaluate implementation costs relative to wet augmented water and paper water rights yields.
- The Program should encourage appropriate land management agencies to provide an assessment estimating increases in water yield to the MRG possible through active watershed management activities. Information of interest includes a compilation of public and private watershed acreages potentially suitable for forest thinning, and a compilation and review of results from similar watershed management efforts in the region producing results potentially applicable to the MRG.
- The Program should identify opportunities to cooperate with, or actively involve watershed land management agencies in the ESA Collaborative Program, to advance watershed management for improving water yield, water quality, and forest heath supported by multiple sources of funding and to the benefit of Program activities.

8.0 REFERENCES


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Walker, J.W. Dugas, W.A., Baird, F.C., Bednarz, S.T., Muttiah, R.S. and Hicks, R.A., 2000, Site Selection for Publicly Funded Brush Control to Enhance Water Yield, Texas Agriculture Experiment Station and USDA-Natural Resources Conservation Service


ZeroNet Water-Energy Initiative, 2003, Fact Sheet – Joint Initiative Between Los Alamos National Laboratory, Electric Power Research Institute, and Public Service Company of New Mexico
1.0 INTRODUCTION AND BACKGROUND

The Water Acquisition and Management Subcommittee (WAMS) envisions meeting Program Water needs through improved management and annual lease/purchases of water from current users, storing such water in upstream reservoirs, with flows released as needed to provide for identified river needs\(^1\). This paper addresses the potential options to store and manage all waters made available by and for the ESA Collaborative Program (Program water). For the most part, the water to be secured, stored and managed for the Program is already being stored and managed in some fashion. Annual water deliveries to Elephant Butte Reservoir, averaging 690,000 acre-feet, have been relied upon to provide the bulk of the flows to meet the above purposes. However, river drying is a recurring condition during the mid-June through October irrigation season in the Isleta and San Acacia reaches of the Rio Grande.

River drying has been addressed in the past by releasing “supplemental water” acquired through voluntary leases with Reclamation’s San Juan-Chama Project (SJC) contractors, coupled with water made available by the 2001 Conservation Water Agreement and the 2003 Emergency Drought Water Agreement between New Mexico and the United States. None of these sources of water are sustainable in the long term.

The Program area has a limited amount of physical storage capacity that might be utilized for the Program, and authorities currently manage the volume of water the Program area reasonably can expect in the future. The difficulties that must be negotiated are timing, physical limitations on storage space, congressional authorizations, compact obligations, complex accounting and meeting the many competing needs on the Rio Grande system.

This paper focuses on determining the storage and management actions suggested under the Water Acquisition Management Subcommittee’s (WAMS’) charge. The current assumed annual amount needed for the Program purposes is characterized in the report in the WAMS’ Program Water Demand Assessment (see Attachment B).

2.0 DESCRIPTION OF EXISTING MANAGEMENT AUTHORITIES

Water management responsibilities in the Program area are presently divided among: local water providers, end water users, state water rights administrators, federal reservoir authorities, federal Native American trustees and the Rio Grande Compact Commission.

- **Federal Authorities** - The *U.S. Fish and Wildlife Service* (Service) ensures that Federal agencies do not take actions that jeopardize the continued existence of Federal threatened and endangered species. The Service also consults with other agencies, whenever a "may affect" situation is predicted, to prevent adverse impacts and encourage recovery actions for the species. Under the Endangered Species Act, it is the responsibility of every Federal agency to conserve listed species. *US Bureau of Reclamation* (USBR), in addition to maintaining certain water storage and delivery systems, provides necessary accounting for deliveries of water under the San Juan-Chama and Middle Rio Grande Projects. *US Army Corps of Engineers* (Corps) has major flood control jurisdiction, operating the reservoirs at Abiquiu and Cochiti dams.

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\(^1\) See related WAMS Position Paper: “Program Water Needs”.

Version: 28 November 2005 E - 55 Storage and Management of Program Water
• **State Authorities** - The Program area lies entirely within the State of New Mexico, making the Program pool subject to state statute. The *New Mexico Interstate Stream Commission* (NMISC) is responsible for NM’s compliance with Rio Grande, Colorado River and Upper Colorado River Basin Compacts. The *New Mexico State Engineer* (NMOSE) is responsible for administration of permits to divert and use water in New Mexico.

• **Local Authorities** - Two local political subdivisions control the preponderance of state water rights within the Program area. The *Middle Rio Grande Conservancy District* (MRGCD) distributes water to irrigation end users within its irrigation service area between the outfall of Cochiti Dam to the north boundary of Bosque del Apache National Wildlife Refuge; water is also supplied to this Refuge. The *City of Albuquerque* distributes potable water to residential and industrial water users within its boundaries.

• **Pueblo Authorities** - Tribal lands and water are sovereign, being subject to the use of Tribal membership, at the discretion of Tribal authority. Tribal rights must be adequately protected.

### 3.0 DESCRIPTION OF EXISTING STORAGE RESERVOIRS

The existing reservoirs that potentially could store and release for the recovery of the listed species (Rio Grande silvery minnow and southwestern willow flycatcher) in the Rio Grande between Cochiti and Elephant Butte Reservoirs include Heron, El Vado, Abiquiu, Cochiti and Jemez Canyon Reservoirs. Groundwater aquifers are not discussed here. The reservoirs vary greatly in authorized operations, as much as in their abilities to capture surface-water runoff.

The sources of acquired water have physical and location implications on storage and release and therefore cannot be completely separated. For example, if a sufficient volume of water cannot be physically captured at a site, and exchanges are not allowed, then specifying a storage intention there is unrealistic.

Among alternatives, it is probably most advantageous to utilize more than one location for Program storage, to provide sufficient storage capacity along with the flexibility to work with their varying hydrologic conditions.

#### 3.1 Heron Reservoir

Heron is a Reclamation dam and reservoir, constructed as the primary feature of the San Juan-Chama Project. Public Law 87-483 authorized the SJC Project in 1962 for project water supply storage and construction was completed in June 1971. The Project authorities include the Colorado River Storage Project Act of April 11, 1956 (70 Stat. 105).

Public Law 87-483 has a number of limitations, including:

- The Secretary of Interior must comply with all applicable provisions of the Colorado River compact, the Upper Colorado River Basin compact, the Boulder Canyon Project Act, the Boulder Canyon Project Adjustment Act, the Colorado River Storage Project Act and the treaty with the United Mexican States and all provisions of the Rio Grande Compact.
- Diversion from the San Juan River basin are not to exceed 1,350,000 acre-feet in any period of ten consecutive years, provided that no more than 270,000 acre-feet are diverted in any single year;
- The Project must be operated to preserve fish and aquatic wildlife of the Navajo and Blanco Rivers below the points of diversion by maintaining minimum bypass requirements;
- Water users must enter into contracts with the Secretary for water that includes provision for the sharing of water supply shortages among other water users of the San Juan River basin.
Heron is located in a very small watershed, but is designed to store up to 400,000 acre-feet of water imported from the San Juan Basin, and to supply a firm yield allocation to 16 contractors of 96,200 acre-feet per year. It is not authorized to store native Rio Grande water. It is characteristically stable in surface elevation, generally only subject to relatively slow fill and drawdown rates.

3.2 El Vado Reservoir

El Vado is a Middle Rio Grande Conservancy District (MRGCD) constructed dam and reservoir completed in 1935. The Bureau of Reclamation (Reclamation) subsequently rehabilitated the dam and operates it pursuant to contract with the MRGCD primarily for water supply for the MRGCD service area, including the six middle Rio Grande Pueblos. Reclamation maintains water in storage in El Vado reservoir to guarantee the prior and paramount demand of the six middle Rio Grande Pueblos.

El Vado Reservoir stores both native and SJC waters, with a total capacity of approximately 186,000 acre-feet. Typical operations include filling during spring runoff and drawdown during irrigation season. Depending on winter conditions, operational constraints maybe enacted to keep water off of the spillway gates. The operation of El Vado Dam is to provide incidental flood control benefits between El Vado and Abiquiu Reservoirs, and to the extent possible, limit maximum flow to about 5,000 cfs in the channel of the Rio Chama downstream from El Vado Dam. It provides “run-of-the-river” power generation through operations by Los Alamos County, whenever flows and elevations fit criteria. El Vado Reservoir substantially fills and drawdown over 1-year cycles.

3.3 Abiquiu Reservoir

Abiquiu Reservoir is a Corps of Engineers dam and reservoir completed in February 1963, under authority of the Flood Control Act of 1948, as a flood and sediment control facility with a flood pool of 551,000 acre-feet and an original sediment reserve pool of 77,039 established in 1963. Public Law 97-140, authorizes Abiquiu Reservoir to store up to 200,000 acre-feet of SJC water. The top of the current storage easement (owned by Albuquerque) is 6220.0 feet. Public Law 100-522, October 1988, authorizes the Corps to store up to 200,000 acre-feet of native water within the unused space of the SJC pool. This storage easement takes up approximately 140,000 acre-feet of the flood pool, and approximately 43,000 acre-feet of remaining unused sediment pool. As of January 1, 2003, the total remaining storage space below elevation 6220.0 is 183,099 acre-feet. Of this amount, the City of Albuquerque has contracted with the Corps of Engineers to store up to 170,900 acre-feet. Other SJC contractors have agreements with the City and the Corps to store within the remaining unused space below elevation 6220 ft.

In April 1986, Los Alamos County was issued a license to operate the newly constructed Abiquiu Dam hydroelectric power plant. This plant is also a run-of-river facility, similar to that at El Vado Reservoir. Releases from Abiquiu Dam are operated to channel capacities of 1800 cfs below the dam, 3,000 cfs at Chamita and 10,000 cfs at the Otowi gage. Abiquiu Reservoir retains flood flows under such conditions, and evacuates them either at earliest possible time, or in a manner prescribed in PL 86-645. In the case of flood water retained in Abiquiu Reservoir after July 1st when the Otowi gage drops below 1,500 cfs, the water is held as “carryover” storage, and then evacuated after November 1st.

Abiquiu Reservoir was used in 2001 through 2003 through the Conservation Water Agreement between New Mexico and the United States, with a deviation from normal operations granted by the Corps pursuant to PL 86-645 (accompanied by a Rio Grande Compact Commission resolution giving its advice and consent) and a permit issued by the NM State Engineer, to capture and release native Rio Grande waters in excess of downstream demand in a beneficial way for endangered species. This agreement demonstrates and exercises potential flexibilities in the operations of Abiquiu Dam, given collaboration between affected parties.
3.4 Cochiti Reservoir

Cochiti Reservoir is a Corps of Engineers dam and reservoir completed in August 1975, under authority of the Flood Control Act of 1960, and Public Law 86-645, as a flood and sediment control reservoir with a flood control pool capacity of about 590,000 acre-feet. Cochiti Reservoir serves as the primary flood protection structure for the most populous areas of New Mexico, the middle Rio Grande. PL 88-293 also granted authority for a permanent recreation pool made up of SJC water. The losses are replaced annually with SJC water as needed up to 5,000 acre-feet, to maintain 1,200 surface acres of open water. To maintain this pool, Cochiti Dam typically stores in the range of 50,000 acre-feet, with the pool gradually evaporating and being replenished annually with SJC from Heron usually during the following winter.

Cochiti Dam passes all inflow except when holding back flood inflows or refilling the permanent pool. As the Rio Grande (mainstem) reservoir above Elephant Butte Reservoir, it directly regulates Rio Grande flows into the middle valley. Currently recognized channel capacity is 7,000 cfs (at the Albuquerque gage at Central Ave. Bridge), with the most critical choke point being at the San Marcial railroad bridge 205 miles downstream (at approximately 4500 cfs capacity.) It must operate in concert with Jemez Canyon (Jemez River tributary below Cochiti Dam) to control these flows. Cochiti Dam and reservoir are on Pueblo de Cochiti land.

3.5 Jemez Canyon Reservoir

Jemez Canyon is a Corps of Engineers dam and reservoir completed in October 1953, under authority of the Flood Control Acts of 1948 and 1950, and Public Laws 80-858 and 81-516, as a flood control and sediment retention reservoir. Jemez Canyon has a capacity of approximately 100,000 acre-feet, which includes a 73,000 acre-foot flood pool and a remaining sediment reserve pool of approximately 24,000 acre-feet. It serves along with Cochiti Dam as a flood protection structure for the metropolitan and rural areas of the middle Rio Grande. Jemez Canyon is operated as a dry reservoir unless storage is induced during flood control operations. The dam and reservoir are on Santa Ana Pueblo lands.

4.0 PROGRAM WATER OWNERSHIP ALTERNATIVES

It is assumed that, whatever entity assumes nominal ownership of acquired rights, NMOSE permits for transfer and storage of Program water will need to be secured. Water rights in the middle Rio Grande are grounded in state water law, which is underpinned by the doctrine that the State holds its waters in trust for the benefit of citizens who put it to beneficial use\(^2\). The question of ownership of state permits for (public) streamflow enhancement purposes has great relevance for management, as river operations for listed species transition from short-term to long term water acquisition.

Following are some alternative ownership models:

- **Bureau of Reclamation** - If Congressional appropriations are to be relied upon to fully fund water lease/purchases, there may be a presumption that water subsidy equates to water control. Reclamation ownership would be consistent with federal ESA and Tribal trust responsibilities.

- **State of New Mexico** - Recent changes in the State law, however, as enacted by the NM legislature in 2005, authorized the Interstate Stream Commission (ISC) to establish a Strategic Water Reserve. This allows the ISC the option to purchase or lease surface and ground water from willing sellers or lessors, and to receive donated water or water rights

\(^2\) Tensions between federal and state prerogatives regarding water are long-standing. Although the federal government can own water rights (very few Reclamation projects would have been constructed without them), federal legal doctrine generally has generally deferred to State water law in the Western US.
or storage rights to develop a water reserve. But, at no time shall the use of this water or water rights result in an increase in net depletions in any of the State’s water basins. The Act also states that the ISC shall pay no more than the appraised market value to purchase or lease water or water rights and storage rights for the strategic water reserve. The ISC may accept money or grants from federal or other governmental entities or other persons to purchase or lease water or water rights for the strategic water reserve and to pay administrative costs. The ISC shall not acquire water or water rights that are served by or owned by an acequia or community ditch. This Strategic Water Reserve legislation could aid the Program in working with the State to acquire water to help meet Program goals. In addition, the City of Albuquerque, in an agreement with environmental groups, set aside 30,000 acre-feet of storage space for water for environmental preservation purposes within Abiquiu Reservoir. This storage space could become available to store water acquired to meet Program goals.

- **A Water Trust** - Some Western states have created water trusts to secure ecological streamflows. Washington, for example, has a state-funded quasi-private entity created to receive water rights in trust. A private corporation could also organize to hold MRG water rights for streamflow. In California and Arizona, the Nature Conservancy has acquired water rights for ESA and other instream uses. The potential of the Water Trust held by the Program itself to hold the proposed water pool should also receive consideration.

### 5.0 PROGRAM WATER MANAGEMENT DECISIONS

Much of the impact of adding Program water will be in the administration and management, through decision-making and record keeping. The statement in the introduction that we already store and release all the water we can reasonably expect is a testimony to this: There’s essentially no more water to be had – it’s a matter of shifting allocations and optimizing the management of existing storage capacity we already have.

It would be an omission to focus solely on arranging to physically store water in reservoirs, without considering how that water will be accounted for and moved through the system, and who will do it.

#### 5.1 River Operations

**Description:** Water stored and managed for the Program joins a complex mix of water delivery prerogatives when it comes to operational decision-making. The system of storing and releasing all types of water in the Rio Grande is very complex and it will become more so upon the addition of a new designation of water, possibly in multiple reservoirs. Consequently, sophisticated management and decision techniques tend to require enactment by the people who currently do hands-on operations and accounting. The present Program water manager, USBR, has been the lead decision-maker and accountant on waters supplied from reservoirs for the various demands, made so by their statutory mandates and historical role in water development in the Program area.

However, drought and ever increasing and competing demands have led to involvement of representatives from other entities into the daily operations process. To ensure balanced decision-making, and to keep all partnering agencies involved in real-time operations, conference calls have been occurring as often as needed for the past several years. These calls would remain a vital part of operations, and Program water releases would join the other special purposes considered in the calls.
5.2 Adaptive Management

**Description:** Adaptive management is gaining currency in resource management circles. Such a process involves a recurring cycle of: assessment of objectives, opportunities and constraints, selection of a management alternative, careful monitoring of the impacts of implementing the alternative and adjusting management prescriptions in light of observations. The advantages of such a process when faced with a variable supply, storage prescriptions in up to five reservoirs and a number of downstream delivery obligations, should be obvious. A “decision matrix” for managing Program water would include a number of considerations:

- **Biological:** The momentary and seasonal ability of naturally occurring flows to support the biology of the species of concern; flow prescriptions (US Fish and Wildlife Service).
- **Water Rights Administration:** The rates of water diversions required by the Middle Rio Grande Pueblos, City and MRGCD; impacts of actions to end users; legal priority of Program water.
- **Forecasts:** real-time snow pack, streamflow and precipitation.
- **Reservoir Operations and Accounting:** The status of storage of San Juan-Chama and native water supplies; availability of unoccupied reservoir space; location of available storage; reservoir authorized purposes; flood operations prescriptions;
- **Rio Grande Compact compliance:** The status of New Mexico’s annual and cumulative compliance with Rio Grande Compact deliveries and restrictions on storage under Articles VI and VII of the Rio Grande Compact.
- **Availability of Program water in storage:** the quantity and location of the acquired water.

Development of an annual Rio Grande water budget and a design hydrograph based upon it could help guide the understanding needed to balance the storage and release of Program water. Efforts to make daily management of Program water more criteria-based might result in greater reliability and more inclusive decision-making prior to the onset of each season.

5.3 Accounting System

**Description:** The implementation of a storage and management system for Program water will necessarily include accounting methods to track Program water, along with all other designations of water. The accounting will consider what water type(s) are included, and how to distribute losses in an equitable manner. There are several categories of accounting associated with the additional storage of Program water: physical-reservoir, San Juan-Chama, Rio Grande Compact and Program water are all part of the total accounting needed. The first three are in place, but may be affected by Program water. The accounting methods developed and implemented under URGWOM\(^3\) are suitable for providing a complete accounting of the storage and transport of Program water.

5.4 Delivery Assurance

**Description:** With so many competing interests and organizations with management authorities over the transport of and access to water, the ubiquitous measuring error, and the highly variable and uncertain hydrologic conditions affecting transport, it is not trivial to accurately deliver water to demand points. A system of monitoring and accounting is needed to provide reasonable accuracy and assurance of the delivery of Program waters as they move with waters for other purposes, with an appropriate allowance

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\(^3\)“Upper Rio Grande Water Operations Model”, which was developed to account for water supply and delivery in the Program area and is seen as an important tool for decision-making.
for sharing the transport/loss and gaging uncertainties. Hence, the key issue of managing of Program water is the timely delivery and ability to ensure compliance with Program objectives.

5.5 End-Of-Year Reporting

**Description:** As an extension of the accounting system, the management of Program water will require a system of reporting to stakeholders, the public, and the Compact Commission. This necessary reporting will require development and inclusion into existing URGWOM accounting reports for other waters.

6.0 AUTHORITY FOR PROGRAM WATER MANAGEMENT

6.1 Adaptive/Collaborative Models

Since 1996, Reclamation has secured supplemental water leases with its San Juan-Chama contractors for silvery minnow conservation, using Congressional appropriations. Because of this continuing funding stream and the fact that its water management actions are subject to consultation for ESA compliance, the Bureau has naturally assumed the lead in managing “minnow water.” However, as time goes on, Reclamation authority might become less compelling, if water stored in reservoirs becomes less directly controlled by this agency. While, it is by no means clear that Reclamation will continue to exert its current management prerogatives over the Rio Grande, it is clear that it and its sister agencies (see “Authorities”, above) will continue to exercise Congressional mandates, as the Program water pool is implemented.

The existing collaborative management approach for the supplemental water programs has proven a workable model over the past 8 years (albeit without tribal participation). Considering the range of stakeholders, a similar adaptive management model should continue to operate, with improvements, at least throughout the life of the Collaborative Program (projected to FY 2014).

6.2 Current Management by Reclamation

The current system of daily conference calls has assisted Reclamation in making daily decisions for operating the river system for both ESA and irrigation purposes. These calls have included many of the agency stakeholders. This management scheme was responsive to the challenges of past years, when short-term “water borrowing” and “last minute leases” were found necessary to meet stream flow prescriptions.

7.0 DESCRIPTION OF RESERVOIR STORAGE ALTERNATIVES

This section attempts to identify storage options that have the most promise of success. Due to the political and legal nature of any actions, and the difficulty in reassuring every one of the technical and accounting impacts associated with any action, what appears to be the common sense choice for storage and management may not prove to be a desirable option. For example, though Cochiti Reservoir might appear to be a best option because of its large capacity and strategic location, it might be determined to be infeasible due to issues with Pueblo de Cochiti or the delta ecosystem; then, another reservoir might become the better option. Any change to operations of any of the reservoirs could have some impact to Rio Grande Compact deliveries, and would require offset accounting and reporting, accordingly. Also,

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4 Abiquiu and Cochiti, potential storage locations for Program water, are Corps facilities; El Vado Reservoir might be returned to MRGCD control before 2014. Effective control of the San Juan-Chama Project is also, arguably, subject to some process of transfer to local beneficiaries and a proposal to do so is currently being discussed (November, 2003).
increasing storage at any reservoir will incrementally increase losses, and such additional losses should be borne by Program water.

**Conclusion:** There is no single best alternative. All reservoir storage alternatives should be fashioned in a manner that would create for it the operation flexibility to maximize reservoir storage under an adaptive storage management scenario, allowing for exchanges of water. The ultimate system of storage and control must be undertaken in a fashion that prevents impairment of existing uses or conflict with statutory authorizations.

### 7.1 Alternative No. 1: HERON STORAGE

When possible, capture all native inflow to Heron and maintain a Program pool by allowing for the carry-over of this storage from one year to the next. The native Rio Grande inflow to Heron averages about 15,000 acre-feet per year, which is believed well short of sustained Program needs. To supplement this supply, the Program could acquire the flexibility to store (and carry-over) in Heron Reservoir SJC water leased to the Program.

**Issues:**
- Amend authorizing legislation to allow for the storage and carry-over of native Rio Grande water.
- Enter into contract with the Secretary to allow for the storage and carryover of Program water.
- Heron’s native watershed is very small, yielding only 15,000 acre-feet per year on average. (SJC diversions provide by far the most inflows.)
- If Heron fills, the stored Program water will require evacuation to make room. This is necessary to avoid impact to the SJC project by Program water.
- Heron almost certainly will require assistance from other reservoirs to provide a sustainable amount of Program water.
- Heron storage is the greatest distance from the endangered species habitat area.
- Adopt URGWOM rules to provide for the accounting of Program water in Heron Reservoir.
- A permit from the State Engineer is needed to store native waters

**Benefits:**
- Minimize evaporation losses of Program water.
- Has a large authorized conservation storage capacity and normally would have adequate available capacity to store Project water.
- Existing downstream supply reservoirs will receive some operational relief from Heron’s new, more flexible operation.

### 7.2 Alternative No. 2: EL VADO RESERVOIR STORAGE

El Vado Reservoir currently has the authorization and flexibility to store Program water. It benefits from most of the Rio Chama native flow as seen coming in at La Puente gage and from Heron Dam releases, therefore, El Vado Reservoir can store native Rio Grande flow and re-regulate SJC releases from Heron Dam.

**Issues:**
- Coordination with MRGCD and the Reclamation would be required. Legal clarification of the approval process would be necessary.
• Storage capacity must be physically available without impairing ability to store for MRGCD, prior and paramount storage, or other storage requirements.

• El Vado Reservoir is the storage reservoir for Prior & Paramount waters to supplement native flows in times of shortage. These highest priority rights cannot be jeopardized by other storage needs.

• There is no access to mainstem Rio Grande flows. Accounting exchanges would be needed if mainstem flow would effectively be captured.

• El Vado Dam is a couple of water-flow days above the habitat areas.

• There are special maintenance needs for keeping storage levels down below spillway gate crest or running anti-ice bubblers during freezing times.

• El Vado Reservoir was constructed after 1929 and conservation storage is subject to the provision of the Rio Grande Compact.

Benefits:

• El Vado Reservoir releases supplements “Wild and Scenic River” reach flows and seasonal rafting flows, to benefit wildlife and recreation, and assists in the maintenance of minimum fishery flows year-round.

• El Vado Reservoir is currently operated to store Rio Grande water as well as SJC water.

• There are lots of opportunities to capture both types of water: SJC and RG.

• El Vado Reservoir has low evaporation loss rates compared to downstream reservoirs.

• Being high in the system, it has the potential to benefit the most needs and interests through carefully managed releases.

7.3 Alternative No. 3: ABIQUIU RESERVOIR STORAGE

Abiquiu Dam bypasses on average, approximately 1/3 of the native yield of the Rio Grande system in New Mexico, and all of the SJC (not lost or stored above Abiquiu Reservoir) passes through or stops there. It therefore has the 2nd best location (behind Cochiti Reservoir) of the five existing storage reservoirs, for the purposes of capturing water for Program use. The easement to store SJC is limited to no greater than the elevation 6220.0 feet, and lies mostly within the flood pool, and partially within the sediment reserve pool. This translates to approximately 183,000 acre-feet of space of which 170,900 acre-feet is contracted by the City of Albuquerque.

In settlement of the litigation in Minnow v. Keyes (pending court approval as of August 26, 2005), the City of Albuquerque and Albuquerque/Bernalillo County Water Utility Authority agreed to provide 30,000 acre-feet of space in Abiquiu for use as a permanent environmental pool for the storage of native and/or San Juan-Chama water acquired by plaintiff environmental groups or others through lease, purchase or donation…including leases, purchases or donations by or through the MRG ESA Collaborative Program. The agreement is subject to the storage needs of the City of Albuquerque and Albuquerque/Bernalillo County Water Utility Authority, requisite environmental approvals and other factors. This is an important step forward in meeting the storage space needs for Program water. The agreement further provides that the parties will work in good faith to complete a future agreement among relevant governmental agencies and in cooperation with the Collaborative Program regarding the details and control and use of the water in the Environmental Pool.

Issues:

• Details regarding control and use of the water in the Environmental Pool at Abiquiu should to be developed cooperatively with the environmental groups, City of Albuquerque and
Alternative scenarios for the operation of the pool should be cooperatively developed and run using a tool such as the URGWOM model planning tool. This will facilitate development of the detailed agreement regarding the control and use of the Environmental Pool.

A permit from the State Engineer is needed to store native waters.

A revision of the Corps water management criteria governing Abiquiu Dam’s operations would be required.

There is no access to mainstem Rio Grande flows.

Program waters, like SJC contractor waters, would require evacuation in the event of flood operations, and Program waters would be first out.

Enhanced accounting would be required for Abiquiu Reservoir operations.

Abiquiu Reservoir is at least one day travel time above the habitat areas.

Benefits:

- Abiquiu Reservoir is currently authorized to store SJC Project and Rio Grande water.
- On the long-term, Albuquerque is not expected to keep their SJC pool full, so there should be space for Program water.
- There are lots of opportunities to capture both types of water: SJC and native Rio Grande.
- Abiquiu Reservoir has reasonably low loss rates compared to downstream reservoirs.
- Abiquiu Reservoir has proven to be the most practical and flexible option for additional storage for a Program pool.

Alternative No. 4: COCHITI RESERVOIR STORAGE

Issues:

- Pueblo de Cochiti would need to approve any alternate operations.
- Cochiti Reservoir is not authorized to store any water except floodwaters, and a permanent “recreation pool”, which was filled by and is replenished by supplemental SJC water.
- It has a wetlands/habitat area at the headwaters, which could be harmed by increased storage and periodic filling and drawdown.
- Loss rates are higher than reservoirs higher in the system.

Benefits:

- Cochiti Dam is located at the top of the habitat reach, which is most convenient for time-critical operations.
- It is the only mainstem reservoir of the five, managing waters from both the Rio Grande and Rio Chama – it has the best capture potential.
- Cochiti Reservoir has a potentially large seasonal volume which could accommodate Program water storage.

5 See also WAMS position paper on Cochiti issues.
• It is not currently involved in supply operations (except that waters for all downstream demands pass through), therefore adds completely new storage space to the system.

**7.5 Alternative No. 5: JEMEZ CANYON STORAGE**

Modifications to URGWOM accounting model are needed. Jemez Canyon is not storing water except excessive flood inflows.

**Issues:**

- Santa Ana Pueblo would need to approve any new operations and storage.
- Jemez Canyon is authorized only to store floodwaters.
- Jemez Canyon would require OSE permitting to store native waters.
- It would require re-regulation approval by the Corps.
- Average annual runoff for period 1920-1990 was approximately 38,000 AF, with the majority occurring during snowmelt runoff.
- The inflows, although intermittent, are relied upon to be bypassed to assist Cochiti Dam outflows in meeting downstream flow demands.
- Loss rates are higher than reservoirs higher in the system.
- A permit from the State Engineer is needed to store native waters.

**Benefits:**

- Jemez Canyon releases join the Rio Grande within the habitat, which is most convenient for time-critical operations.
- Storing water could provide some wildlife benefits.

**Conclusion:** No single reservoir seems to offer adequate capacity or management flexibility to permit the storage of multiple year acquisitions of Program water. We recommend study and actions to create the maximum possible flexibility in each of the reservoirs and adoption of an Adaptive Management concept for Program water storage.

**8.0 CONCLUSIONS AND RECOMMENDATIONS**

- Upstream storage capacity available for Program water is limited by pool limitations on physical storage space in reservoirs; Congressional authorizations of water projects along the MRG ESA Project area; complex accounting that attempts to minimize negative impacts to water users basins, states, and Mexico; and meeting the many competing needs on the Rio Grande system.
- For the most part, the water to be stored and managed for this Program is already stored and managed in some fashion.
- The Water Acquisition and Management Committee envisions meeting Program water needs through improved water management and the voluntary annual lease or purchase of water from current users, storing such water in upstream reservoirs, with flows released as needed to provide for identified river needs.
- While the preponderance of ESA stream flow needs can be met through naturally occurring flows, an annual average of about 50,000 AF must be acquired, through voluntary transfers, to meet Program purposes.
• Obtaining Program water requires obtaining the physical ability to store water in reservoirs, defining how that water will be accounted for and moved through the system, and identifying who will do it.

• A number of difficulties must be negotiated, including the timing of storage, physical limitations on storage space, congressional authorizations, complexity in accounting and meeting all competing uses on the Rio Grande system.

• There is no single best alternative. All reservoir storage alternatives should be fashioned in a manner that would create for it the operation flexibility to maximize reservoir storage under an adaptive storage management scenario, allowing for exchanges of water. The ultimate system of storage and control must be undertaken in a fashion that prevents impairment of existing uses or conflict with statutory authorizations.

• Due to the agreement on the Environmental Pool at Abiquiu (court approval pending as of 8/26/05) the initial focus of the Program’s participation in reservoir management studies should be at Abiquiu Reservoir.

Storage

• A pool of Program water, including carry-over of unreleased water from previous years, must be secured to enable an optimal river management program for Program purposes.

• The five existing reservoirs that could store and release Program water vary in size, legislative authorization and potential to capture runoff. These include Heron, El Vado, Abiquiu, Cochiti, and Jemez Canyon reservoirs.

• The Program should pursue all options to secure and utilize space in the five reservoirs:
  o Heron Reservoir – Pursue if-and-when storage\(^6\) for Program water storage with Bureau; authorizing legislation.
  o El Vado Reservoir – Explore temporary storage options with MRGCD.
  o Abiquiu Reservoir – Pursue the detailed studies required for the Environmental Pool at Abiquiu.
  o Cochiti Reservoir – Explore use as a re-regulating reservoir with Cochiti de Pueblo; study the costs and benefits of creating new storage to capture mainstem flows.
  o Jemez Canyon Reservoir – Explore temporary storage options

Management

• A system of monitoring and accounting is needed to provide reasonable accuracy and assurance of the delivery of Program waters as they move with waters for other purposes, with an appropriate allowance for sharing the transport/loss and gaging uncertainties.

• As an extension of the accounting system, the management of Program water will require a system of reporting to stakeholders, the public, and the Compact Commission. This necessary reporting will require development and inclusion into existing accounting reports for other waters.

• In 2005, the NM legislature authorized the ISC to establish a Strategic Water Reserve. This allows the NMISC the option to purchase or lease surface and ground water from willing sellers or lessors, and to receive donated water or water rights or storage rights to develop a water reserve.

\(^6\) If-and-when storage means a contract to store water in the space contracted to another entity, which is not being used by that entity. If and when the original contract holder needs that space, the if-and-when stored water would be evacuated so as not to impair the original contract use of that space.
• Under the Draft Authorizing Legislation for the Program, Reclamation is assigned the lead authority for water acquisition activities intended to benefit Program’s goals.

• Ideally, water management directed toward meeting the Program goals would be governed through an overarching, collaborative management model, featuring full stakeholder access and appropriate local control; while day-to-day operation would be directed by designated local representatives from Reclamation, with input from the Program, NMISC, USFWS, and others to assure that federal and other Program signatory interests are maintained.

• Active participation of all stakeholders, including federal and state agencies, Pueblos, water users, and conservation groups, should be accommodated.
Attachment E-13

WATER ACQUISITION AND MANAGEMENT SUBCOMMITTEE BACKGROUND PAPER:
COCHITI LAKE WATER ISSUES

1.0 INTRODUCTION

- Various options have been discussed in recent years on whether Cochiti Lake would or should have a role in water operations for the endangered Rio Grande silvery minnow within the Middle Rio Grande.
- Judge Parker, in his 19 April 2002 Opinion and Order on the Minnow v. Keys case, agreed with the Corps of Engineers’ (Corps) interpretation of its authorities for the operation of Cochiti Lake.
- Under those authorities, Corps operates Cochiti Lake for flood and sediment control. In addition, PL 88-293 specifically authorizes a permanent recreational pool of 1,200 surface acres (approximately 50,000 acre-feet) with 5,000 acre-feet provide annually by the Bureau of Reclamation (Reclamation) from the San Juan-Chama Project.

2.0 ONGOING INVESTIGATIONS-OPERATIONS AND FLOOD CONTROL

- The NM Interstate Stream Commission (ISC), Reclamation, and the Corps are conducting an Environmental Impact Statement (EIS) to refine and update the water operations in the Rio Grande Basin under existing authorities.
- Relative to Cochiti Dam, this EIS is evaluating potentials to increase the maximum rate of release of water during flood control operations.
- The Corps criteria for flood control operations in the Middle Rio Grande is to limit maximum flood releases to 7,000 cubic feet per second (cfs) at the Albuquerque gage.
- The EIS will include evaluated alternatives that range up to 12,500 cfs at the Albuquerque gage.

3.0 PROPOSED INVESTIGATIONS AND POTENTIAL AUTHORIZATION CHANGES

- The Corps is also working with the Pueblo de Cochiti (Pueblo) in seeking funds to jointly conduct an Environmental Baseline Study, expected to take two years, to assess a variety of potential water management changes for this reservoir.
- This baseline study would focus on impacts of reservoir volume and pool elevation changes, including no change, draining to half the current pool, and completely draining the reservoir to support the needs of endangered species.
- The study would also include the prospect of storing Pueblo water and other native Rio Grande water.
- Since most of the Cochiti Lake project is on Pueblo lands, the Pueblo will decide internally whether it is in their best interest to support a change in the present operations authorization. The proposed study would be fundamental, but not necessarily the most important basis for their decision.
- If the Pueblo supports a change in the operation of Cochiti Lake, the Corps would then recommend an expanded scope of review to the entire affected community. This proposed
investigation could lead ultimately to a proposed change in Congressional authorization for this Corps project.

4.0 **PROGRAM CHARGE TO THE WAMS REGARDING COCHITI RESERVOIR OPERATIONS**

- Task number 36 of the MRG ESA Collaborative Program’s Implementation Plan states: “Think through and write down how the fundamental uncertainty associated with establishment of continuous silvery minnow habitat restoration through Cochiti Reservoir will impact the development of the interim plan and the long-term program.”
- Tremendous uncertainty exists associated with the concept of habitat restoration related to a redeveloping channel through a potentially drained area of a reservoir.
- The Pueblo must be involved in any change to the management of the permanent pool and their support of any proposed changes is critical.
- If the Pueblo agreed to drain the lake and restore minnow habitat through the reservoir area, the daunting task of dealing with fish passage through the dam would remain. Also, the reservoir area would still be subjected to periodic inundation for flood control operations during above average snowmelt runoff years and abnormal precipitation events.
- Another issue is the concern of sediment redistribution, as there are significant changes due to large releases of this material from a dry reservoir. The environmental health risks that may develop and impacts to habitat areas as the sediments are redistributed will need to be analyzed.
- There may also be issues associated with southwestern willow flycatcher and bald eagle habitat in the delta area of the upper reservoir as a result of any potential change in its operation.

5.0 **CONCLUSIONS**

- The Corps adheres to the position that actions involving potential modifications to the operation of Cochiti Reservoir be deferred during the development of the interim plan to provide time for the Pueblo and/or the Pueblo and the Corps to complete the proposed Environmental Baseline Study.
- The WAMS concurs with this position and recommends that the Program maintain a communication dialog with the Pueblo leadership to examine impacts and alternatives to all scenarios relative to a change in operations and program objectives of the ESA Collaborative Program.
- The WAMS additionally recommends that issues concerning the future operation of Cochiti Reservoir regarding the long-term goals of Program also be deferred until a decision is made on the results of the Environmental Baseline Study.
Attachment E - MRG ESA Collaborative Program Water Plan

Attachment E-14

WATER ACQUISITION AND MANAGEMENT SUBCOMMITTEE BACKGROUND PAPER:
RESERVOIR EVAPORATION WATER

1.0 INTRODUCTION

- Previous assessments summarized by SSP&A for the NMISC in 2000 estimated that reservoir evaporation for Elephant Butte Reservoir over the past 50 years ranged from less than 50,000 to over 250,000 acre-feet/year, and for Cochiti Reservoir between 1976 to 1999 to range from about 5,000 to 20,000 acre-feet/year (http://www.ose.state.nm.us/water-info/mrgwss/mrgwss-final-rpt.pdf).
- This position paper presents reservoir free-water surface evaporation rates for Heron, El Vado, Abiquiu, Cochiti, Jemez Canyon, Elephant Butte, and Caballo Reservoirs calculated using pan evaporation measurement data collected near each of the reservoirs during 1985-1999. These data were obtained from the Upper Rio Grande Water Operations Model (URGWOM) web page.
- Daily pan evaporation measurements are collected year around only at Elephant Butte and Caballo Reservoirs. For Heron, El Vado, Abiquiu, Cochiti, and Jemez Canyon Reservoirs the daily pan evaporation data in the URGWOM data set include data collected from April 1 to October 31. The URGWOM data set also includes modeled estimates of daily pan evaporation for November 1 to March 31 at Abiquiu, Cochiti, and Jemez Canyon Reservoirs over the most recent 3-4 years of available data (i.e., 1996-1999).
- The URGWOM data set also includes 1985-1999 estimates for percent daily ice cover for Heron, El Vado, Abiquiu, Cochiti, and Jemez Canyon Reservoirs. These values are based on visual observations, with extrapolations projected to fill data gaps. The ice cover data are used in this position paper to estimate daily average percent free-water surface occurring on the reservoirs during the year.
- Additional data characterizing the physical attributes of the reservoirs, including reservoir spillway elevations, areas, and volume, were compiled from information obtained from various USACE and USBR web pages, plus additional information obtained directly from USBR and USACE staff for El Vado and Abiquiu Reservoirs.

2.0 METHODS

- The URGWOM data set were compile in Excel spreadsheets and arranged to allow the calculation of daily averages of pan evaporation and percent reservoir ice cover using the 15-year of URGWOM data available for each reservoir (February 29 data were deleted).
- Regression-based relationships of daily pan evaporation rates were computed for the April 1 to October 31 data for both Heron and El Vado Reservoirs relative to daily pan evaporation data from Abiquiu Reservoir during the same period. Then, based on these two regression relationships, November 1 to March 31 daily pan evaporation estimates were computed for both Heron and El Vado Reservoirs using the averages for the modeled Abiquiu Reservoir daily pan evaporation available from the URGWOM data for November 1 to March 31.
- Daily estimates of surface evaporation per unit area were then computed for each reservoir using their respective daily average pan evaporation rates and a pan-evaporation correction factor of 0.7, a commonly used factor to adjust pan evaporation estimates to surface water values. Also,
for periods of ice cover, the daily free-water surface evaporation rates were calculated by multiplying by (one minus the daily percent of ice cover), as reported in the URGWOM data set.

- Estimates of maximum annual potential evaporation for each reservoir were computed using the maximum reservoir surface area at the spillway elevation and the annual total of the daily average annual evaporation rates estimated for each of the reservoirs. (Areas from available area-capacity relationships developed for each reservoir can be used to scale reservoir evaporation estimates to other areas of interest.)

3.0 ASSUMPTIONS AND CAUTIONS

- Pan evaporation rates provide only approximate estimates of true reservoir evaporation rates.
- Pan evaporation rates are more affected by daily solar heating and potential shading than are natural water bodies. A constant pan evaporation correction factor of 0.7 was applied to estimate daily surface evaporation at each reservoir. However, a higher correction factor (>0.7) may be more appropriate during at least part of the year at Elephant Butte and Caballo Reservoirs, where solar heating more affects shallow surface waters.
- Placement of evaporation pans affects measured evaporation rates. For example, the evaporation pan at Heron Reservoir is located in a sparsely forested and bushy campground area, which is undoubtedly less affected by wind action than the reservoir. Consequently, evaporation estimates for Heron Reservoir may be greater than estimated here. Pan placement may also account for the decrease in the annual pan evaporation rates from Elephant Butte Reservoir to Caballo Reservoir.
- Estimates of percent evaporation reduction relative to Elephant Butte Reservoir, as presented below, cannot be directly evaluated in terms of likely water savings because actual evaporation rates are directly related to daily and seasonal operational scenarios that affect available storage and water surface areas within the reservoirs.

4.0 RESERVOIR/FREE-WATER SURFACE EVAPORATION RELATIONSHIPS

- Estimates of annual pan evaporation rates range from 53.2 inches/year at Heron Reservoir to 111.3 inches/year at Elephant Butte Reservoir (Table 1).
- Estimates of annual free-water surface reservoir evaporation rates range from 36 inches/year at Heron Reservoir to 77.9 inches/year at Elephant Butte Reservoir (Table 1).
- Estimates of annual free-water surface reservoir evaporation rates on a per unit area basis are as low as 46% (at Heron Reservoir) of that estimated for Elephant Butte Reservoir (Table 1).
- Estimates of theoretical maximum annual free-water surface reservoir evaporation rates range from 233,596 acre-feet/year at Elephant Butte Reservoir to 8,337 acre-feet/year at El Vado Reservoir (Table 1).
  - Elevation incorporated 94% percent of the variation occurring in the estimated evaporation at the reservoirs (Figure 1). This indicates a very strong relationship between estimated reservoir evaporation rates and reservoir elevation.

5.0 CONCLUSIONS

- Significant savings of water could be possible if greater proportions of New Mexico’s Rio Grande water were stored upstream of Elephant Butte Reservoir at locations of increased elevation.
The magnitude of this saving would depend on operations and available reservoir capacities affecting the seasonal upstream storage volumes and surface areas of water stored in each reservoir.

The information introduced here should be further developed through a subsequent study to evaluate water saving potentials under alternative reservoir operation scenarios using realistic allocations of water storage volumes and surface areas among these reservoirs for a selection of wet to dry water years. The objectives for these studies should be to define appropriate water operation alternatives to minimize reservoir evaporation losses and to maximize the conservation of water available to meet Program goals.
Table 1

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Spillway Crest Elevation (feet AMSL)</th>
<th>Surface Area at Spillway Elevation (acres)*</th>
<th>Capacity at Spillway (AF)*</th>
<th>Estimated Annual Pan Evaporation (inches/year)</th>
<th>Estimated Annual Free-Water Surface Evaporation (inches/year)</th>
<th>Estimated Percent Surface-Unit Evaporation Relative to EBR</th>
<th>Estimated Maximum Annual Free-Water Surface Evaporation at Area of Spillway Elevation (acre-feet/year)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heron</td>
<td>7,186</td>
<td>5,950</td>
<td>401,320</td>
<td>53.2</td>
<td>36.0</td>
<td>46%</td>
<td>17,850</td>
</tr>
<tr>
<td>El Vado</td>
<td>6,879</td>
<td>2,452</td>
<td>196,500</td>
<td>60.3</td>
<td>40.8</td>
<td>52%</td>
<td>8,337</td>
</tr>
<tr>
<td>Abiquiu</td>
<td>6,350</td>
<td>12,430</td>
<td>1192801*</td>
<td>76.5</td>
<td>52.1</td>
<td>67%</td>
<td>53,967</td>
</tr>
<tr>
<td>Cochiti</td>
<td>5,461</td>
<td>9,307</td>
<td>582,019</td>
<td>91.2</td>
<td>61.9</td>
<td>79%</td>
<td>48,009</td>
</tr>
<tr>
<td>Jemez Canyon</td>
<td>5,232</td>
<td>2,943</td>
<td>97,425</td>
<td>103.1</td>
<td>71.5</td>
<td>92%</td>
<td>17,535</td>
</tr>
<tr>
<td>Elephant Butte (EBR)</td>
<td>4,450</td>
<td>35,984</td>
<td>2,023,400</td>
<td>111.3</td>
<td>77.9</td>
<td>100%</td>
<td>233,596</td>
</tr>
<tr>
<td>Caballo</td>
<td>4,182</td>
<td>11,532</td>
<td>326,670</td>
<td>104.3</td>
<td>73.0</td>
<td>94%</td>
<td>70,153</td>
</tr>
</tbody>
</table>

* These areas, capacities, and maximum evaporation rates are theoretical and used to provide standardized comparisons. For example, although the spillway is higher, the USACE is authorized to store only up to the 6,283.5 foot elevation in Abiquiu Reservoir, with a maximum capacity of 545,784 acre feet.

Figure 1

![Elevation vs. Reservoir Evaporation](image)

- Evap = 135.8 - 0.0135(Elevation)
- $r^2 = 0.94; P = 0.0003$
Attachment E-15

WATER ACQUISITION AND MANAGEMENT SUBCOMMITTEE BACKGROUND PAPER:
EVAPOTRANSPIRATION AND WATER SALVAGE

1.0 INTRODUCTION

- Evapotranspiration (ET) is the combined transfer to the atmosphere through evaporation of liquid water from water, soil, and other environmental surfaces plus the transpiration of liquid and gaseous water from plants.
- A basis for estimating and comparing evaporation water rates in the environment is daily measurements of evaporative water loss from a standard, “Class A” evaporation pan (metal pans having 4-foot diameters and vertical sides).
- Because of the relatively small diameter and shallow depths of evaporation pans, they tend to have higher evaporation rates than other environmental surfaces.
- In general, the magnitude of annual water loss from different surfaces occurs as follows: pan evaporation > open water > bare saturated soil > riparian vegetation > upland vegetation > dry soil.
- A ratio of approximately 0.7 exists between pan evaporation rates and evaporation rates from large water bodies like reservoirs and greater ratios can occur for evaporation from other environmental surfaces.
- Claimed increases in salvaged water related to removal of saltcedar and other non-native phreatophytes could increase ground water and surface water, including the flow of water in a river, have been met with skepticism because various studies have failed to show that the removal of saltcedar had no apparent change in water quantity. However, there are many variables that could influence the flow of water in a river or the quantity of water in an aquifer. Specifically, many studies of water salvage following saltcedar removal have not been sufficiently comprehensive in scale or scope.
- The Departments of Interior and Agriculture have launched a Cooperative Initiative to Control Saltcedar in the Southwest, which is intended to address potential approaches to increase water supply, improve water supply, and other potential benefits.

2.0 BASIN DEPLETIONS AND RIPARIAN ET

- Estimated total average annual ET water losses along the Rio Grande from Otowi to Elephant Butte (674,000 acre-feet per year, including groundwater uses). These basin depletions are disturbed distribute among crops (34 percent, 230,000 acre-feet per year), riparian plants (33 percent, 222,000 acre-feet per year), reservoir evaporation (19 percent, 128,000 acre-feet per year) and urban uses (14 percent, 94,000 acre-feet per year) (SSP&A 2000).
- The invasion by non-native saltcedar and Russian olive into the Rio Grande bosque, with resulting widespread dense expanses of these exotic phreatophytes, is generally viewed as having significantly increased the ET rate by the riparian community and basin depletion losses of water for the MRG. In turn, restoration of the native riparian plant community along the Rio Grande is generally forecasted as expected to produce measurable decreases in riparian ET, basin depletion rates, and increase flows in the river.
• Saltcedar stands are frequently reported to use more water per unit land area than native riparian species (Gatewood et al. 1950, Weeks et al. 1987, King and Bawazir 2000), but saltcedar transpiration rates have been found to be no greater than native riparian plants on a per unit leaf area basis (Sala et al. 1996). Apparently, the relatively greater water consumption potentials of saltcedar is based on their tendencies to produce very dense stands having very high total leaf areas.

• Greater groundwater depths increase the energetic requirements of transpiration and reduce potential transpiration rates (Weeks et al. 1987, Doorenbos et al. 1992). A significant difficulty in interpreting transpiration rates for native and non-native riparian plant species along the MRG is the lack of comparative measurements for both plant groups collected at equal groundwater depths.

• Saltcedar cleared from 21,500 acres of floodplain of the Pecos River between Acme and Artesia, NM was projected to increase baseflow in the river by 10,000 to 20,000 acre feet per year, but such flow gains were not subsequently observed in the stream-flow gage records (Weeks et al. 1987). It was suggested that possible gains may have been masked by variations in climate, increased groundwater pumping, and/or increases in groundwater recharge rates. (It is also possible that potential ET benefits from removal of non-native communities were projected using incorrect, over optimistic estimators for potential ET reductions.)

3.0 ESTIMATED RANGES FOR ENVIRONMENTAL ET RATES ALONG THE MRG

• Estimated ET values used at Los Lunas restoration site for seven environmental cover types (USACE and USBR 2002):

<table>
<thead>
<tr>
<th>Environmental cover types</th>
<th>Low Estimate</th>
<th>High Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ET Value (feet/year)</td>
<td></td>
</tr>
<tr>
<td>Open water</td>
<td>4.2</td>
<td>5.1</td>
</tr>
<tr>
<td>Saltcedar/Russian olive</td>
<td>4.2</td>
<td>4.9</td>
</tr>
<tr>
<td>Willow (no range available)</td>
<td>4.2</td>
<td>4.2</td>
</tr>
<tr>
<td>Sweet clover/sunflower (alfalfa/wheat)</td>
<td>3.0</td>
<td>5.9</td>
</tr>
<tr>
<td>Cottonwood</td>
<td>3.0</td>
<td>4.8</td>
</tr>
<tr>
<td>Wet sandbar (no range available)</td>
<td>1.75</td>
<td>1.75</td>
</tr>
<tr>
<td>Grassland</td>
<td>0.0</td>
<td>1.99</td>
</tr>
</tbody>
</table>

Dahm et al. (2002) reported estimated ET at four MRG sites with distinctive vegetation characteristics:

<table>
<thead>
<tr>
<th>Vegetation type</th>
<th>Annual (growing season) ET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mature cottonwood with extensive saltcedar and Russian olive understory, without flooding (South Albuquerque valley)</td>
<td>123 cm/yr (4.0 ft/yr)</td>
</tr>
<tr>
<td>Mature, closed canopy cottonwood stand, with flooding (Belen)</td>
<td>98 cm/yr (3.2 ft/yr)</td>
</tr>
<tr>
<td>Dense salt cedar, with flooding (Bosque del Apache)</td>
<td>111-122 cm/yr (3.6 – 4.0 ft/yr)</td>
</tr>
<tr>
<td>Moderately dense saltcedar stand, rare flooding (Sevilleta)</td>
<td>74-76 cm/yr (ca. 2.5 ft/yr)</td>
</tr>
</tbody>
</table>
• Based on data from sites in the last two rows, Cleverly et al. (2002) concluded that ET rates were 61 percent lower in unflooded relative to flood saltcedar communities along the MRG.

4.0 CONCLUSION AND RECOMMENDATIONS

• Variations in measured ET values for non-native and native stands indicate that local differences in stand characteristics (e.g., leaf area densities), soils, ambient climate, depth to water table, and flooding complicate the extrapolation of ET data over time and space.

• Accurate determinations of riparian depletions along the MRG also require site-specific characterization of soil, groundwater depth, topography, flooding characteristics, groundwater, and vegetation condition, with quantitative understanding of vegetation responses to variations in these physical characteristics.

• The available data suggest that conversion of non-native to native riparian vegetation stands may not always result in reduced ET rates and reduced depletions. Available data indicate that after restoration of native riparian communities long-term increases may follow short-term reductions in ET, particularly if flood frequency is increased.

• Activities such as island shaving and removal (i.e., the conversion from either native or non-native vegetated island communities to open water surfaces, likely to result when stabilizing vegetation is removed from islands) may result in initial short-term (e.g., 1-2 year) reductions in ET, followed by longer-term increases in ET losses and depletions.

• Until ET relationships are better defined on a site-by-site basis, conservatively biased ET values may be used to estimate potential restoration related affects on ET.

• The potential benefits in reducing ET based depletions along the MRG through the restoration of non-native to native riparian communities and restoration options should continue to be assessed. The Program should encourage studies to assess the potentials for reducing ET-based depletions and increasing water salvage along the MRG and identify suitable alternates where conversion of non-native habitat areas may be productively converted to native riparian communities to produce net water savings, with real potentials for increasing river flows.

• To the extent possible, the Program should partner with the Cooperative Initiative to Control Saltcedar in the Southwest to help ensure maximizing potential benefits obtainable under this Initiative in addressing potential water salvage benefits along the MRG.

• The WAMS encourages the Program to lend support to the development of one or more comprehensive monitoring projects intending to assess potential benefits from Initiative supported large-scale saltcedar control projects in producing wet water flows along the MRG.

5.0 LITERATURE CITED


1.0 INTRODUCTION AND BACKGROUND

The Water Acquisition and Management Subcommittee (WAMS) has developed a listing of potential water sources and water management options that might provide supplemental flows to aid meeting the goals of the Middle Rio Grande (MRG) ESA Collaborative Program. These options include the possibility of retaining flood-flow water in ponds or lakes located along the floodplain of the MRG. The intent of retaining flood-flow water is to provide a short-term source of water for release in the event of reduced flows. The most likely application for this procedure is for the capture of excess water from summer thunderstorms.

This discussion focuses its consideration on existing facilities within the middle Rio Grande. Specifically, three wildlife refuges or management areas currently exist within the middle Rio Grande valley. Bosque del Apache and Sevilleta are National Wildlife Refuges managed by the U. S. Fish and Wildlife Service. The Ladd S. Gordon Waterfowl Management Complex is managed by the New Mexico Department of Game and Fish (NMDGF) and consists of four waterfowl areas: Belen, Casa Colorada, Bernardo, and La Joya.

2.0 ASSESSMENT

Based on current conditions, the ponds located on Bernardo and La Joya are the only feasible locations for consideration of retaining floodwater for future river release. Bosque del Apache is located south of Socorro and water released from this facility would be available only below San Marcial. Sevilleta is located north of San Acacia, but currently has very little pond development.

Of the four Game and Fish waterfowl areas, only Bernardo and La Joya have developed ponds. The purpose of these ponds is to provide winter-feeding and resting habitat for migratory waterfowl. Under their present operation, water is retained in the ponds from October through February. The surface acreage of all ponds combined is approximately 1,100 acres; the average depth of the ponds is about 3 feet. The total storage capacity of the ponds is estimated at 3000 to 3500 acre-feet.

The largest logistical concern with storing and releasing water from these facilities is the current inlet and outlet operations. In some cases, it takes about 2 weeks to fill the ponds, and at least the same time to drain them. Further, the ponds are designed to empty into the Unit 7 drain. Direct discharge to the river is not possible, so the water would not be available above San Acacia without developing a new discharge configuration. The entire system’s capabilities are limited by the maximum capacity of the Middle Rio Grande Conservancy District (MRGCD) delivery system.

There are also biological concerns. Once the ponds are filled in October, water continues to flow through the ponds to produce a flushing action. This prevents water stagnation and minimizes disease concerns, such as avian cholera and avian botulism. Water retained during spring and summer months would need to be retained for very short periods to alleviate this concern. The presence of water during the spring and summer months may create an ideal situation for the invasion of undesirable non-native weed species. Additionally, summer storage of water generates concern about mosquito habitat and associated west Nile virus.

Water quantity and quality may pose problems to effective storage during spring and summer months. Long-term storage is subject to considerable reduction due to evaporative loss, which tends to reach
maximum rates during June and July along the middle Rio Grande. On average, 7 days of storage in the La Joya ponds could lead to 2.5 to 3.0 inches of evaporation loss in June and July, 2.0 to 2.5 inches of loss in August, and 1.5 to 2.0 inches of loss in September. The resulting loss to the entire 1100 surface acres for one week of storage would be 230 to 275 acre-feet of evaporative loss in June or July, 180 to 230 acre-feet of loss for one week in August, or 140 to 180 acre-feet of loss for one week of storage in September. Evaporation of large quantities of water will concentrate natural and artificial contaminants (i.e. salinity, decaying vegetation, herbicides, and pesticides) resulting in compromised water quality.

There is an additional concern related to the interruption of “natural cycles”. At the end of the winter migratory period, remaining water is currently released from the ponds in February to reduce the potential for creating waterfowl reproductive habitat causing waterfowl to stay in the valley and become residents instead of migrating north. There is also a possibility that capturing peaking river flows associated with large rain events may disrupt the natural river processes.

The final major concern is of a legal nature. Spring and summer storage of water in the ponds in the Middle Rio Grande valley would require approval from the Office of the State Engineer (OSE).

3.0 CONCLUSIONS

1. Potentials exist for utilizing the Bernardo and La Joya ponds for temporary short-term flood-flow retention and release. Potentials also exist to develop new ponds on Sevilleta for the same purpose. However, such operations would require renovating or replacing the inlet and outlet structures for the ponds, and addressing biological and legal concerns.

2. Additional investigation and evaluation through a pilot project is required to define the physical logistics of capturing flood flows. For example, how will the timing and volume of flood flow diversions be determined? How will flood flow water be delivered and captured?

3. Additional administrative concerns would need to be addressed. For example, who will determine when flood flow should be captured? And, who will be responsible for assuring that flood flow is appropriately captured, retained, and released?

4. Based on the identified concerns, floodplain lakes and flood flow retention basins may have a potential for providing water to the river during dry periods. However, this alternative should be considered after other more feasible and long term alternatives have been exhausted.
Attachment I

The following is a partial list of the authorization for water use and storage at the Bernardo and La Joya Waterfowl Areas:

1. By contract dated October 21, 1960 between Bureau of Reclamation (USBR), NMDGF, and MRGCD the diversion of as much water as necessary to maintain specified elevation at the six lakes on the La Joya waterfowl area is allowed from the Sabinal Riverside Drain. This diversion is allowed only during the period from October 1 to February 1. This contract was entered into as mitigation for the construction and extension of the unit 7 drain.

2. By contract dated August 9, 1973 between USBR, NMDGF and MRGCD, the diversion of up to 600 acre feet to irrigate 200 acres was authorized. The Department is to pay MRGCD an assessment for any lands irrigated in excess of 200 acres. This contract does not affect the 1960 contract in any way.

3. Application for an alternate point of diversion (supplemental well) was approved by the OSE on December 1, 1977. This permit allowed the diversion of 572.49 acre feet from all sources for application to 190.83 acres. A pond 44 acres in size, to be maintained only during winter months was approved as part of the 190.83 acres.
1.0 INTRODUCTION

The ESA Collaborative Program is exploring options for maintaining flows in the Rio Grande for endangered species. Groundwater pumping has been proposed as an option that could be used to supplement river flows during periods of low flow. This pumping could include:

- **Pumping of shallow, alluvial groundwater**: intermittent pumping from existing or new shallow alluvial groundwater wells in the Middle Rio Grande floodplain, allowing wells to recharge naturally during periods of non-pumping;
- **Pumping of non-alluvial groundwater with natural recharge**: intermittent pumping from non-alluvial wells in the Middle Rio Grande floodplain, or at locations further from the river, allowing wells to recharge naturally during periods of non-pumping;
- **Pumping of non-alluvial groundwater with active recharge (aquifer storage and recovery)**: intermittent pumping from non-alluvial wells, coupled with active recharge of the aquifer during periods of non-pumping (i.e. development of an aquifer storage and recovery system); or
- **Pumping and Desalinization of Deep Saline Groundwater**: pumping and desalinization of deep, saline groundwater, and use of the desalinized water as needed to support river flows.

The primary constraint on the first three of these options is water availability. It is well known that the surface water and groundwater supplies throughout the Middle Valley are, in almost all areas, hydraulically connected. It is also well known that surface-water supplies in the Middle Valley are fully appropriated. Consequently, application of any groundwater pumping plan involving one or more of the first three options would need to do one of the following:

- Utilize water contained in the basin that is currently unappropriated;
- Affect water timing only, incurring little or no additional water loss to the system;
- Incorporate leasing, or buying and retiring, water rights to offset the consumptive use incurred by the plan; or
- Mine groundwater resources, which will deplete streamflow at some point in the future.

The fourth option, pumping of deep, saline groundwater, involves mining of a groundwater resource, but would mine a new source of water to this system, and would be designed so as not to impact streamflows in the foreseeable future (the effects may not be felt on the river for centuries). All of these options would require approval from the New Mexico Office of the State Engineer (OSE), and the operations would be under the jurisdiction of the OSE.

2.0 PUMPING OF SHALLOW, ALLUVIAL GROUNDWATER

Pumping of shallow, alluvial groundwater could be utilized as a short-term method for supplementing river flows during times of low flow. This option should be viewed as a management option during critical low-flow periods only, although it could be valuable for this purpose. Shallow alluvial wells in the MRG valley can be pumped at rates up to about 1,000 gallons per minute – therefore, even the high-production wells could contribute at most approximately 2 cfs to the river. These rates are sufficient that a wellfield or series of wells could provide water during emergency situations on the river during low-
flow or drying events, or to provide localized flooding to support Southwest Willow Flycatcher habitat, but would not be anywhere near sufficient to provide overbank or spawning flows.

A program of pumping of shallow, alluvial groundwater could be administered in a number of ways, including:

- Pumping from shallow alluvial wells, and discharging the pumped water directly into the river,
- Pumping from shallow alluvial wells and discharging the pumped water into MRGCD drains that discharge to the river further downstream.
- Pumping from riverside drains or other valley drains into the river in order to supplement flows in critical reaches, as is presently done from the Low Flow Conveyance Channel (which today functions as a drain). This could be done from other drains in the MRG Valley if the removal of water from a particular drain is determined to not adversely impact downstream irrigators and the operation of the MRGCD.
- Supply of some irrigated acreage through pumping of a farm well, with the arrangement that the irrigator not receive surface-water delivery, but instead forgo the diversion of his farm-delivery allotment from the river. It should be noted that this option shares many of the feasibility concerns inherent in the development of an irrigation forbearance program in the MRG Valley.

None of these options provides a source of new water. Any shallow alluvial groundwater pumping would result in depletion of streamflow in the river at a later point in time, since water would naturally flow from the river, and also possibly MRGCD canals, into the aquifer to replace water that was removed through groundwater pumping. This decrease in streamflow could occur near the location of the pumping, or further downstream. During both application and recovery periods, groundwater elevations would need to be monitored and impacts on the river accounted for. Also, the MRGCD relies on drainflows to provide water to some of its irrigators. Therefore, the impacts of pumping of groundwater or drain water on the operation of the MRGCD would need to be monitored and ameliorated as appropriate.

Wells used for the pumping of groundwater could be either privately owned or developed specifically for river management. The infrastructure required to develop a wellfield for this purpose sufficient to provide meaningful flows would be substantial, and costly. For comparison, the entire City of Albuquerque wellfield combined, with a total of 97 wells, pumps a total of only 140 cfs.

3.0 PUMPING OF NON-ALLUVIAL GROUNDWATER WITH NATURAL RECHARGE

Pumping of non-alluvial groundwater, including deep water below the floodplain or water from aquifers outside the floodplain, without actively recharging the aquifer, will result in groundwater mining, with eventual resulting decreases in streamflow, which would be first noticeable several years to several decades in the future. In a fully appropriated basin, these decreases would necessarily result in the denial of water to valid water-rights holders in the future. This approach is not recommended, and would be unlikely to be approved by the OSE.

4.0 PUMPING OF NON-ALLUVIAL GROUNDWATER WITH ACTIVE RECHARGE (AQUIFER STORAGE AND RECOVERY)

Under this alternative, during periods when unappropriated water is available, this unappropriated water would be used to recharge the aquifer. This recharge could be accomplished through injection wells, or infiltration from basins. During periods of low flow, this water would be withdrawn and pumped into the Rio Grande Floodway to maintain flows. Though a more expensive option than either alluvial or non-alluvial groundwater pumping without active recharge, this option offers the opportunity to bank water for future use rather than run a short or long-term water deficit that requires repayments.
The biggest problem with this option is that it requires unappropriated water in the system that can be banked. Water rights could be purchased for this purpose. It has also been proposed that unappropriated water be banked during times of excess water. The following section describes the limitations on the availability of unappropriated water that can be banked.

5.0 UTILIZATION OF UNAPPROPRIATED WATER

Ideally, banked water would be basin water that is currently unappropriated. Since the Middle Rio Grande is a fully-appropriated system, and the Rio Grande Compact caps Middle Valley water usage at 405,000 acre-feet for Otowi Index flows in excess of 1.1 million acre-feet, only during spill years does the Middle Valley even potentially have access to more than 405,000 acre-feet of water from the Rio Grande. And even in a spill year, the practical and administrative availability of any additional water has yet to be proven through the vetting of an application for its use through the OSE.

Spill years have occurred 6 times since the Elephant Butte Reservoir was constructed. It is unlikely that aquifer storage of excess water in a spill year is a viable option given this type of return period for flows. Although the total volume of water spilled since 1982 is significant -- approximately 1.4 million acre-feet, or an average of 70,000 acre-feet per year -- this does not mean that this water would be available for appropriation in the basin. Any evaluation of extra water potentially available would have to consider all of the provisions of the Rio Grande Compact, not just the amount of water that actually spilled. New Mexico could not, for example, take water for storage and in so doing prevent a spill without the concurrence of Colorado. Also, the 1982-2001 period has been particularly wet, having experienced 4 of 6 historic spills, and is therefore biased toward overestimating available water. In addition, given the low frequency and high volume of occurrence, successful capture of the spill water for aquifer storage would be difficult and expensive.

If it is actually determined that unapropriated water is available in a spill year, it is also unclear whether spill water would remain unappropriated. Many entities (regional water planning groups, for example) have taken note that spill water is currently not spoken for and are considering plans for utilizing this water. Any storage or use of this water, either by the Program or by other entities, would require approval of the OSE.

6.0 CHANGES TO WATER TIMING WITH NO CONSUMPTIVE USE COMPONENT

As dictated by the Rio Grande Compact, 57% or more of the water that flows past Otowi Bridge must be delivered to Texas. Consequently, there is a large amount of water potentially available for short-term storage by New Mexico in the Middle Valley. Theoretically, water destined for delivery to Texas could be temporarily stored in an aquifer and pumped back into the river during low-flow periods. In reality, however, this option is subject to the same constraints as water storage in up-stream reservoirs and will only be of value for water that cannot be stored in reservoirs due to lack or space, or inability to capture it in a reservoir.

Nonetheless, significant amounts of water may fall into this category, including: Rio Puerco and Rio Salado flows, flows from the drainage channels of the Albuquerque Metropolitan Flood Control Authority (AMAFCA), high flows resulting from monsoon events, etc. Constraints on capture and use of these flows will include: Rio Grande Compact requirements, water quality considerations, and location of available water relative to the proposed aquifer storage and recovery project.

Implementation of aquifer storage and recovery may incur some consumptive use component. There may be small losses associated with recharging the aquifer. More importantly, running water down the Rio Grande during low flow periods (generally summer) rather than during moderate to high-flow periods, would likely result in significantly higher depletions through evapotranspiration. At low flow periods, a
higher percentage of the water in the river goes to evaporation than at higher flows. This additional depletion would need to be offset with leased or purchased water rights.

7.0 PUMPING AND DESALINIZATION OF DEEP SALINE GROUNDWATER

River flow could also be supplemented through the pumping and desalination of deep, saline groundwater. This would likely be a very expensive option, but could be considered, should this technology become economically competitive and be ecologically sound. Desalination on a large scale is a fairly new technology, with only a few plants on-line, but is rapidly growing. Prices for water from desalination plants around the world currently range from $1,220 to $2,900 per acre-foot per year ($3.75 to $9.00 per 1,000 gallons). However, new plants proposed for Tampa Bay, FL:

(http://www.tampabaywater.org/MWP/MWP_Projects/Desal/Desal.htm)

and Los Angeles, CA anticipate pricing on the order of $760 per acre-foot per year ($2.08 per 1,000 gallons). In the Rio Grande region, Sandia National Laboratory and the US Bureau of Reclamation are working toward a research desalination plant in the Tularosa Basin (http://wrri.nmsu.edu/tbndrc/tbndrc.html). They are currently preparing a feasibility study and forecast having a plant initially on line in 2004 and at full operation in 2005. There is also proposal in progress for a private desalination plant using water from the Estancia Basin.

The potential for application of desalination technology within the Middle Rio Grande is significant – there are large saline groundwater reservoirs that could be tapped, particularly in the Socorro basin. Saline groundwater basins that are not connected to the Rio Grande could be pumped with no hydrologic impact on the Rio Grande Compact deliveries, although an assessment of local effects would still be required, including impacts on any adjacent freshwater aquifers and the potential for ground subsidence. Groundwater could be pumped with minimal restrictions in undeclared groundwater basins, or at depths greater than the OSE jurisdiction of 2500 feet.

If brackish water from non-tributary basins could be developed, these supplies would augment the supply available for both diversion and consumptive use, and provide significant flexibility in the timing of augmented supplies. From a physical perspective, this option has high potential for improving the water supply to the region. However, it also carries a very high price tag, including the capital costs for the deep wells, land acquisition for and construction of desalination plants, plus operation and maintenance costs, and brine by-product disposal costs (which could be quite significant). There are also ecological concerns associated with the disposal of the high concentration brine by-product.

8.0 SUMMARY AND CONCLUSIONS

- Groundwater pumping to supplement river flows is of most use to the program as a method of short-term water storage and recovery, such as for storing of spring flows in the groundwater system of the floodplain for release or natural flow back to the river during low flows of the summer months.

- The volumes of water that could be supplied this way would likely to be sufficient to supplement flows in critical reaches in low-flow periods, or to provide localized flooding to support southwestern willow flycatcher habitat, but would not be sufficient for such purposes as providing spawning pulses or overbank flows.

- The infrastructure required for groundwater pumping that could significantly affect flows would be very large. For comparison, the entire City of Albuquerque wellfield combined pumps a total of approximately 140 cfs.
• Additional depletions associated with the increased summer flows would have to be offset through the purchase or lease of water rights. However, the non-consumptive portion of these flows should be achievable through a permit from the OSE.

• Some potential also exists for the use of aquifer storage and recovery in deep wells either in or out of the floodplain, but less directly connected to the river than the floodplain wells. However, there are likely to be very few instances where excess water is available in the system for aquifer recovery, unless water rights are specifically purchased or leased for this purpose.

• River flow could also be supplemented through the pumping and desalination of deep, saline groundwater. This would likely be a very expensive option, but could be considered, should this technology become economically competitive and be ecologically sound.
Attachment E-18

WATER ACQUISITION AND MANAGEMENT SUBCOMMITTEE BACKGROUND PAPER:
SUPPLEMENTING MIDDLE RIO GRANDE FLOWS THROUGH PUMPING FROM THE
LOW FLOW CONVEYANCE CHANNEL (LFCC)

1.0 INTRODUCTION

During the irrigation season, flows in the Middle Rio Grande between the San Acacia Diversion Dam and the headwaters of the Elephant Butte Reservoir can become intermittent, particularly in dry years, potentially causing adverse impacts to the Rio Grande silvery minnow. This reach of the river channel (designated by Congress as the Rio Grande Floodway) is paralleled by a second conveyance, the Low Flow Conveyance Channel (LFCC), which now serves as a riverside drain and collects significant water from several sources, including the river, irrigation surface and subsurface return flows, stormwater inflow, and groundwater seepage. One option for maintaining flows in the river channel in this reach is through pumping from the adjacent Low Flow Conveyance Channel (LFCC) into the river channel.

The March 2003 Biological Opinion specifies that Reclamation shall pump water from the LFCC to the river when intermittency is likely. Since 2001, the US Bureau of Reclamation (USBR) (with funding from the Collaborative Program in FY 2002) has undertaken a “Temporary Pumping Program” to fulfill these requirements. The initial pumping program had a total of three stations in the San Acacia Reach. These pumps augmented flows throughout the reach of the Rio Grande within and below the Bosque del Apache National Wildlife Refuge (Refuge). This program reduced the amount of intermittency in the river in 2001. In 2002, the pumping was expanded to five stations located in the San Acacia Reach from about 3 miles upstream of US 380 to near Old Fort Craig. The pumping stations at the southern boundary of the Refuge and Fort Craig created approximately 16 miles of flowing water. A new pumping station located approximately 4 miles north of the southern boundary of the Refuge was constructed during the 2003 season, and will provide approximately 4 miles of additional flowing water when sufficient water is available in the LFCC. With these pumping stations, flow can be maintained for approximately 20 continuous miles of river, from near the middle of the Refuge, to Elephant Butte Reservoir. The total available pumping capacity for all pump locations is now approximately 200 cfs, although the maximum total combined rate is limited to 150 cubic feet per second. As the reservoir decreases in water surface area and volume, the length of the river that the pumps maintain could be longer.

During the 2001, 2002, and 2003 irrigation seasons, the temporary LFCC pumping program helped to minimize conservation water releases from Abiquiu, Heron and El Vado reservoirs by reducing the amount of water required to keep the Socorro reach continuous from November 16 through June 15, and reducing the rate of release required to meet the BO Wet Year requirement of 100 cfs at San Marcial during the same period. The USBR has proposed a feasibility study for the design and construction of permanent pumping facilities in this reach. These permanent pumping facilities could increase the efficiency and reliability of the pumping operations, and may decrease the cost in the long term if the program is continued significantly into the future. The WAMS allocated FY2003 funding to this feasibility study.

2.0 USBR LFCC PUMPING PROGRAM HISTORY

The Bureau’s Temporary Pumping Program involves operation and maintenance of 17 portable diesel-driven pumps to transfer water from the LFCC to the Rio Grande. During the 2002 irrigation season, the pumps were located at the following five locations between Socorro and Elephant Butte Reservoir on the LFCC (Figure 1):
• Neil Cupp Diversion Structure (approximately 2.8 miles north of the Highway 380 Bridge in San Antonio)
• North Boundary of Bosque del Apache Diversion Structure
• Mid-Bosque del Apache Diversion Structure (site added August 2002; located near the geographic center of the Bosque del Apache National Wildlife Refuge. This site provides additional operational flexibility for managing river recession events)
• South Boundary of Bosque del Apache
• Fort Craig (approximately 5 miles downstream of the San Marcial LFCC gage)

Pumping discharge at each location is measured using either sheet pile weirs or flow meters (depending on the constraints presented by each pumping site). Discharge measurements made at the Neil Cupp, North Boundary Bosque del Apache, and South Boundary Bosque del Apache pumping stations are transmitted via telemetry installations at these locations, and are posted on Bureau’s ET Toolbox web site:

www.usbr.gov/rsmg/awards/Nm/rg/RioG/gage/schematic/SCHEMATICsouth.html

Measurement and telemetry installations will be completed at the Middle Bosque del Apache and Fort Craig pump stations during the 2003-2004 calendar year. The telemetry equipment was purchased using New Mexico Interstate Stream Commission funding provided via Cooperative Agreement NO. 02-CF-40-6110, Agreement for Cooperative Program for Water Conservation Measures Along the Rio Grande, Middle Rio Grande Project.

Pump operation and maintenance is performed using a contractor, with Bureau’s Socorro Field Office personnel acting as backup. Personnel are scheduled to provide 24 hour/day, 7 day/week coverage of pump operation and maintenance. Pumping operations may occur as early as March and as late as November depending on observed conditions along the Rio Grande. Since 2001 Reclamation’s Socorro office and the New Mexico Interstate Stream Commission have provided 24-hour “river eyes” surveillance of the Rio Grande to help determine the condition of river flows and coordinate operation of pumping and endangered fish rescue efforts.

The following total amounts of water were pumped from the LFCC to the Rio Grande floodway in 2001 and 2002:
• 2001 - 25,200 AF
• 2002 - 32,500 AF

For the year 2002, pumping operations occurred from March 15 through September 30. The following table (Table 1) lists the approximate annual volume pumped by location during the 2002-pumping season.

**Table 1. Approximate annual volume pumped by location during the 2002-pumping season.**

<table>
<thead>
<tr>
<th>Pumping Location</th>
<th>No. of Pumps</th>
<th>Approximate Annual Volume (acre-ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neil Cupp</td>
<td>4</td>
<td>7,260</td>
</tr>
<tr>
<td>North Boundary Bosque del Apache NWR</td>
<td>3</td>
<td>3,850</td>
</tr>
<tr>
<td>Middle Bosque del Apache NWR</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>South Boundary Bosque del Apache NWR</td>
<td>5</td>
<td>17,210</td>
</tr>
<tr>
<td>Fort Craig</td>
<td>3</td>
<td>4,120</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>17</strong></td>
<td><strong>32,470</strong></td>
</tr>
</tbody>
</table>
3.0 **BIOLOGICAL OPINION REQUIREMENTS**

Many of the “Reasonable and Prudent Alternatives” (RPAs) contained within the USFWS’ March 17, 2003 *Biological and Conference Opinion of the Effects of Actions Associated with the Programmatic Biological Assessment of the Bureau of Reclamation’s Water and River Maintenance Operations, Army Corps of Engineers’ Flood Control Operation, and Related Non-Federal Actions on the Middle Rio Grande, New Mexico* (BiOp) either require or are supported by the Bureau of Reclamation’s LFCC pumping operations. Water Operations Elements G, K, and O specifically reference pumping from the LFCC as a tool for managing recessions in flow and maintaining river connectivity to provide habitat for the Rio Grande silvery minnow and the southwest willow flycatcher. Water Operations Elements E, H, and L require continuous flows in the Rio Grande from Cochiti Dam to the southern boundary of silvery minnow habitat from November 16 through June 15. The LFCC pumps have proven instrumental in maintaining river connectivity south of San Acacia diversion dam during the early spring period when runoff flows can be insufficient to maintain a continuous river while MRGCD is actively diverting from the mainstem and water is being captured and stored in El Vado Reservoir on the Rio Chama. Water Operations Element D requires that water be provided to active flycatcher territories supported by the existing LFCC pumping sites from June 15 through September 1. Several of the Elements state the total pumping capacity must meet or exceed the total capacity of the pumps used during the 2002 irrigation season, which was approximately 150 cfs.

4.0 **RIO GRANDE SILVERY MINNOW LFCC PUMPING AND OPERATIONAL CHALLENGES**

4.1 **Variable LFCC flow rates**

The greatest current challenge to LFCC pumping operations is the highly variable nature of the flows within the Low Flow Conveyance Channel.

- Flows within the LFCC are directly impacted by MRGCD and Bosque del Apache irrigation operations through either direct diversion from the LFCC or irrigation return flows through system drains and groundwater seepage.
- LFCC flows also tend to mirror flow conditions within the Rio Grande because these systems are hydraulically connected through the shallow groundwater aquifer.
- During periods of extended drought such as experienced the past three summers, LFCC flows have been observed to decrease rapidly as flow conditions with the Rio Grande deteriorate. Thereby, these conditions create a situation where LFCC water becomes unavailable for pumping at precisely the time when it would be most beneficial.
- The Bosque del Apache National Wildlife Refuge diverts water from the same point as the North Boundary pumping station. At North Boundary, the LFCC pumping operations are often in direct competition with Bosque del Apache to utilize limited flows within the LFCC. Therefore, the success of the pumping operations at this location are dependent on the Bosque del Apache and the Socorro Field Division of USBR working cooperatively to manage LFCC pumping operations and Bosque del Apache diversion requirements at North Boundary.
- The MRGCD diverts water directly from the LFCC upstream of the Neal Cupp pumping station, which can reduce the rate of flow available for pumping at Neal Cupp. Again, the success of the pumping operations at this location are dependent on the MRGCD and the Socorro Field Division of USBR working cooperatively to manage LFCC pumping operations and MRGCD diversion requirements Neil Cupp.
Operational changes within the MRGCD and Bosque del Apache distribution and irrigation systems can dramatically impact the volume of water returning to the LFCC through drains and return seepage. Return flows into the LFCC decrease in parallel with reduced flows within the MRGCD and Bosque del Apache irrigation systems, resulting in a decrease in the rate of flow available for the LFCC pumps. Changes in the routing of water through the MRGCD and Bosque del Apache systems can dramatically alter the rate of flow returning to the LFCC through drains or seepage, as well as the location along the LFCC that these return flows occur. This routing change can result in localized reductions or increases in flows within the LFCC. LFCC pumping operations can be negatively impacted when these reductions occur in close proximity to one of the LFCC pumping stations.

4.2 San Marcial Gage Reporting Frequency

The BO contains flow requirements at certain times of the year for the gage in the Rio Grande floodway at San Marcial. LFCC pumping operations aid greatly in assuring that these flow targets can be met. Therefore, gage readings at this site can be an important factor in determining LFCC pumping operations. San Marcial flow data on the USGS Real-time website is currently updated at 4 hour intervals. The variable nature of San Marcial flows combined with the 4 hour interval between gage updates, as well as the travel times between the pumping locations and the gage, creates a situation where flows can be reported as stable or increasing at one point in time, yet dip below the flow targets prior to the following 4 hour update. This situation complicates the pumping operations, and necessitates the performance of regular, on the ground observations of river conditions at San Marcial.

The following table (Table 2) provides estimates of the time it takes flows to reach San Marcial from the various pumping stations.

<table>
<thead>
<tr>
<th>Pumping Station</th>
<th>Distance to San Marcial</th>
<th>Estimated Travel Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neil Cupp</td>
<td>21.6 miles</td>
<td>18 hours</td>
</tr>
<tr>
<td>North Boundary</td>
<td>15.6 miles</td>
<td>13 hours</td>
</tr>
<tr>
<td>South Boundary</td>
<td>5.4 miles</td>
<td>5 hours</td>
</tr>
</tbody>
</table>

5.0 CONCLUSIONS

- During the irrigation season, flows in the Middle Rio Grande between the San Acacia Diversion Dam and the headwaters of the Elephant Butte Reservoir can become intermittent, particularly in dry years, potentially causing adverse impacts to the Rio Grande silvery minnow.
- This reach of the river channel (designated by Congress as the Rio Grande Floodway) is paralleled by a second conveyance, the Low Flow Conveyance Channel (LFCC), which now serves as a riverside drain and collects significant water from several sources, including the river, irrigation surface and subsurface return flows, stormwater inflow, and groundwater seepage.
- The operation of a pumping program to pump water from the LFCC to the Rio Grande floodway when intermittency is likely in the San Acacia reach of the Rio Grande is a requirement of the Programmatic Biological Opinion of March 17, 2003.
- The USBR has implemented a “temporary” pumping program, utilizing portable pumps, in the San Acacia reach of the Rio Grande since 2000. This program pumped 25,000 to 35,000 acre-feet of water from the LFCC into the Rio Grande floodway in 2001 and 2002, respectively, and has been successful in maintaining flows in some critical sub-reaches.
• USBR’s LFCC pumping program is performed pursuant to permitting actions of the New Mexico Office of the State Engineer.

• The LFCC pumping program can help to minimize conservation water releases by reducing the amount of water required to keep the Socorro reach continuous from November 16 through June 15, or reducing the rate of release required to meet the Wet Year requirement of 100 cfs at San Marcial during the same period. The pumps have been used to maintain river continuity prior to June 15 when water is being stored in El Vado and/or MRGCD is diverting for irrigation.

• The WAMS allocated funds in FY 2003 to the USBR for the completion of a feasibility study for the construction of permanent pumping plants, which could improve the efficiency and reliability of the system, and lower the long-term cost if the pumping program is expected to be continued significantly into the future.

• The design and construction of permanent pumping facilities is not recommended if re-engineering of the river channel in the San Acacia reach (see WAMS position paper on this topic) is deemed feasible and has any likelihood of being performed.
Figure R-1 – Map Showing Low Flow Conveyance Channel Pumping Locations
WATER ACQUISITION AND MANAGEMENT SUBCOMMITTEE BACKGROUND PAPER:
STUDY OF RECONFIGURATION FOR THE SAN ACACIA REACH

1.0 HISTORY/DESCRIPTION OF CURRENT SYSTEM

The Middle Rio Grande Project, authorized by the Flood Control Acts of 1948 and 1950 (Public Laws 80-858 and 81-516, respectively), in addition to providing for flood control and rehabilitation of the Middle Rio Grande Conservancy District (MRGCD), authorized the Bureau of Reclamation (Reclamation) to reduce non-beneficial consumption of water by native vegetation in the flood plain of the Rio Grande above Caballo Reservoir. One of the main goals of this legislation was to assist New Mexico with meeting its obligations under the Rio Grande Compact. The legislation essentially authorized the a comprehensive plan, developed jointly in 1947 by Reclamation and the Corps of Engineers, that included elements of river channel rectification and maintenance. More specific plans were detailed in a 1952 report. The plan called for a floodway with a maximum capacity of 8,000 cubic feet per second and a bottom width of 500 feet for the reach from the south boundary of the MRGCD to the head of Elephant Butte Reservoir with maintenance dredging through the life of the project. The goal was to relieve the sedimentation problem between Socorro and San Marcial.

The San Acacia Reach extends from the San Acacia Diversion Dam downstream to the headwaters of Elephant Butte Reservoir. In 1941 Elephant Butte reservoir reached its highest level ever recorded (Figure 1) with a storage volume of about 2.3 million AF (compared to the current capacity of generally less than 2.0 MAF). Slack reservoir water levels extended up to about Fort Craig. These slack, high-water levels persisted for about two years and resulted in the deposition of a massive sediment delta in the upper levels of the reservoir that quickly became infested with saltcedar. Between the southern boundary of the Bosque del Apache National Wildlife Refuge (Refuge) and the narrows of Elephant Butte Reservoir, the river became discontinuous, interspersed with reaches where the channel was completely silted in. As a result of the obstructed flows and attendant high evapotranspiration throughout the Middle Rio Grande, New Mexico was unable to meet its delivery requirements under the Rio Grande Compact and accumulated a debit of several hundred thousand acre-feet (Figure 2).

The Bureau of Reclamation built the Low Flow Conveyance Channel (LFCC) as part of the MRG Project’s channel rectification program. The LFCC was designed as part of the Middle Rio Grande Project to efficiently carry all flows below San Acacia up to a nominal capacity of 2,000 cfs, with higher flows to be routed down the river channel. The LFCC was built to the west of the river and all return flows from the Socorro Division of the MRGCD and from Bosque del Apache National Wildlife Refuge are routed to the LFCC instead of the river. The LFCC also collects groundwater inflow as the valley thalweg (drainage). Near San Marcial the LFCC was excavated to an invert elevation approximately 18 feet below the riverbed and floodplain, since reduced to about 12 feet by a higher accumulation of sediment in the LFCC versus the river.

High reservoir levels in the mid-1980s and 1990s allowed greater quantities of sediment to deposit in the shallower, upper reaches of the reservoir delta. In addition, the riverbed has been rising (aggrading) in the

FIGURE 1
ELEPHANT BUTTE RESERVOIR STORAGE

FIGURE 2
NEW MEXICO’S RIO GRANDE COMPACT CUMULATIVE DELIVERY DEPARTURE
San Marcial reach at an average rate of 0.23 feet per year (24 feet between 1895 and 1989). This recent increase is apparently due to the combined influences of increased sediment deposition and bed aggradation in delta reach and reduced scouring flows in the San Acacia reach. It is important to acknowledge Leopold et al. documented that significant sediment accumulation in this reach occurred prior to closure of the Dam; however, these sedimentation rates appear to have started increasing during the early to mid-1930s, prior to the time this early analysis ended in 1935 and prior to the filling of Elephant Butte Reservoir in 1941. In the constricted floodplain established with the construction of the Middle Rio Grande Project, the riverbed between Socorro and the reservoir has become filled with sediment to the extent that the river in this reach is drastically perched above the adjacent valley floor.

Because it is perched and adjacent to the LFCC, the river channel loses flow by seepage to the LFCC and shallow alluvial aquifer and standing surface water bodies, all at lower head. The LFCC was been important in helping New Mexico overcome an accumulated debit under the Compact of over 500,000 AF. The original design included advantages that allowed the flows diverted to the LFCC to have a relatively free-flowing thalweg channel, free of sediment deposits and salt cedar impediments, and limited excessive riparian ET depletions. (Riparian depletions between San Acacia and Elephant Butte are currently estimated at about 110,000 AFY compared to more than 140,000 AF prior to the Middle Rio Grande Project.)

Another main function of the LFCC is as a source of the surface water supply for the Socorro Division of the MRGCD and Refuge. The MRGCD diverts water at three locations off of the LFCC (at Lemitar, Socorro, and Neil Cupp) at which flows of the LFCC are routed into adjacent canals and drains. These drains are then checked up so that flows from the drains are routed into canals for distribution to agricultural fields. The Refuge has two points of diversion off the LFCC, one at the north boundary of the Refuge and one located in the southern portion of the Refuge. Diversions off the LFCC provide the Refuge with dependable year around surface water, which is essential to their ability to provide habitat for migratory birds and other species dependant on this floodplain area as wintering, breeding and feeding grounds.

2.0 ELEMENTS OF A RECONFIGURATION STUDY

The major elements associated with analyzing the reconfiguration of the reach below San Acacia would require assessing the potential positive and negative impacts including:

- Modifying or removing the LFCC
- Potential for reconstruction of the river channel as the valley thalweg in different subreaches of the San Acacia Reach
- The river flows or mechanical maintenance alternatives necessary to improve and maintain the existing river channel
- Acceptable strategies to improve sediment management through the reach
- Removal and management of exotic vegetation in the existing floodplain
- Changes to present river/floodplain dynamics on aquatic and terrestrial habitats
- Needs to ensure surface water deliveries to MRGCD and the Refuge

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• Whether the existing the riverside drain would be sufficient to maintain required water table depths for the adjacent farmlands or whether engineering an alternative drainage systems would be required

• Potentials to improve compliance with Compact delivery requirements

• Whether the existing levee system is adequate or whether modifications would be required

Such a re-engineering and reconfiguring would potentially result in the following, which would need to specifically addressed through a more complete assessment of the potential benefits of any such reconfiguration project:

• Improved ability to transport sediments through this reach

• Establish a healthier, self-sustaining riparian community and an improved aquatic habitat

• Produce perennial river flows except under the most extreme drought conditions for at least a portion of this reach of Rio Grande, reducing or eliminating the need for supplemental flows

• Improve water delivery to surface water users in the reach and downstream to Elephant Butte Reservoir, including Compact requirements

Finally, any reconfiguration project should further the goals of the Endangered Species Act Collaborative Program. With this in mind, the project should result in protection and improvement of listed species and their habitat.

3.0 CONCLUSIONS AND RECOMMENDATIONS

• The current lack of the sustainability of low flows in the Rio Grande below San Acacia is due to excessive riparian depletions and the fact that the river channel is perched through much of the valley. As such, the present river channel receives no irrigation return flows and the current groundwater gradient is away from the river to the LFCC.

• The portion of the Middle Rio Grande Project designed and constructed below San Acacia (the LFCC and the Floodway) did not permanently solve the Compact delivery problem because it did not deal effectively with the real problem – the movement of sediment through the system below San Acacia.

• The combination of reduction in groundwater drainage away from the river, improved management of irrigation return flows, and decreased riparian depletions by reconfiguring the reach below San Acacia would result in improved river flows except under the most extreme drought conditions, thus reducing or eliminating the need for supplemental flows in this reach.

• Analysis of the existing irrigation surface water delivery system in the reach should be accomplished to assure alternative strategies for delivery to the MRGCD and Refuge. This analysis would determine whether to incorporate return flows to the river where possible or maintain those flows within the irrigation system if needed to offset loss of LFCC diversions. Alternatives for delivering reliable surface water supplies to MRGCD and Refuge would need to be developed.

• The combination of changes to groundwater drainage and decreased riparian depletions that could result by implementing one or all of the above four recommendations in the reach below San Acacia would need to be thoroughly analyzed. Potential benefits to perennial river flows, the need for supplemental flows in this reach, sediment management, the diversity of existing aquatic and riparian habitats, and surface water delivery to water users and Elephant Butte Reservoir would be a part of this analysis.
The Program should either seek Federal funding for a study or should seek proposals for such a study in the next round of RFPs. Any study should incorporate the existing evaluations, plans and information available in the analysis of alternatives for this reach of the Rio Grande.