RECLAMATION
Managing Water in the West

Value Planning – Final Report

New Mexico Unit

U.S. Department of the Interior
Bureau of Reclamation
Design, Estimating, and Construction (DEC)
Oversight and Value Program Office
Denver, Colorado

October 2015

Mission Statements

The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information of those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

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

Value Planning
Final Report

New Mexico Unit

Prepared by the Bureau of Reclamation for the New Mexico Interstate Stream Commission

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Acknowledgements

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Abbreviations and Acronyms

ac-ft/AF	Acre Feet / Acre Foot
AWSA	2004 Arizona Water Settlements Act
AZ	Arizona
BHI	Bohannan-Huston, Inc.
BLM	Bureau of Land Management
CAP	Central Arizona Project
cfs	Cubic Feet Per Second
CRBPA	1968 Colorado River Basin Project Act
CUFA	Consumptive Use and Forbearance Agreement
CY/cy	Cubic Yard
DOI	Department of Interior
El./el.	Elevation
ESA	Endangered Species Act
ft./ft	Feet / Foot
FHA	Federal Highway Administration
FMI	Freeport McMoRan Incorporated
GRIC	Gila River Indian Community
GSFWC	Gila San Francisco Water Commission
HDPE	High-Density Polyethylene
ISC	New Mexico Interstate Stream Commission
LCRBDF	Lower Colorado River Basin Development Fund
LEDPA	Least Environmentally Damaging Practical Alternative
LF/lf	Linear Foot
LLDPE	Linear Low-Density Polyethylene
MERL	Materials Engineering & Research Laboratory
M&I	Municipal and Industrial
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NLPA	Natural Lands Protection Act
NM	New Mexico
NMISC	New Mexico Interstate Stream Commission
NMDOT	New Mexico Department of Transportation
O&M	Operations and Maintenance
OM&R	Operations, Maintenance, and Replacement
PHX	Phoenix, Arizona
PR&G	Principles, Requirements, and Guidelines
RM	River Miles
ROD	Record of Decision
SCIDD	San Carlos Irrigation and Drainage District
SF	Square Foot
TNC	The Nature Conservancy
TSC	Technical Service Center
UGWSS	Upper Gila Water Supply Study
USBR	Bureau of Reclamation (Reclamation)

USFS	U.S. Forest Service
USFWS	U.S. Fish & Wildlife Service
USGS	U.S. Geological Survey
UVD	Upper Valley Diverter
yr	Year

Table of Contents

List of Tables

List of Figures

Appendix A

Executive Summary

The Value Study was undertaken in cooperation with Reclamation, New Mexico Interstate Stream Commission (NMISC), NMISC consultants, and a representative of the proposed New Mexico CAP Entity (Entity). The results are available to the Entity to assist in their decision-making, and to the Entity, NMISC, and Reclamation for the development of a proposed New Mexico (NM) Unit.

This study utilized existing work products from consultants Bohannan-Huston, Inc. (BHI) and RJH Consultants, Inc., the NMISC, and Reclamation. Study participants consisted of 13 specialists. The technical specialties included: constructability and cost estimating; ecology and environmental permitting; geomorphology and sediment transport; dam engineering; geotechnical engineering; tunneling; hydrology, water modeling and yield; civil engineering; water resources engineering; hydraulic structures and conveyance; materials engineering; geology; and value engineering and life-cycle costing. The specialties were selected based on the broad technical needs and focus areas of the NM Unit project. Representatives from the U.S. Forest Service and Gila-San Francisco Water Commission also attended the study.

The purpose of the Value Study was to:

- Better develop and compare New Mexico Unit alternatives
- Develop technically sound alternatives that can be constructed in phases
- Investigate ways to reduce costs

The Value Planning Study Team met on June 15, 2015, for a five-day study of the NM Unit Project. The estimated cost of the Value Planning Study is approximately $100,000.

The Team developed the following problem statement: Develop alternatives for a functional project of the NM Unit. The team defined a functional project as:

- Ability to divert and convey up to 350 cfs of water from the Gila River upstream of the Cliff-Gila Valley in New Mexico, and store water in side canyons in the Cliff-Gila Valley with a target of 13,000 ac-ft of storage in Phase One, and deliver water for agricultural and environmental purposes.
- Expandability for future phases to provide a target overall project storage equal to 46,000 ac-ft and a conveyance to serve M&I uses in the Mimbres Basin to the east of the continental divide. This includes a pipeline to the City of Deming, NM.

The Team developed twelve alternatives that were evaluated and ranked in a decision matrix. The Team focused on developing alternatives that provided all the storage in one or two canyons (one alternative has three canyons) in the upper portion of the Cliff-Gila Valley. This upper valley storage provides the potential for delivering water to multiple locations, reducing the pumping costs for the deliveries, and limiting environmental impacts to the least number of canyons.

The Team acknowledges there are potentially lower cost alternatives that incorporate smaller storage features, or existing diversion and conveyance systems. However, these alternatives were not considered in this report because they were beyond the scope of the study.

Pursuant to Section 212 of the AWSA, environmental review in accordance with NEPA, ESA, NHPA, and other applicable environmental statutes is required for the implementation of the New Mexico Unit Agreement. As part of this environmental review process, some or all of these alternatives, as well as other alternatives, may be analyzed further. A no action alternative will also be analyzed.

The Value Study results indicate that a phased approach may be necessary. The study team discussed the scope, complexity, and the cost of the full project, which for this study was defined as delivery of water to the Mimbres Basin. Because the AWSA Federal funding is not sufficient to construct the full project, the team determined it was appropriate to consider a phased approach as a means to achieve the ultimate project goals. In any case, this initial phase would be a necessary component for subsequent development of the full project. Another advantage of phasing would be to allow the requirements and scope of water conveyance to the Mimbres Basin to evolve, as would be expected for a project of this size and complexity. With these considerations in mind, the team defined the three phases that are described throughout this report.

Phase I has a target storage of 13,000 acre-feet for agricultural and environmental uses in the Cliff/Gila Valley. Phase II would optimize storage and/or other features to transition to Phase III. Phase III would involve the full build-out to convey water to the Mimbres Basin with a target storage of 46,000 acre-feet. One of the alternatives studied could be paid for with federal funding identified in the 2004 Arizona Water Settlement Act (AWSA), although the alternative did not meet the target storage criteria.

Decision Matrix

The Team developed a decision matrix to rank the twelve alternatives by:

1. Selecting the criteria, scoring system, and weighting each alternative.
   The criteria (weighting) are:
   a. Storage Capacity for Phase I (18%)
   b. Storage Capacity for all three phases (15%)
   c. Capital Costs for Phase I (19%)
   d. Capital Costs for all three phases (15%)
   e. OM&R Energy Costs for all three phases (11%)
   f. Potential Environmental Impacts for all three phases (10%)
   g. Potential Impacts to Existing Infrastructure for all three phases (4%)
   h. Permitting Complexity for all three phases (8%)
2. Determining a score for each criteria for each alternative
3. Multiplying each criteria score for each alternative by the criteria weighting in order to develop a total score for each alternative

This matrix (Table 1) illustrates project alternative preference based upon the study team's scoring and weighting.

Summary of Results

The Value Study analysis only compares the twelve proposed alternatives against each other. Because only 92 points separate the scores (241-333) for all the alternatives, this shows, based on the selected scoping criteria, small changes in the scoring or weighting can affect the ranking of an alternative. The colors shown in Table 1 indicate groupings of weighted scores. The highest score of 333 represents only 67% of the 500 total points possible, indicating the current alternatives for the NM Unit may be challenging to pursue, and that other alternatives and concepts should continue to be evaluated.

Phase I Analysis

The top two ranked alternatives, Winn (9A) and Bell (9B) Canyons, indicate that building an embankment dam to meet the Phase I storage target of 13,000 ac-ft in one of these two canyons is economical, compared to the other alternatives,

Alternative 1 (Small Spar/Upper Spar) ranks third, losing ranking mainly due to small storage capacity for Phase I (1,642 ac-ft) and pumping costs from small spar reservoir to the Upper Spar Reservoir. The estimated $240 million capital cost for Phase 1 is lower than the estimated capital costs for Alternatives 9A and 9B.

All Three Phases Analysis

The top two alternatives (9A and 9B) indicate that raising Winn and Bell dams to obtain a total storage of 46,000 ac-ft for all three phases is economical, relative to the other alternatives, with a capital cost of $800 million (Winn), and $910 million (Bell). This is less than seven of the other alternatives with costs over $1,000 million.

Alternative 1 (Small Spar/Upper Spar) has similar capital costs ($830 million) and total storage for all three phases (47,642 AF) as Alternatives 9A and 9B.

Alternative 7 (Original Winn/Greenwood) is the most economical in terms of capital costs for all three phases coming in at $700 million. However, this only provides 28,750 ac-ft of storage that is substantially less than the storage target of 46,000 ac-ft for all three phases. This alternative requires pumping from Greenwood to make deliveries to the upper Cliff-Gila Valley.

Additional Combinations

The Team did not have sufficient time to synthesize the results in order to determine and/or develop additional combinations. The Team recommends reviewing these results and trying to develop other combinations that could meet the target storage and/or revisiting the target storage.

Value Study Contribution

The major contributions that this Value Study Team provided to the NM Unit Project are:

- Developing target storage capacities for Phase I and all Three Phases

- Developing alternatives to meet the target storage capacities for Phase I and all Three Phases
- Developing alternatives that can be split into three phases:
    - Phase I - Diversion, conveyance, small reservoir
    - Phase II - Larger reservoir in another canyon or by raising the dam
    - Phase III - Pipeline to Deming, NM
- Ranking the alternatives to determine which alternatives may be more preferable (9A, 9B, and 1)
- Proposing larger dams in the Winn (9A) and Bell (9B) Canyons to obtain a much larger reservoir
- Proposing ring dams[1] in the Pope (4) and Garcia (5) Canyons to obtain more Phase I storage
- Proposing a smaller dam in Greenwood Canyon for Phase I and raising that dam for Phase I
- Ensuring alternatives are technically sound at a preliminary engineering level
- Providing unit costs and construction approach to lining reservoirs to reduce see page
- Comparing alternatives

[1] Ring Dam – an embankment dam forming a closed basin in plan constructed of suitable earth excavated from within the ring. Depending upon the required crest elevation (El.) and topography, the ring may or may not be continuous and can extend beyond where a canyon enters a valley.

Table 1. Summary Table of Decision Matrix Results[2]**.**

			Phase One			All Three Phases				
Alternative	Weighted Score	Ranking	Meets Phase One Target 13,000 ac-ft	Phase One Costs	Ac-Ft Storage for Phase One	Costs for All Three Phases	Ac-Ft Storage for All Three Phases	Preferred Supply Conveyance Type	Siphons Under Gila River	Requires Pumping for Phase Two Deliveries to Upper Gila
Alt 9A - Small Winn / Large Winn	333	**1**	Yes	$360M	13,000	$800M	46,000	Tunnel/Canal	Yes	No
Alt 9B - Small Bell / Large Bell	318	**2**	Yes	$410M	13,000	$910M	46,000	Tunnel/Canal	Yes	No
Alt 1 - Small Spar / Upper Spar	293	**3**	No	$240M	1,642	$830M	47,642	Tunnel/Canal	No	No
Alt 7 - Original Winn / Small Greenwood	282	**4**	No	$125M	2,750	$700M	28,750	Canal	Yes	Yes
Alt 5 - Large Garcia / Greenwood	280	**5**	Yes	$440M	13,000	$1,050M	59,000	Tunnel/Canal	No	Yes
Alt 4 - Large Pope / Greenwood	272	**6**	Yes	$490M	13,000	$1,100M	59,000	Tunnel/Canal	No	Yes
Alt 8 - Small Greenwood / Greenwood	269	**7**	Yes	$490M	15,000	$850M	46,000	Tunnel/Canal	No	Yes
Alt 9C - Small Winn / Greenwood	255	**8**	Yes	$360M	13,000	$1,050M	59,000	Tunnel/Canal	Yes	Yes
Alt 9D - Small Bell / Greenwood	255	**8**	Yes	$410M	13,000	$1,100M	59,000	Tunnel/Canal	Yes	Yes
Alt 2 - Small Pope / Greenwood	247	**9**	No	$430M	8,732	$1,050M	54,732	Tunnel/Canal	No	Yes
Alt 3 - Small Garcia & Small Pope / Greenwood	243	**10**	Yes	$540M	12,832	$1,180M	58,832	Tunnel/Canal	No	Yes
Alt 6 - Small Spar / Greenwood	241	**11**	No	$240M	1,642	$1,050M	47,642	Tunnel/Pipe	No	Yes

Score 300-500 (green) — Total Possible Score = 500
Score 275-300 (yellow)
Score 250-275 (red)
Score 225-250 (blue)

[2] The costs include a liner for all the reservoirs. The Team made this conservative assumption because a Geotechnical investigation has not been performed to determine if liner(s) are required.

Details for the 12 Alternatives are summarized below. All alternatives divert and convey up to 350 cfs from the Gila River from proposed diversion site 2A (El. 4736 ft), except for Alternative 7, that diverts water from proposed diversion site 1 (El. 4668 ft.).

Alternative 1 – Lower Spar/Upper Spar Reservoirs.

- Phase I – Small Spar Reservoir – 1,642 ac-ft
- Phase II – Upper Spar Reservoir – 46,000 ac-ft with a 50 cfs pump station from small Spar
- Phase III - Pipeline to Deming, NM
- Estimated cost of Phase I is approximately $240 million and the estimated cost of all three Phases is approximately $830 million

Alternative 2 – Small Pope / Greenwood Reservoirs.

- Phase I – Small Pope reservoir – 8,732 ac-ft
- Phase II – Greenwood reservoir – 46,000 ac-ft (requires pumping of deliveries to Cliff-Gila Valley)
- Phase III – Pipeline to Deming, NM
- Estimated cost of Phase I is approximately $430 million and the estimated cost of all three Phases is approximately $1,050 million

Alternative 3 – Small Garcia & Small Pope/Greenwood Reservoirs.

- Phase I – Small Garcia Reservoir – 4,100 ac-ft and Small Pope Reservoir – 8,732 ac-ft
- Phase II – Greenwood Reservoir – 46,000 ac-ft (requires pumping of deliveries to Cliff-Gila Valley)
- Phase III – Pipeline to Deming, NM
- Estimated cost of Phase I is approximately $540 million and the estimated cost of all three Phases is approximately $1,180 million

Alternative 4 – Large Pope/Greenwood Reservoirs.

- Phase I – Large Pope (ring dam) Reservoir – 13,000 ac-ft
- Phase II – Greenwood Reservoir – 46,000 ac-ft (requires pumping of deliveries to Cliff-Gila Valley)
- Phase III – Pipeline to Deming, NM
- Estimated cost of Phase I is approximately $490 million and the estimated cost of all three Phases is approximately $1,100 million

Alternative 5 – Large Garcia/Greenwood Reservoirs.

- Phase I – Large Garcia (ring dam) Reservoir – 13,000 ac-ft
- Phase II – Greenwood Reservoir – 46,000 ac-ft (requires pumping of deliveries to Cliff-Gila Valley)
- Phase III – Pipeline to Deming, NM
- Estimated cost of Phase I is approximately $440 million and the estimated cost of all three Phases is approximately $1,050 million

Alternative 6 – Small Spar/Greenwood Reservoirs.
- Phase I – Small Spar Reservoir – 1,642 ac-ft
- Phase II – Greenwood Reservoir – 46,000 ac-ft (requires pumping of deliveries to Cliff-Gila Valley)
- Phase III – Pipeline to Deming, NM
- Estimated cost of Phase I is approximately $240 million and the estimated cost of all three Phases is approximately $1,050 million

Alternative 7 – Original Winn/Greenwood Reservoirs.
- Phase I – Original Winn Reservoir – 2,750 ac-ft
- Phase II – Greenwood Reservoir – 26,000 ac-ft (requires pumping of deliveries to Cliff-Gila Valley)
- Phase III – Pipeline to Deming, NM
- Estimated cost of Phase I is approximately $125 million and the estimated cost of all three Phases is approximately $700 million

Alternative 8 – Small Greenwood/Greenwood Reservoirs.
- Phase I – Small Greenwood Reservoir – 15,000 ac-ft
- Phase II – Larger Greenwood Reservoir (dam raise) – 31,000 ac-ft (additional, requires pumping of deliveries to Cliff-Gila Valley)
- Phase III – Pipeline to Deming, NM
- Estimated cost of Phase I is approximately $490 million and the estimated cost of all three Phases is approximately $850 million

Alternative 9A – Small Winn / Large Winn Reservoirs.
- Phase I – Small Winn reservoir – 13,000 ac-ft
- Phase II – Larger Winn reservoir – 33,000 ac-ft (additional)
- Phase III – Pipeline to Deming, NM
- Estimated cost of Phase I is approximately $360 million and the estimated cost of all three Phases is approximately $800 million

Alternative 9B – Small Bell/Large Bell Reservoirs.
- Phase I – Small Bell Reservoir – 13,000 ac-ft
- Phase II – Larger Bell Reservoir – 33,000 ac-ft (additional)
- Phase III – Pipeline to Deming, NM
- Estimated cost of Phase I is approximately $410 million and the estimated cost of all three Phases is approximately $910 million

Alternative 9C – Small Winn/Greenwood Reservoirs.
- Phase I – Small Winn Reservoir – 13,000 ac-ft
- Phase II – Greenwood Reservoir – 46,000 ac-ft (requires pumping of deliveries to Cliff-Gila Valley)
- Phase III – Pipeline to Deming, NM
- Estimated cost of Phase I is approximately $360 million and the estimated cost of all three Phases is approximately $1,050 million

Alternative 9D – Small Bell/Greenwood Reservoirs.

- Phase I – Small Bell Reservoir – 13,000 ac-ft
- Phase II – Greenwood Reservoir – 46,000 ac-ft (requires pumping of deliveries to Cliff-Gila Valley)
- Phase III – Pipeline to Deming, NM
- Estimated cost of Phase I is approximately $410 million and the estimated cost of all three Phases is approximately $1,100 million

The Team developed costs for major components of each of the alternatives primarily using unit prices from BHI and Reclamation reports. In some cases, the Team developed unit prices based on their experience when there was a large difference between the unit prices in BHI and Reclamation reports or when unit costs were not provided in the referenced reports. To facilitate comparison between alternatives, consistent unit costs were used for each alternative and adjustments were not made to account for site-specific conditions.

The cost estimates for each alternative developed in this report are at a Preliminary level (Reclamation's lowest level estimate) in 2014 dollars and are included in the Appendix. Preliminary cost estimates are prepared for studies conducted at the very early stages of the planning process. They are developed and produced to document a very preliminary analysis performed to look at a given problem, need, or opportunity utilizing readily available data. The estimates do not meet the criteria used for preparation of either Appraisal or Feasibility cost estimates. The cost estimates represent the Total Project Cost that includes design contingencies due to the high level of uncertainty during planning level designs (e.g. lack of geotechnical investigations); construction contingencies; and non-contract costs. These contingencies and non-contract costs are compounded to yield the Total Project Costs.

The Team developed cost estimates to compare costs amongst the alternatives. The Team had limited time and resources to prepare cost estimates for each alternative. Therefore, the Team recommends that these cost estimates *not* be used for budget or construction purposes. As feasibility design progresses for the alternatives in the environmental compliance process, the designer will more accurately quantify the estimated costs.

New Mexico Unit Project

Background

The Gila River flows in a southerly direction from its headwaters in western New Mexico (NM), through the Gila Wilderness Area and turns westward into Arizona (AZ). It drains a watershed of approximately 60,000 square miles and joins the Colorado River near Yuma AZ. Figure 1 shows the general project area and Figure 2 is a location map of the Gila River and many side canyons in the Cliff-Gila Valley.

Section 301(a) of the Colorado River Basin Project Act of 1968 (CRBPA) authorized "Hooker Dam and Reservoir, or suitable alternative" to be constructed as part of the Central Arizona Project (CAP) as a mechanism to make the water available for use in NM. Diversions from the Upper Gila in New Mexico would be permitted to the extent supported by deliveries of CAP water to downstream Gila River water users in AZ in lieu of deliveries of Gila River water. The CRBPA required deliveries of CAP water to downstream Gila River users in AZ in an amount sufficient to replace consumptive use of water from the Gila River in New Mexico.

In 1980, Reclamation initiated the Upper Gila Water Supply Study (UGWSS) to evaluate Hooker Dam and Reservoir and suitable alternatives. The project area for the UGWSS extended from the boundary of the Gila Wilderness Area in New Mexico to Ashurst-Hayden Diversion Dam in Arizona. The Hooker Dam site was proposed to be located approximately one mile above the confluence of Mogollon Creek and the Gila River.

The focus of UGWSS efforts was to develop an adequate supply of Gila River water to meet the reasonably anticipated future water needs in southwest New Mexico. Hooker Dam was eliminated from further study due to high costs and environmental impacts. During UGWSS Stage II planning, significant environmental information related to native fish communities on the Gila and San Francisco Rivers was compiled, and two species of native fish were found in the Gila River within the study area. The spikedace (*Meda fulgida*) and the loach minnow (*Tiaroga cobitis*) were given protection under the Endangered Species Act in 1986. These listings eliminated consideration of a mainstream dam.

The Arizona Water Settlement Act (AWSA) was enacted in 2004. The AWSA modified the terms of the NM CAP exchange in the CRBPA and provided funding for the NM Unit of the CAP. The modified terms in the AWSA reduced the amount of water for which the Secretary can contract with water users in NM for consumptive use in NM. AWSA water is defined as water from the Gila River, its tributaries, including the San Francisco River, and underground water sources in amounts that will permit consumptive use of water in New Mexico of not to exceed an annual average in any period of 10 consecutive years of 14,000 acre-feet. This volume includes the consumptive uses over and above those provided for by article IV of the decree of the Supreme Court of the United States in *Arizona v. California* (376 U.S. 340) as described in Section 304(f) of the Colorado River Basin Project Act of 1968, as amended by Section 212(d) of the AWSA, including reservoir evaporation. The AWSA also ratified the New Mexico Consumptive Use and Forbearance Agreement (CUFA), an agreement among the Secretary, the Gila River Indian Community, the San Carlos Irrigation and Drainage District, Phelps-Dodge Corporation (now Freeport-McMoRan, Inc.) and certain Upper Valley irrigation districts, canal companies, and ditch associations regarding water diversions.

With respect to funding, the AWSA provides to New Mexico up to $128 million in pre-indexed, non-reimbursable funds from the Lower Colorado River Basin Development Fund (LCRBDF): $66 million for costs of a NM Unit or other water utilization alternative(s) to be paid in 10 equal annual installments beginning in 2012; $34 million for additional construction costs of a NM Unit, subject to completion of environmental compliance; and an additional $28 million for construction of a NM Unit only if the rate of return in the LCRBDF exceeds 4 percent annually. Payment of the $28 million is unlikely given earnings to date. Approximately $36 million has been paid to NMISC since 2012 ($9.04 million per year of the total $90.4 million indexed amount).

The delivery cost for CAP water is currently $157/AF for CAP users for fixed Operations, Maintenance, and Replacement and pumping energy costs, which may approximate the cost to New Mexico.

New Mexico is currently considering opportunities through public-private partnerships to help fund the project.

In accordance with the AWSA, New Mexico was required to notify the Secretary by December 31, 2014 if it intended to construct a NM Unit. The State of New Mexico, through NMISC, provided that notice on November 24, 2014. The AWSA requires that within one year of receipt of the notice, the Secretary and the NM CAP Entity must execute the NM Unit Agreement.

The AWSA provided that execution of the CUFA and the Agreement would not be considered a major federal action, but that implementation would be subject to full environmental compliance. The AWSA designated Reclamation as the lead agency for environmental compliance, while providing for NM, upon its request, be designated as a joint lead. NM has requested to be joint lead.

Purpose and Goals of Value Study

Between passage of the AWSA in 2004 and the NMISC's notice to the Secretary in November 2014, the NMISC investigated potential NM Unit alternatives and other water utilization alternatives to meet water supply demand in the Southwest Water Planning Region. Under a Memo of Understanding (MOU) between Reclamation and NMISC, NMISC asked Reclamation to provide technical assistance to the NMISC. Reclamation's report, published in June 2014, identified numerous components of diversion, offstream storage, and conveyance options at an appraisal level. To better develop and compare NM Unit alternatives, the ISC requested Reclamation to initiate and facilitate the Value Planning Study.

The Value Study was undertaken in cooperation with Reclamation and NMISC. Value study team representatives included Reclamation, NMISC, NMISC consultants, U.S. Forest Service, and Gila-San Francisco Water Commission (for the future New Mexico CAP Entity). The results will be available to the Entity to assist in decision-making, and to the Entity, NMISC, and Reclamation for the development of a proposed NM Unit. The results will also be available publicly on the NMISC's AWSA website at www.nmawsa.org.

This study utilized existing work products from consultants Bohannan-Huston, Inc. (BHI) and RJH Consultants, Inc., the NMISC, and Reclamation. Study participants consisted of 13 specialists. The technical specialties include: constructability and cost estimating; ecology and environmental permitting; geomorphology and sediment transport; dam engineering; geotechnical engineering; tunneling; hydrology, water modeling and yield; civil engineering; water resources engineering; hydraulic structures and conveyance; materials engineering; geology; and value engineering and life-cycle costing. The specialties were selected based on the broad technical needs and focus areas of the NM Unit project. Representatives from the U.S. Forest Service (USFS) and Gila-San Francisco Water Commission attended, providing local knowledge and input related to their interests and expertise.

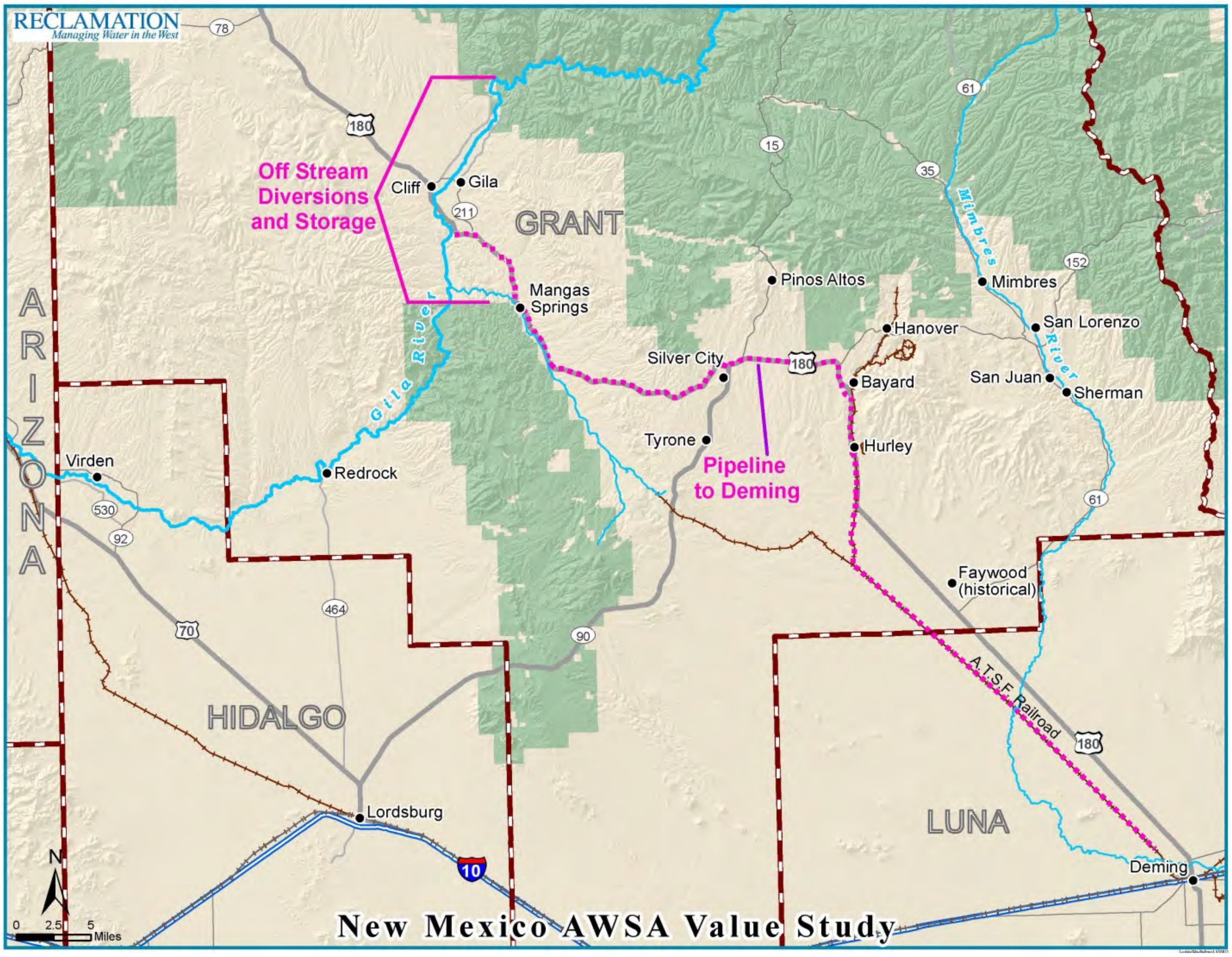

Figure 1. Study Area.

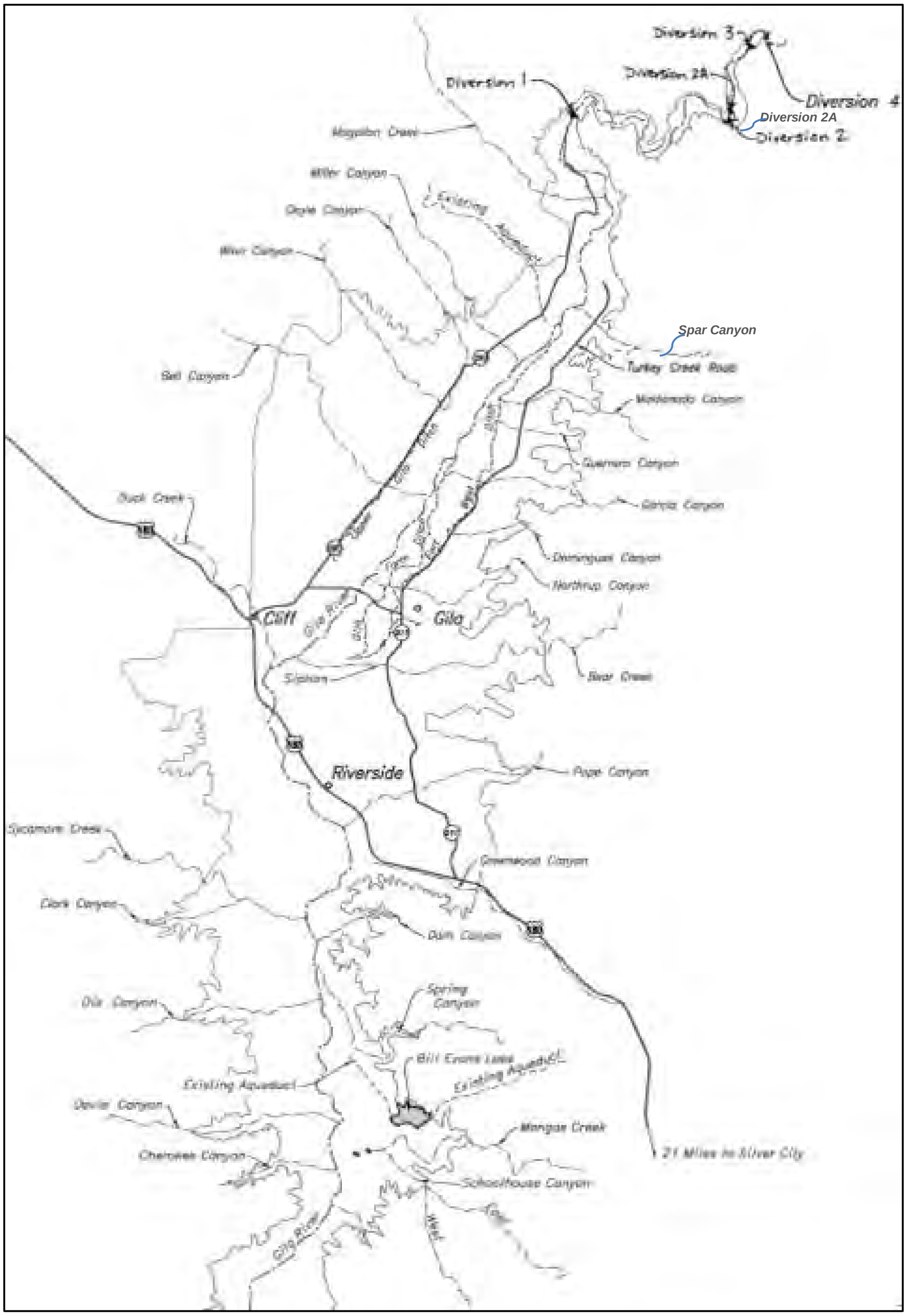

Figure 2. Location Map of the Gila River in New Mexico, between Turkey Creek confluence and Mangas Creek confluence.

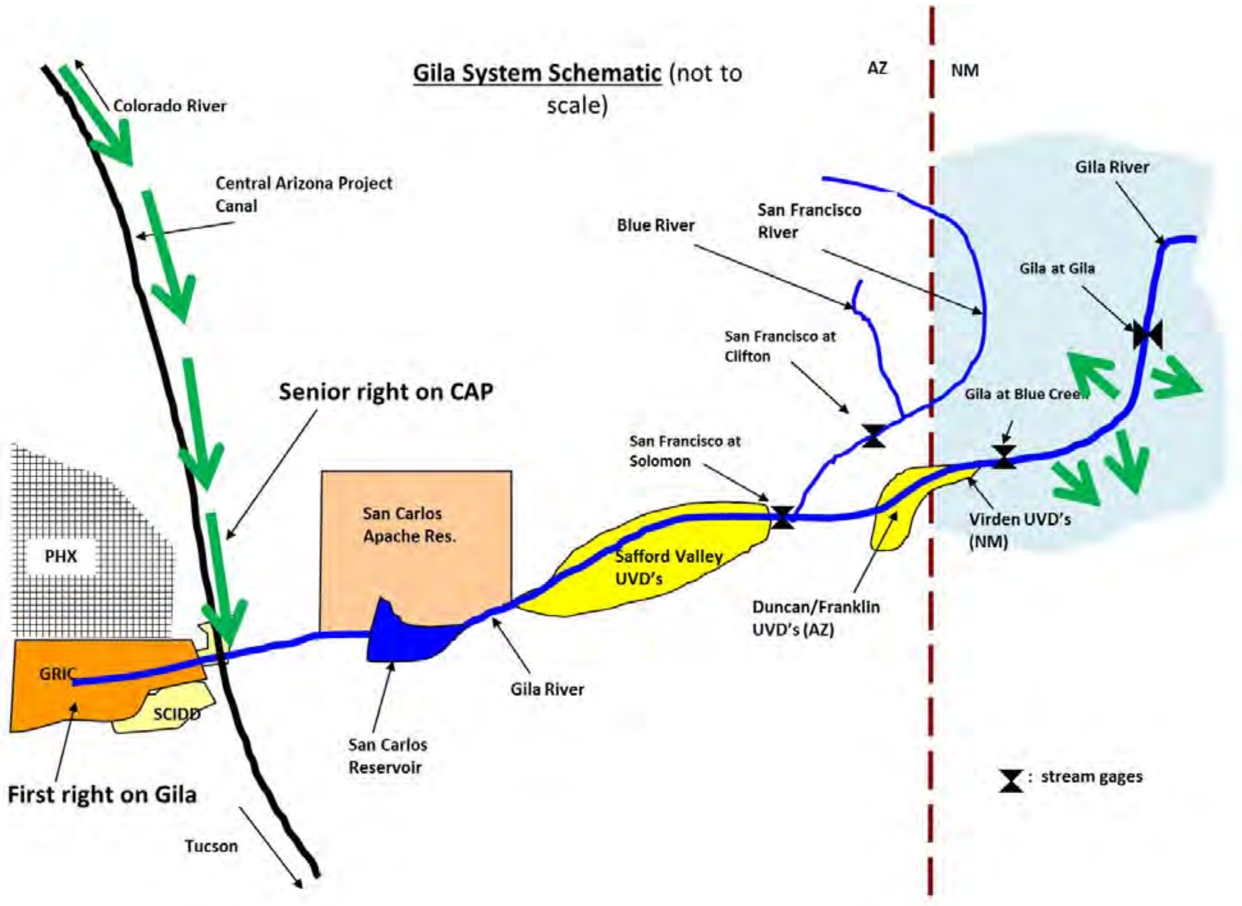

Figure 3. Exchange Mechanism in New Mexico and Arizona Under AWSA. Green arrows in NM are potential diversions in New Mexico. Green arrows in AZ are deliveries of New Mexico CAP Water.

Problem Statement

The Team developed the following problem statement: Develop alternatives for a functional project of the NM Unit. The Team defined a functional project as:

- Ability to divert and convey up to 350 cfs of water from the Gila River upstream of the Cliff-Gila Valley in New Mexico, and store water in side canyons in the Cliff-Gila Valley with a target of 13,000 ac-ft of storage in Phase One, and deliver water for environmental and agricultural purposes.
- Expandability from Phase 1 to future phases in order to provide an overall project storage equal to 46,000 ac-ft and a conveyance to serve Municipal and Industrial (M&I) uses in the Mimbres Basin to the east of the Continental Divide. This includes a pipeline to the City of Deming, NM (See Figure 1).

The goal of the Team was to develop alternatives for the least amount of cost.

Development of the Target Storage

The Team developed a target storage of 13,000 ac-ft for Phase I and a total target of 46,000 ac-ft for all three phases. Phase I target storage of 13,000 acre-feet is based on agricultural and environmental uses in the Cliff/Gila Valley. Phase II would optimize storage and/or other features to transition to Phase III. Phase III would involve the full build-out to convey water to the Mimbres Basin with a target storage of 46,000 acre-feet. Table 2 below gives a breakdown of the Phase 1 needs, which were selected based on generalized data; the Team did not perform any demand/yield studies as part of this study.

Table 2. Phase I Water Needs.

Area	Estimated Need (ac-ft)	Use
Cliff-Gila (Grant County)	3,000	Agricultural
Virden (Hidalgo County)	4,000	Agricultural
Environmental (Grant and Hidalgo Counties)	1,000	Environmental
Total	**8,000**	
Storage Capacity Required to Meet Estimated Need[3]	**13,000**	

The Phase II and III storage target of 46,000 acre-feet was developed in the *Value Engineering Report, Southwest Regional Water Supply Project*, November 2014 by RJH Consultants, Inc.

Owner and Stakeholders

Table 3 shows the Owners and Stakeholders and the Team's understanding of their issues or concerns as related to the NM Unit Project.

Table 3. Owner, User, and Stakeholder Issues of Concern[4].

Owner	Owner Issues of Concern
New Mexico CAP Entity	Secure water, minimize capital costs, minimize O&M costs, balance capital and O&M costs, reliable water supply, protect price of water, meet multiple needs (humans and environment)
Stakeholder	**Stakeholder Issues of Concern**
US Forest Service	Project consistent with forest management, aesthetics of facilities, project is not in wilderness area, potential effects to recreation, roadless areas, cooperation with NEPA process
Recreationists (e.g. rafting, fishing, hunting, birding)	Access, flow rates, no obstruction across floodplain, aesthetics
Environmental Groups	Protect the environmental resources, fauna, and attributes of the Gila River and associated riparian environments / protect unique resources

[3] The yield and capacity need more thorough modeling and evaluation. The Phase I storage capacity was roughly modeled as 13,000 AF to provide 8,000 AF annual yield for the estimated needs, assuming minimal seepage from a lined reservoir

[4] These issues represent the Team's understanding of each of the owners stakeholders issues of concern.

Stakeholder	Stakeholder Issues of Concern
The Nature Conservancy (TNC)	Protect the environmental resources, fauna, and attributes of the Gila River and associated riparian environments, protect unique resources, preserve habitat and flow on Gila River, oppose access / construction on their land, reduce length and duration of dry stretches on Gila River
US Fish & Wildlife Service	Protect endangered species, cooperation with NEPA process
US Corps of Engineers	404 permit, cooperation with NEPA process, want the Least Environmentally Damaging Practical Alternative (LEDPA)
NMDOT and FHA	Impacts to existing roads
NM Office of State Engineer	Dam safety, location of dam, water regulation, well permits
BLM	Impacts to land managed by BLM
Freeport McMoRan (FMI)	Impacts to their land, water rights, added diversions
Local Cities / Counties	Floodplain permits, impacts to roads, economic impacts / benefits, declining water resources, meeting water needs for future growth, cost of project
Tribal Governments	CUFA compliance, water quality
State of AZ and Water Providers	Impacts to water supply
Reclamation	Assist process; potential to design, build, operate, and maintain the Project; co-lead on NEPA
State of NM	Secure water, meet multiple needs, cost effectiveness, co-lead on NEPA
Department of the Interior	Functional project maintaining water deliveries to downstream users to AZ, signatory on NM Unit Agreement, diversion in compliance with CUFA, sign ROD
Private Landowners	Concerns with public access to reservoirs, impacts to their land
Irrigators	Sufficient water supply, current declines in agricultural economies

New Mexico Consumptive Use and Forbearance Agreement (CUFA) Diversion Constraints

Multiple conditions must be met before NM can divert the AWSA water. The major conditions are:

- Maximum diversion rate of 350 cfs
- Minimum monthly flow bypasses ranging from 75.5 cfs[5] to 442.5 cfs
- 140,000 ac-ft in any running 10-year period

[5] Modeling by NMISC shows that NM could maintain a minimum of 150 cfs after diverting and still harvest the water available under the CUFA. This limit is double the median flow (73 cfs) and would apply to December, January, and February.

- Maximum diversion of 64,000 ac-ft/yr
- San Carlos Reservoir storage
- Pre-Banking NM CAP Water

Cost Estimate Information

The Team developed costs for major components of each of the alternatives primarily using unit prices from BHI and Reclamation reports. In some cases, the Team developed unit prices based on their experience when there was a large difference between the unit prices in BHI and Reclamation reports or when unit costs were not provided in the referenced reports. To facilitate comparison between alternatives, consistent unit costs were used for each alternative and adjustments were not made to account for site-specific conditions.

The cost estimates for each alternative developed in this report are at a Preliminary Level (Reclamation's lowest level of cost estimating) in 2014 dollars and are included in the Appendix. Preliminary cost estimates are prepared for studies conducted at the very early stages of the planning process. They are developed and produced to document a very preliminary analysis performed to look at a given problem, need, or opportunity utilizing readily available data. The estimates do not meet the criteria used for preparation of either Appraisal or Feasibility cost estimates. The cost estimates represent the Total Project Cost that includes design contingencies due to the high level of uncertainty during planning level designs (e.g. lack of geotechnical investigations); construction contingencies; and non-contract costs. These contingencies and non-contract costs are factored in to yield the Total Project Costs.

Design Contingencies cover unlisted items, minor changes in design and scope, and minor estimating refinements. Unlisted items are minor items for which it is not practical to develop designs and quantities during early stages of a project; for example, fencing associated with a treatment plant may be necessary, but is a minor component of the overall project. Construction contingencies are for unforeseen project costs incurred after the contractor is awarded the Project. Construction contingencies cover minor differences in actual and estimated quantities, unforeseeable difficulties at the site, changed site conditions, possible minor changes in plans, and other uncertainties.

Non-Contract costs refer to work or services provided in support of the project and other work that is of such a broad non-specific nature that it can only be attributed to the project as a whole. These costs generally originate for work or services provided by agency personnel (or contractor personnel used to augment agency resources), or land or right-of-way acquisitions to facilitate project development. Non-Contract costs cover items such as engineering and design, studies, investigations, construction management, right-of-way acquisition, etc.

The Team developed cost estimates to compare costs amongst the alternatives. The Team had limited time and resources to prepare cost estimates for each alternative. Therefore, the Team recommends that these cost estimates *not* be used for budget or construction purposes. As the design progresses, the designer will more accurately quantify the estimated costs.

Decision Matrix

The Team developed twelve alternatives each of which can be constructed in three phases. In order to determine which alternatives may be more preferable, the Team developed a decision matrix. The decision matrix was developed as follows:

1. Selecting the criteria and scoring system
2. Weighting the criteria
3. Determining a score for each criteria for each alternative
4. Multiplying each criteria score for each alternative by the criteria weighting in order to calculate a total score for each alternative

Criteria and Scoring System

The Team developed the following criteria and scoring system to evaluate the twelve alternatives.

A. Storage Capacity for Phase I
   What is the storage capacity in Phase I?
   5 > 20,000 ac-ft
   4 – 15,000 ac-ft to 19,999 ac-ft
   3 – 10,000 ac-ft to 14,999 ac-ft
   2 – 5,000 ac-ft to 9,999 ac-ft
   1 < 4,999 ac-ft

B. Storage Capacity for all three phases
   What is the storage capacity for all three phases?
   5 > 60,000 ac-ft
   4 – 50,000 ac-ft to 59,999 ac-ft
   3 – 40,000 ac-ft to 49,999 ac-ft
   2 – 30,000 ac-ft to 39,999 ac-ft
   1 < 30,000 ac-ft

C. Capital Costs for Phase I
   What is the estimated cost of Phase I?
   5 - < $150M
   4 – $150M-$199M
   3 – $200M-$274M
   2 – $275M-$349M
   1 – > $350M

D. Capital Costs for all three phases
   What is the estimated cost of all three phases?
   5 < $700M
   4 – $700M-$774M
   3 – $775M-$849M
   2 – $850M-$949M
   1 > $950M

E. OM&R Energy Costs for all three phases
What is the OM&R Energy Costs for all three phases? Does the alternative require pumping for storage and/or Cliff-Gila deliveries?
5 – None to Low
4 – Low to Moderate
3 – Moderate
2 – Moderate to High
1 – High

F. Potential Environmental Impacts for all Three Phases
To what extent does the alternative potentially affect the environment: riparian and wetland habitat, river fragmentation, water quality of releases, endangered species, carbon emissions, aesthetics, and inundation of habitat?
5 – None to Low
4 – Low to Moderate
3 – Moderate
2 – Moderate to High
1 – High

G. Potential Impacts to Existing Infrastructure for all Three Phases
To what extent does the alternative impact existing infrastructure (roads, structures, pipes, etc.)?
5 – None to Low
4 – Low to Moderate
3 – Moderate
2 – Moderate to High
1 – High

H. Permitting Complexity for all Three Phases
What is the complexity of the permitting?
5 – None to Low
4 – Low to Moderate
3 – Moderate
2 – Moderate to High
1 – High

Criteria Weighting

The criteria weighting method employed by the team was adapted from the Combinex® matrix system developed in the early 1960's by Carlos Fallon. The first step in the Decision Matrix consists of constructing a Criteria Scoring Matrix (Table 4) which compares each criterion side-by-side. The criterion that has the greatest perceived importance is chosen, and the degree of difference between the two criteria is placed in the corresponding cell below. When two criteria tie, a zero value is entered in either box. The number range used for the Criteria Matrix was 1 through 3 (1 being a minor preference and 3 being a major preference). If any criterion has a raw score of zero, it is given a rating of one. The lettering of the Criteria Matrix corresponds to the lettering given above in 'Criteria'.

The criterion assigned the most weight by the Team were Capital Costs for Phase I (19 percent). The other corresponding criteria in order of descending weights are Storage Capacity for Phase I (18 percent), Capital Costs for all Phases (15 percent) and Storage Capacity for all Phases (15 percent each), OM&R Energy Costs for all Phases (11 percent), Potential Environmental Impacts for all Phases (10 percent), Permitting Complexity for all Phases (8 percent), and Potential Impacts to Existing Infrastructure for all Phases (4 percent).

The environmental criterion was given a lower weight because alternatives that clearly had high environmental impacts were eliminated from consideration early on and are not considered in this report.

Table 4. Criteria Matrix.

Criteria Scoring Matrix

Criteria:	Preference		Preference		Preference		Preference		Preference		Preference		Preference		Raw Score	Weight (1 to 10)	Normalized to 100	Rounded Percentage
	A or	B	A or	C	A or	D	A or	E	A or	F	A or	G	A or	H				
A. Storage Capacity for Phase One	1			1	2				2		3		2		10	4.3	18.1	18%
	B or	C	B or	D	B or	E	B or	F	B or	G	B or	H						
B. Storage Capacity for All Phases			1			1	2		3		2				8	3.7	15.3	15%
	C or	D	C or	E	C or	F	C or	G	C or	H								
C. Capital Costs for Phase One	2				2		3		3						11	4.7	19.4	19%
	D or	E	D or	F	D or	G	D or	H										
D. Capital Costs for All Phases		1	2		3		3								8	3.7	15.3	15%
	E or	F	E or	G	E or	H												
E. OM&R Energy Costs for All Phases			2		1										5	2.7	11.1	11%
	F or	G	F or	H														
F. Potential Environmental Impacts for All Phases	3														3	2.0	8.3	10%
	G or	H																
G. Potential Impacts to Existing Infrastructure for All Phases		3													0	1.0	4.2	4%
H. Permitting Complexity for All Phases															3	2.0	8.3	8%

Decision Matrix

Each alternative was evaluated based on the criteria and each criterion was given a score ranging from one to five: one representing the least favorable (or poor) and five representing the most favorable outcome (or excellent). These scores were multiplied by the criteria weightings and scores were summed for each alternative in the decision matrix (Table 5). The decision matrix enabled the Team to determine the relative ranking of the twelve alternatives. Figure 4 displays the point breakdown per criterion for each alternative.

This decision matrix was developed by the Team using its knowledge and understanding of the Project at the time of the study. With continued progress and data collection on the Project, the criteria, weighting of the criteria, and scoring for each Alternative could change. This decision matrix can be updated, modified, and adjusted as the NM Unit Project is developed.

Table 5. Decision Matrix.

	Storage Capacity for Phase One		Storage Capacity for All Phases		Capital Costs for Phase One		Capital Costs for All Phases		OM&R Energy Costs for All Phases		Potential Environmental Impacts for All Phases		Potential Impacts to Existing Infrastructure for All Phases		Permitting Complexity for All Phases				
	A		B		C		D		E		F		G		H				
	18		15		19		15		11		10		4		8				
Alternative	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted	Raw Score	Weighted Score	Ranking
Alt 9A - Small Winn / Large Winn	3	54.2	3	45.8	1	19.4	3	45.8	5	55.6	5	50.0	5	20.8	5	41.7	25	333.3	**1**
Alt 9B - Small Bell / Large Bell	3	54.2	3	45.8	1	19.4	2	30.6	5	55.6	5	50.0	5	20.8	5	41.7	24	318.1	**2**
Alt 1 - Small Spar / Upper Spar	1	18.1	3	45.8	3	58.3	3	45.8	2	22.2	4	40.0	5	20.8	5	41.7	21	292.8	**3**
Alt 7 - Original Winn / Small Greenwood	1	18.1	1	15.3	5	97.2	5	76.4	4	44.4	1	10.0	1	4.2	2	16.7	19	282.2	**4**
Alt 5 - Large Garcia / Greenwood	3	54.2	5	76.4	1	19.4	1	15.3	5	55.6	3	30.0	1	4.2	3	25.0	21	280.0	**5**
Alt 4 - Large Pope / Greenwood	3	54.2	5	76.4	1	19.4	1	15.3	5	55.6	3	30.0	1	4.2	2	16.7	20	271.7	**6**
Alt 8 - Small Greenwood / Greenwood	4	72.2	3	45.8	1	19.4	2	30.6	3	33.3	3	30.0	1	4.2	4	33.3	20	268.9	**7**
Alt 9C - Small Winn / Greenwood	3	54.2	4	61.1	1	19.4	1	15.3	5	55.6	2	20.0	1	4.2	3	25.0	19	254.7	**8**
Alt 9D - Small Bell / Greenwood	3	54.2	4	61.1	1	19.4	1	15.3	5	55.6	2	20.0	1	4.2	3	25.0	19	254.7	**8**
Alt 2 - Small Pope / Greenwood	2	36.1	4	61.1	1	19.4	1	15.3	5	55.6	3	30.0	1	4.2	3	25.0	19	246.7	**9**
Alt 3 - Small Garcia & Small Pope / Greenwood	3	54.2	5	76.4	1	19.4	1	15.3	5	55.6	1	10.0	1	4.2	1	8.3	17	243.3	**10**
Alt 6 - Small Spar / Greenwood	1	18.1	3	45.8	3	58.3	1	15.3	4	44.4	3	30.0	1	4.2	3	25.0	18	241.1	**11**

Total Possible Score = 500

- Score 300-500
- Score 275-300
- Score 250-275
- Score 225-250

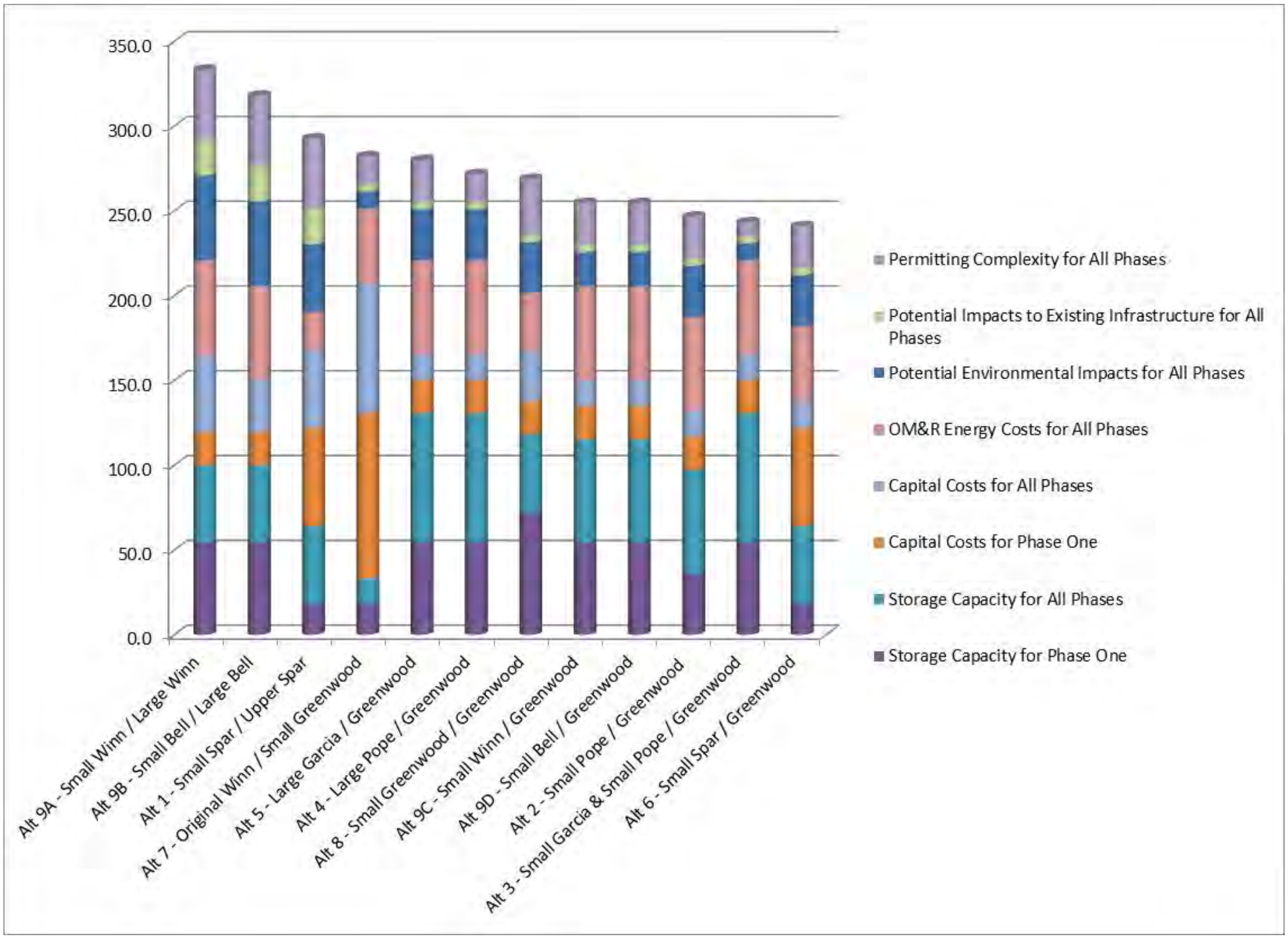

Figure 4. Graphical Display of Decision Matrix (Points of Each Criterion for all Alternatives).

Summary of Results

The Value Study analysis compares the twelve proposed alternatives against each other. Because only 92 points separate the scores (241-333) for all the alternatives, this shows, based on the selected scoping criteria, small changes in the scoring or weighting can affect the ranking of an alternative. For instance, if the capital cost of Alternative 9C (Small Winn/Greenwood) decreases from $360 million down to $349 million, the score increases from 255 to 274 and the ranking changes from eighth to sixth.

The colors shown in Table 6 indicate groupings of weighted scores. The highest score of 333 represents only 67 percent of the 500 total points possible, thus indicating that the current alternatives for the NM Unit may be challenging and complex to pursue, and that other alternatives and concepts should continue to be evaluated.

The Value Study results indicate that a phased approach may be necessary and appropriate for this project. The study team discussed the scope, complexity, and the cost of the full project, which for this study was defined as delivery of water to the Mimbres Basin. Because the Federal AWSA funding is not sufficient to construct the full project, the team determined it was appropriate to consider a phased approach to the project as a means to achieve the ultimate project goals. In any case, this initial phase would be a necessary component for subsequent development of the full project. Another advantage of phasing would be to allow the requirements and scope of water conveyance to the Mimbres Basin to evolve, as would be expected for a project of this size and complexity. With these considerations in mind, the team defined the three phases that are described throughout this report.

Phase I has a target storage of 13,000 acre-feet for agricultural and environmental uses in the Cliff/Gila Valley. Phase II would optimize storage and/or other features to transition to Phase III. Phase III would involve the full build-out to convey water to the Mimbres Basin with a target storage of 46,000 acre-feet. One of the alternatives studied could be paid for with federal funding identified in the 2004 Arizona Water Settlement Act (AWSA), although the alternative did not meet the target storage criteria.

Phase I Analysis

The top ranked alternatives are Alternatives 9A and 9B, in which building a large enough embankment dam to meet the Phase I target storage of 13,000 ac-ft in Winn and Bell Canyons is considered.

Alternative 1 (Small Spar/Upper Spar) ranks third, lower than the top ranked alternatives mainly due to small storage capacity for Phase I (1,642 ac-ft) and pumping costs from Small Spar reservoir to the Upper Spar Reservoir, even though the capital cost of $240 million is lower than Alternatives 9A and 9B.

Alternative 7 (Original Winn/Greenwood) shows the least expensive Phase I capital cost coming in at $125 million. However, this only provides 2,750 ac-ft of storage that is substantially less than the Phase I storage target of 13,000 ac-ft, and ranks fourth.

Alternative 5 (Large Garcia/Greenwood) ranks fifth. This alternative meets Phase I storage target of 13,000 ac-ft, but requires pumping which increases OM&R energy costs for all phases. The capital cost of this alternative is $440 million, which is more than alternatives 9A and 9B. This alternative requires pumping to the upper Cliff-Gila Valley for agricultural and environmental uses.

All Three Phases Analysis

The top two alternatives (9A and 9B) include raising and lengthening the Phase I Winn and Bell dams to obtain a total storage of 46,000 ac-ft. The capital cost is 800 million for Alternative 9A (Winn), and $910 million for alternative 9B (Bell).

Third ranked Alternative 1 (Small Spar/Upper Spar) has similar capital costs ($830 million) and total storage for all three phases (47,642 AF) as compared to Alternatives 9A and 9B.

Fourth ranked Alternative 7 (Original Winn/Greenwood) is the least expensive capital cost for all three phases coming in at $700 million. However, the estimated storage capacity of 28,750 ac-ft of storage is less than the storage target of 46,000 ac-ft for all three phases. Additionally, this alternative requires pumping from Greenwood to make deliveries to the upper Cliff-Gila Valley.

Additional Combinations

The Team did not have sufficient time to synthesize the results in order to determine and/or develop additional combinations. The Team recommends reviewing these results and trying to develop other combinations that could meet the target storage and/or revisiting the target storage.

Alternatives Incorporating Existing Diversion and Conveyance Systems

The Team acknowledges there are potentially lower cost alternatives that incorporate smaller storage features or existing diversion and conveyance systems. However, these alternatives were not considered in this report because they were beyond the scope of this study.

Value Study Contribution

The major contributions that this Value Study Team provided to the NM Unit Project are:

- Developing target storage capacities for Phase I and all three phases
- Developing alternatives to meet the target storage capacities for Phase I and all three phases
- Developing alternatives that can be split into three phases;
    - Phase I - Diversion, conveyance, small reservoir
    - Phase II - Larger Reservoir in another canyon or by raising the dam
    - Phase III - Pipeline to Deming, NM
- Ranking the alternatives to determine which alternatives may be more preferable (9A, 9B, and 1)
- Proposing larger dams in the Winn (9A) and Bell (9B) Canyons to obtain a much larger reservoir

- Proposing ring dams[6] in the Pope (4) and Garcia (5) Canyons to obtain more Phase I storage
- Proposing a smaller dam in Greenwood Canyon for Phase I and raising that dam for Phase II
- Ensuring that alternatives are technically sound
- Providing unit costs and construction approach to lining reservoirs to reduce see page
- Comparing alternatives

[6] Ring Dam - an embankment dam forming a closed basin in plan constructed of suitable earth excavated from within the ring. Depending upon the required crest elevation and topography, the ring may or may not be continuous and can extend beyond where a canyon enters a valley.

Table 6. Summary Table of Decision Matrix Results[7].

Alternative	Weighted Score	Ranking	Phase One: Meets Phase One Target 13,000 ac-ft	Phase One: Phase One Costs	Phase One: Ac-Ft Storage for Phase One	All Three Phases: Costs for All Three Phases	All Three Phases: Ac-Ft Storage for All Three Phases	Preferred Supply Conveyance Type	Siphons Under Gila River	Requires Pumping for Phase Two Deliveries to Upper Gila
Alt 9A - Small Winn / Large Winn	333	**1**	Yes	$360M	13,000	$800M	46,000	Tunnel/Canal	Yes	No
Alt 9B - Small Bell / Large Bell	318	**2**	Yes	$410M	13,000	$910M	46,000	Tunnel/Canal	Yes	No
Alt 1 - Small Spar / Upper Spar	293	**3**	No	$240M	1,642	$830M	47,642	Tunnel/Canal	No	No
Alt 7 - Original Winn / Small Greenwood	282	**4**	No	$125M	2,750	$700M	28,750	Canal	Yes	Yes
Alt 5 - Large Garcia / Greenwood	280	**5**	Yes	$440M	13,000	$1,050M	59,000	Tunnel/Canal	No	Yes
Alt 4 - Large Pope / Greenwood	272	**6**	Yes	$490M	13,000	$1,100M	59,000	Tunnel/Canal	No	Yes
Alt 8 - Small Greenwood / Greenwood	269	**7**	Yes	$490M	15,000	$850M	46,000	Tunnel/Canal	No	Yes
Alt 9C - Small Winn / Greenwood	255	**8**	Yes	$360M	13,000	$1,050M	59,000	Tunnel/Canal	Yes	Yes
Alt 9D - Small Bell / Greenwood	255	**8**	Yes	$410M	13,000	$1,100M	59,000	Tunnel/Canal	Yes	Yes
Alt 2 - Small Pope / Greenwood	247	**9**	No	$430M	8,732	$1,050M	54,732	Tunnel/Canal	No	Yes
Alt 3 - Small Garcia & Small Pope / Greenwood	243	**10**	Yes	$540M	12,832	$1,180M	58,832	Tunnel/Canal	No	Yes
Alt 6 - Small Spar / Greenwood	241	**11**	No	$240M	1,642	$1,050M	47,642	Tunnel/Pipe	No	Yes

Score 300-500 (green) — Total Possible Score = 500
Score 275-300 (orange)
Score 250-275 (red)
Score 225-250 (blue)

[7] The costs include a liner for all the reservoirs. The Team made this conservative assumption because a Geotechnical investigation has not been performed to determine if liner(s) are required.

Value Planning Alternatives

Alternative 1: Lower Spar/Upper Spar Reservoirs

Alternative Description:

This alternative diverts 350 cfs of the AWSA water from the Gila River at proposed diversion site 2A, el. 4736 ft (see Figure 2). The 350 cfs conveyance consists of a 108-inch diameter buried pipe for a length of 1,000-feet and a 108-inch diameter tunnel for a length of 3 miles that outfalls to a small storage reservoir in Spar Canyon (1,642 ac-ft) for Phase I.

Phase II consists of building a larger reservoir (46,000 ac-ft) upstream of the small reservoir with a 50 cfs pump station that pumps from the small reservoir to the large reservoir. Phase III consists of building a pipeline from the larger Spar reservoir to the City of Deming, NM. See Figure 1-1 for a sketch of this alternative. This alternative is very similar to an idea (P01-014) developed during the Value Engineering Study by RJH Consultants, Inc. in November 2014.

Water would be released from the Small Spar reservoir outlet works for agricultural and environmental uses in Cliff-Gila and Virden Valleys for Phases I and II. Phase III includes pumping water from Spar reservoir over the Continental Divide to the Mimbres Basin for potential future municipal and industrial uses.

Critical Items to Consider:

- Additional evaluation is needed to specify the pumping rate and pump sizes from Small Spar to Upper Spar.
- Diversion 2A and a small portion of the reservoirs would be on USFS land.
- Additional geologic data are needed for the dam locations, especially depth to bedrock and bedrock properties such as permeability.
- Lining costs are a large percentage of the total costs. Need better seepage and hydrology data to better evaluate the need for lining.

Ways to Implement:

- Phase I includes construction of diversion, tunnel, and a small reservoir in lower Spar Canyon.
- Phase II includes construction of a larger reservoir in upper Spar Canyon and a pump station and pipeline from Lower Spar to Upper Spar.
- Phase III includes construction of a pipeline to Deming, NM.

Potential Risks:

The capacity of Small Spar may not be sufficient to serve as a reliable forebay for Upper Spar. A quick calculation shows that there is not enough storage at 46 percent of the days in Small Spar to hold the water that is being diverted at a maximum rate of 350 cfs. That is, the inflow rate would be much higher than the outflow rate for this reservoir. In addition, its capacity may not be sufficient to provide the necessary firm yield to the Cliff-Gila and Virden Valleys under extreme sustained low flow or drought conditions prior to construction of Phase II. Under very long-term sustained optimal flow conditions, the low reservoir capacity may require release or non-capture of AWSA water when the reservoir is full. After implementation of Phase II, this risk no longer exists.

Advantages:

- Only one canyon would be inundated, which is favorable from a permitting standpoint.
- Spar Canyon is on the east side of the valley, which is suitable for pumping to Deming, NM. No additional infrastructure (siphon, etc.) would be needed to cross the Gila River Valley.
- The location of Spar Canyon is very suitable to release from the reservoir(s) for agricultural and environmental uses in the Cliff-Gila Valley.
- Small Spar could be used as a settling basin for suspended solids in water diverted from the river.
- The combined capacity of the two reservoirs of 47,642 ac-ft (1,642 ac-ft plus 46,000 ac-ft), provides additional capacity just above the target design capacity of 46,000 ac-ft for all three phases.

Disadvantages:

- 1,642 ac-ft capacity of Spar does not meet the target of 13,000 ac-ft for Phase I.

Relative Costs:

Phase I Project Cost ~ $240M
Total for all three Phases ~ $830M

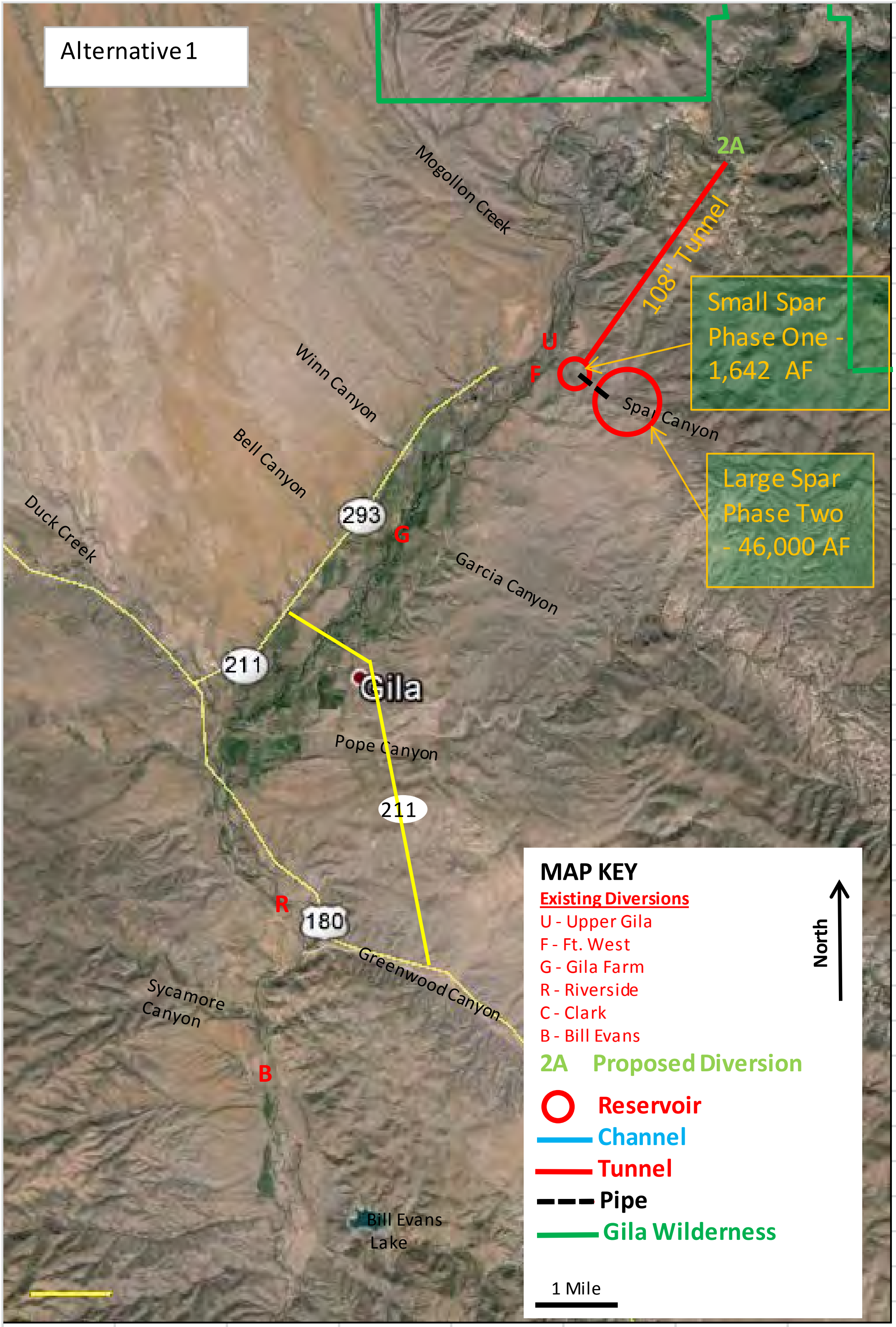

Figure 1-1. Aerial Sketch of Alternative 1.

Alternative 2: Small Pope/Greenwood Reservoirs

Alternative Description:

This alternative diverts 350 cfs of the AWSA water from the Gila River at proposed diversion site 2A, el. 4736 (see Figure 2). The 350 cfs conveyance consists of a 108-inch diameter buried pipe for a length of 1,000-feet and a 108-inch diameter tunnel for a length of 3 miles to Spar Canyon. At Spar Canyon, the conveyance would change from a tunnel to an open concrete lined channel, which would extend 5.5 miles to a lined water storage reservoir at Pope Canyon (8,732 ac-ft) for Phase I.

Phase II consists of an open concrete lined channel conveyance from the Pope Canyon Reservoir to a lined water storage reservoir (46,000 ac-ft) in Greenwood Canyon. Phase II also includes a pump station and buried pipe from the outlet works in Greenwood Canyon to the delivery point at Upper Gila. Phase III consists of building a pipeline from the Greenwood reservoir to the City of Deming, NM. See Figure 2-1 for a sketch of this Alternative.

Water would be released from the small Pope Reservoir outlet works for agricultural and environmental uses in Cliff-Gila and Virden Valleys for Phase I. Phase II deliveries would come from the Greenwood reservoir through buried pipe to a pump station and additional buried pipe to the Upper Gila delivery point. Phase III includes pumping water from Greenwood reservoir over the Continental Divide to the Mimbres Basin for potential future municipal and industrial uses.

Critical Items to Consider:

- Diversion 2A is on USFS land.
- Additional geologic data are needed for the dam locations, especially depth to bedrock and bedrock properties such as permeability.
- Lining costs are a large percentage of the total costs. Need better seepage and hydrology data to evaluate the need for lining.

Ways to Implement:

- Phase I includes construction of diversion, tunnel, open channel, and a small reservoir in Pope Canyon.
- Phase II includes construction of open channel conveyance and siphon from the reservoir in Pope Canyon to a larger reservoir in Greenwood Canyon.
- Phase III includes construction of a pipeline to Deming, NM.

Potential Risks:

The Phase I capacity of Pope Canyon Reservoir most likely will not provide the necessary firm yield to the Cliff-Gila and Virden Valleys under sustained low flow or drought conditions. Under sustained optimal flow conditions, the low/moderate reservoir capacity may require release or non-capture of AWSA water when the reservoir is full. After implementation of Phase II, this risk no longer exists.

Advantages:

- Greenwood Canyon is on the east side of the valley, which is suitable for pumping to Deming, NM. No additional infrastructure (siphon, etc.) would be needed to cross the Gila River valley.
- The combined capacity of the two reservoirs of 54,732 ac-ft (8,732 ac-ft plus 46,000 ac-ft), provides additional capacity in excess of the target design capacity of 46,000 ac-ft for all three phases.
- The dam abutments, and possibly the entire dam at the Greenwood canyon, will likely be founded on rhyolite. The rhyolite foundation would be expected to have a lower permeability and provide a better foundation compared to the conglomerate foundation further upstream in the Cliff-Gila Valley.

Disadvantages:

- Two canyons would be inundated, which is not favorable from a permitting standpoint.
- 8,732 ac-ft capacity of Pope does not meet the target of 13,000 ac-ft for Phase I.
- Requires relocating US Highway 180 around the Greenwood Canyon inundation area at an estimated cost of $55 million.
- Requires relocating an intersection and a small portion State Highway 211 due to the inundation in Greenwood and Pope Canyons.
- Requires pumping from Greenwood reservoir to the delivery point at the existing Upper Gila diversion location.

Relative Costs:

Phase I Project Cost ~ $430M
Total for all Three Phases ~ $1,050M

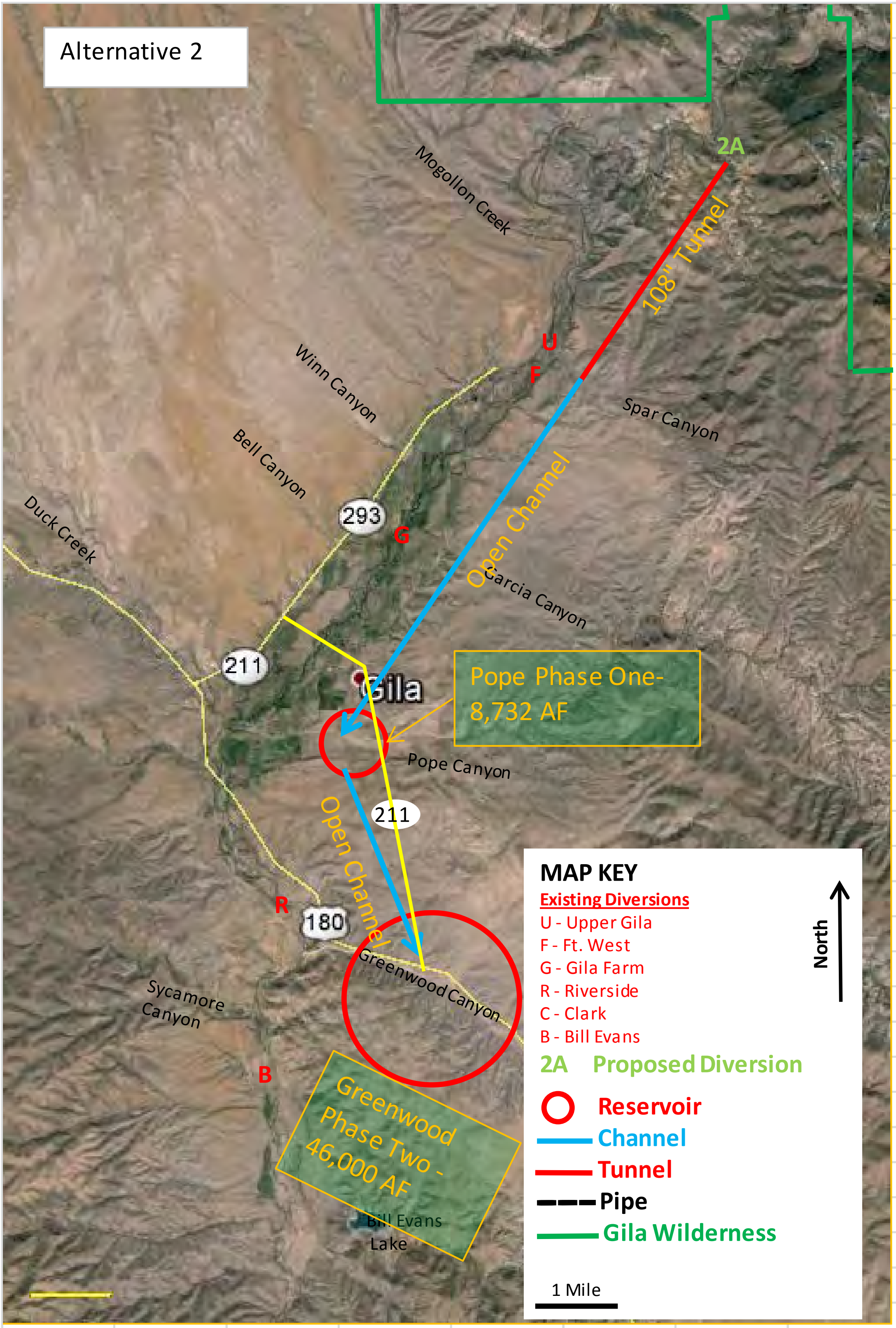

Figure 2-1. Aerial Sketch of Alternative 2. The open channels were drawn as a straight line instead of along the contour.

Alternative 3: Small Garcia & Small Pope/Greenwood Reservoirs

Alternative Description:

This alternative diverts 350 cfs of the AWSA water from the Gila River at proposed diversion site 2A, el. 4736 (see Figure 2). The 350 cfs conveyance consists of a 108-inch diameter buried pipe for a length of 1,000-feet and a 108-inch diameter tunnel for a length of 3 miles to Spar Canyon. At Spar Canyon, the conveyance would change from a tunnel to an open concrete lined channel, which would extend 2.5 miles to a lined water storage reservoir at Garcia Canyon (4,100 ac-ft). A 3-mile open concrete lined channel conveyance would run from the Garcia Canyon reservoir to a lined water storage reservoir in Pope Canyon (8,732 ac-ft) for Phase I.

Phase II consists of an open concrete lined channel conveyance from the Pope Canyon Reservoir to a lined water storage reservoir (46,000 ac-ft) in Greenwood Canyon. Phase II also includes a pump station and buried pipe from the outlet works in Greenwood Canyon to the delivery point at Upper Gila. Phase III consists of building a pipeline from the Greenwood reservoir to the City of Deming, NM. See Figure 3-1 for a sketch of this Alternative.

Water would be released from the Garcia and Pope reservoirs outlet works for agricultural and environmental uses in Cliff-Gila and Virden Valleys for Phase I. Phase II deliveries would come from the Greenwood Reservoir through buried pipe to a pump station and additional buried pipe to the Upper Gila delivery point. Phase III includes pumping water from Greenwood Reservoir over the Continental Divide to the Mimbres Basin for potential future municipal and industrial uses.

Critical Items to Consider:

- Diversion 2A is on USFS land.
- Additional geologic data are needed for the dam locations, especially depth to bedrock and bedrock properties such as permeability.
- Lining costs are a large percentage of the total costs. Need better seepage and hydrology data to better evaluate the need for lining.

Ways to Implement:

- Phase I includes construction of diversion, tunnel, open channel to Garcia Canyon, small reservoir in Garcia Canyon, open channel from Garcia Canyon to Pope Canyon, small reservoir in Pope Canyon.
- Phase II includes construction of open channel conveyance and siphon from the reservoir in Pope Canyon to a larger reservoir in Greenwood Canyon.
- Phase III includes construction of a pipeline to Deming, NM.

Potential Risks:

The Phase I capacities of the Garcia and Pope Canyon Reservoirs may not be sufficient to provide the necessary firm yield to the Cliff-Gila and Virden Valleys under extreme sustained low flow or drought conditions prior to construction of Phase II. Under very long-term sustained optimal flow conditions, the moderate reservoir capacity may require release or non-capture of the AWSA water when the reservoir is full. After implementation of Phase II, this risk no longer exists.

Advantages:

- Increased reliability of firm yield in Phase I to the Cliff-Gila Valley when compared to Alternatives 1, 2, 6, and 7, thus decreasing the likelihood of having to forgo available AWSA water due to lack of storage.
- Greenwood Canyon is on the east side of the valley, which is suitable for pumping to Deming, NM. No additional infrastructure (siphon, etc.) would be needed to cross the Gila River valley.
- The combined capacity of the two reservoirs of 59,000 ac-ft (4,100 ac-ft plus 8,732 ac-ft, 46,000 ac-ft), provides additional capacity in excess of the target design capacity of 46,000 ac-ft for all three phases.
- The dam abutments, and possibly the entire dam at Greenwood Canyon, will likely be founded on rhyolite. The rhyolite foundation would be expected to have a lower permeability and provide a better foundation compared to the conglomerate foundation further upstream in the Cliff-Gila Valley.

Disadvantages:

- Three canyons would be inundated, which is not favorable from a permitting standpoint.
- Requires relocating US Highway 180 around the Greenwood Canyon inundation area at an estimated cost of $55 million.
- Requires relocating an intersection and a small portion State Highway 211 due to the inundation in Greenwood and Pope Canyons.
- Requires pumping from Greenwood reservoir to the delivery point at the existing Upper Gila diversion location.

Relative Costs:

Phase I Project Cost ~ $540M
Total for all Three Phases ~ $1,180M

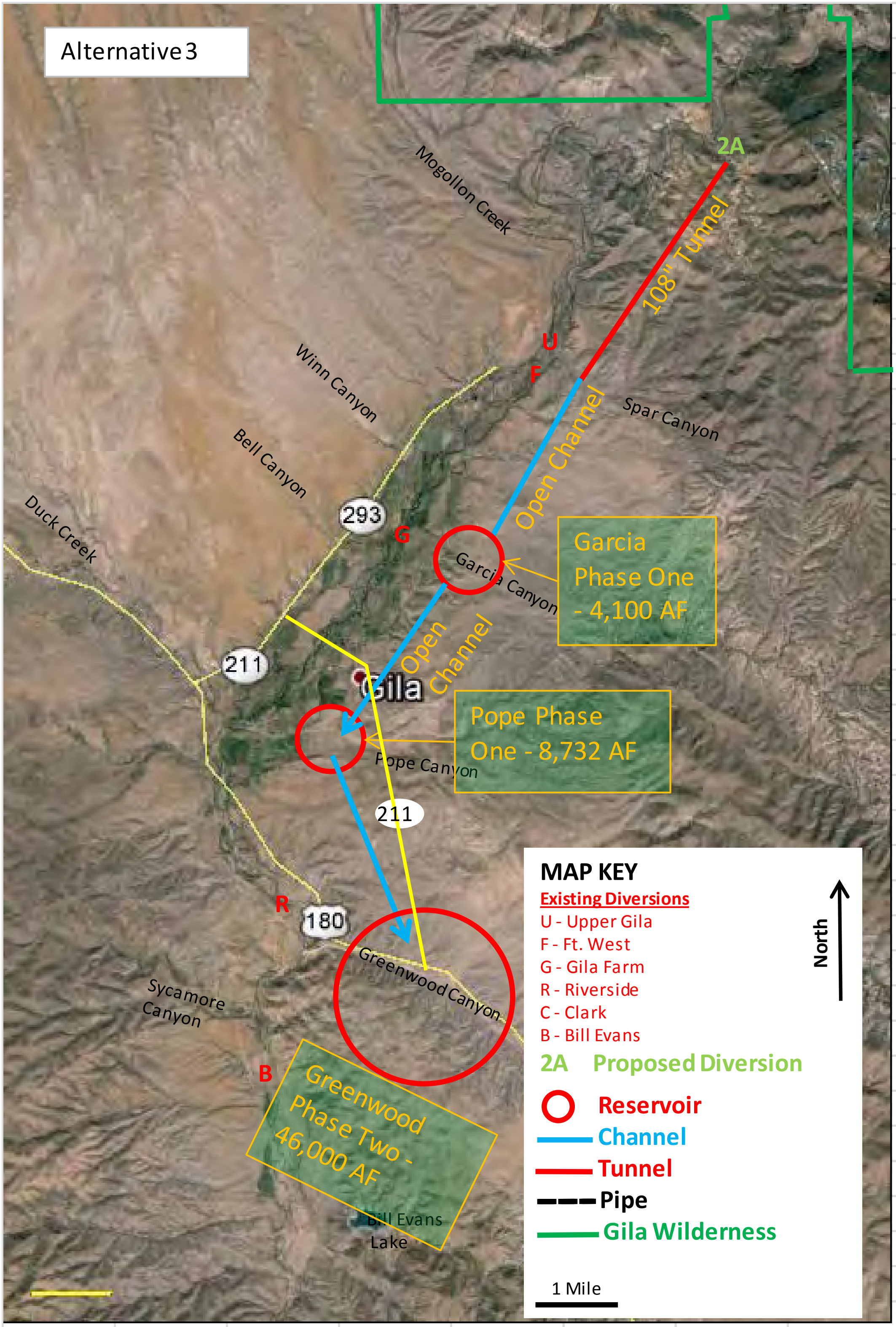

Figure 3-1. Aerial Sketch of Alternative 3. The open channels were drawn as a straight line instead of along the contour.

Alternative 4: Large Pope/Greenwood Reservoirs

Alternative Description:

This alternative diverts 350 cfs of the AWSA water from the Gila River at proposed diversion site 2A, el. 4736 (see Figure 2). The 350 cfs conveyance consists of a 108-inch diameter buried pipe for a length of 1,000-feet and a 108-inch diameter tunnel for a length of 3 miles to Spar Canyon. At Spar Canyon, the conveyance would change from a tunnel to an open concrete lined channel, which would extend 5.5 miles to a lined water storage reservoir at Pope Canyon (13,000 ac-ft) for Phase I. The additional storage capacity in Pope Canyon is obtained by installing a ring dam downstream of the proposed dam.

Phase II consists of an open concrete lined channel conveyance from the Pope Canyon Reservoir to a lined water storage reservoir (46,000 ac-ft) in Greenwood Canyon. Phase II also includes a pump station and buried pipe from the outlet works in Greenwood Canyon to the delivery point at Upper Gila. Phase III includes pumping water from Greenwood reservoir over the Continental Divide to the Mimbres Basin for potential future municipal and industrial uses. See Figure 4-1 for a sketch of this Alternative.

Water would be released from the Pope Reservoir outlet works for agricultural and environmental uses in Cliff-Gila and Virden Valleys for Phase I. Phase II deliveries could come from the Pope reservoir through buried pipe to a pump station and additional buried pipe to the Upper Gila delivery point. Phase III includes pumping water from Greenwood reservoir over the Continental Divide to Mimbres Basin, potentially for municipal and industrial uses.

Critical Items to Consider:

- Diversion 2A is on USFS land.
- Additional geologic data are needed for the dam locations, especially depth to bedrock and bedrock properties such as permeability.
- Lining costs are a large percentage of the total costs. Need better seepage and hydrology data to better define the need for lining.

Ways to Implement:

- Phase I includes construction of diversion, tunnel, open channel to Pope Canyon, ring dam for a small reservoir in Pope Canyon.
- Phase II includes construction of open channel conveyance and siphon from the reservoir in Pope Canyon to a larger reservoir in Greenwood Canyon.
- Phase III includes construction of a pipeline to Deming, NM.

Potential Risks:

The Phase I capacity of the Pope Canyon Reservoir may not be sufficient to provide the necessary firm yield to the Cliff-Gila and Virden Valleys under extreme sustained low flow or drought conditions prior to construction of Phase II. Under very long-term sustained optimal flow conditions, the moderate reservoir capacity may require release or non-capture of AWSA water when the reservoir is full. After implementation of Phase II, this risk no longer exists.

Advantages:

- Increased reliability of firm yield in Phase I to the Cliff-Gila Valley when compared to Alternatives 1, 2, 6, and 7, thus decreasing the likelihood of having to forgo available AWSA water due to lack of storage.
- Greenwood Canyon is on the east side of the valley, which is suitable for pumping to Deming, NM. No additional infrastructure (siphon, etc.) would be needed to cross the Gila River Valley.
- The combined capacity of the two reservoirs of 59,000 ac-ft (13,000 ac-ft plus 46,000 ac-ft) provides additional capacity in excess of the target design capacity of 46,000 ac-ft for all three phases.
- The dam abutments and possibly the entire dam at the Greenwood Canyon will likely be founded on rhyolite. The rhyolite foundation would be expected to have a lower permeability and provide a better foundation compared to the conglomerate foundation further upstream in the Cliff-Gila Valley.

Disadvantages:

- Two canyons would be inundated, which is not favorable from a permitting standpoint.
- Requires relocating US Highway 180 around the Greenwood Canyon inundation area at an estimated cost of $55 million.
- Requires relocating an intersection and a small portion State Highway 211 due to the inundation in Greenwood and Pope Canyons.
- May require pumping from Pope Reservoir to the delivery point at the existing Upper Gila diversion location.

Relative Costs:

Phase I Project Cost ~ $490M
Total for all Three Phases ~ $1,100M

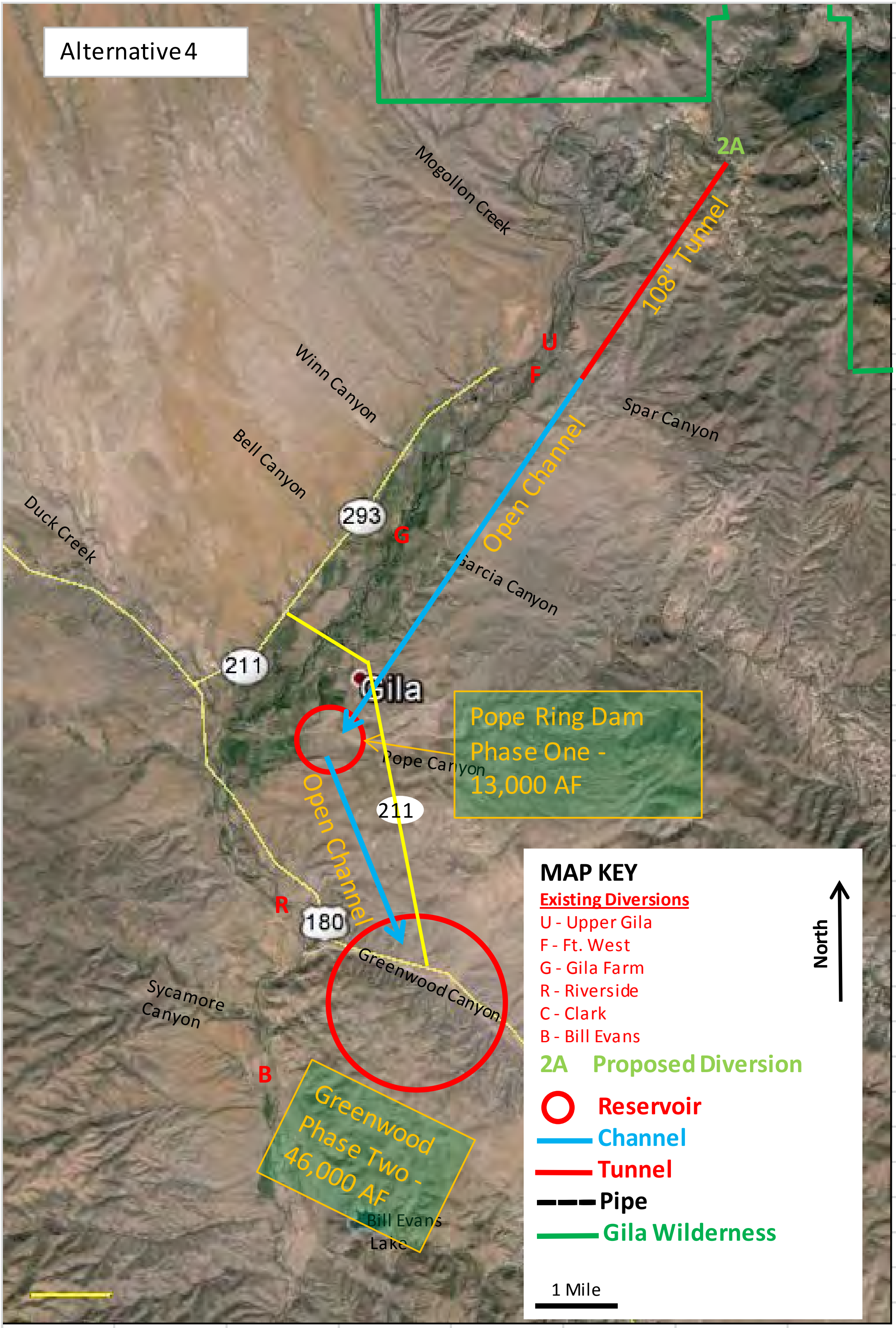

Figure 4-1. Aerial Sketch of Alternative 4. The open channels were drawn as a straight line instead of along the contour.

Alternative 5: Large Garcia/Greenwood Reservoirs

Alternative Description:

This alternative diverts 350 cfs of the AWSA water from the Gila River at proposed diversion site 2A, el. 4736 (see Figure 2). The 350 cfs conveyance consists of a 108-inch diameter buried pipe for a length of 1,000-feet and a 108-inch diameter tunnel for a length of 3 miles to Spar Canyon. At Spar Canyon, the conveyance would change from a tunnel to an open concrete lined channel, which would extend 2.5 miles to a lined water storage reservoir at Garcia Canyon (13,000 ac-ft) for Phase I. The additional storage capacity in Garcia Canyon is obtained by installing a ring dam downstream of the proposed dam.

Phase II consists of an open concrete lined channel conveyance from the Garcia Canyon Reservoir to a lined water storage reservoir (46,000 ac-ft) in Greenwood Canyon. Phase II also includes a pump station and buried pipe from the outlet works in Greenwood Canyon to the delivery point at Upper Gila. Phase III consists of building a pipeline from the Greenwood Reservoir to the City of Deming, NM.

Water would be released from the Garcia Reservoir outlet works for agricultural and environmental uses in Cliff-Gila and Virden Valleys for Phase I. Phase II deliveries would come from the Garcia Reservoir through buried pipe to a pump station and additional buried pipe to the Upper Gila delivery point. Phase III includes pumping water from Greenwood Reservoir over the Continental Divide to the Mimbres Basin for potential future municipal and industrial uses.

Critical Items to Consider:

- Diversion 2A is on USFS land.
- Additional geologic data are needed for the dam locations, especially depth to bedrock and bedrock properties such as permeability.
- Lining costs are a large percentage of the total costs. Need better seepage and hydrology data to better evaluate the need for lining.

Ways to Implement:

- Phase I includes construction of diversion, tunnel, open channel to Garcia Canyon, ring dam for a small reservoir in Garcia Canyon.
- Phase II includes construction of open channel conveyance and siphon from the reservoir in Garcia Canyon to a larger reservoir in Greenwood Canyon.
- Phase III includes construction of a pipeline to Deming, NM.

Potential Risks:

The Phase I capacity of the Garcia Canyon Reservoir may not be sufficient to provide the necessary firm yield to the Cliff-Gila and Virden Valleys under extreme sustained low flow or drought conditions prior to construction of Phase II. Under very long-term sustained optimal flow conditions, the moderate reservoir capacity may require release or non-capture of AWSA water when the reservoir is full. After implementation of Phase II, this risk no longer exists.

Advantages:

- Increased reliability of firm yield in Phase I to the Cliff-Gila Valley when compared to Alternatives 1, 2, 6, and 7, thus decreasing the likelihood of having to forgo available AWSA water due to lack of storage.
- Greenwood Canyon is on the east side of the valley, which is suitable for pumping to Deming, NM. No additional infrastructure (siphon, etc.) would be needed to cross the Gila River Valley.
- The combined capacity of the two reservoirs of 59,000 ac-ft (13,000 ac-ft plus 46,000 ac-ft), provides additional capacity in excess of the target design capacity of 46,000 ac-ft for all three phases.
- The dam abutments and possibly the entire dam at the Greenwood Canyon will likely be founded on rhyolite. The rhyolite foundation would be expected to have a lower permeability and provide a better foundation compared to the conglomerate foundation further upstream in the Cliff-Gila Valley.

Disadvantages:

- Two canyons would be inundated, which is not favorable from a permitting standpoint.
- Requires relocating US Highway 180 around the Greenwood Canyon inundation area at an estimated cost of $55 million.
- Requires relocating an intersection and a small portion State Highway 211 due to the inundation in Greenwood Canyon.
- Requires pumping from Garcia Reservoir to the delivery point at the existing Upper Gila diversion location.

Relative Costs:

Phase I Project Cost ~ $440M
Total for all Three Phases ~ $1,050M

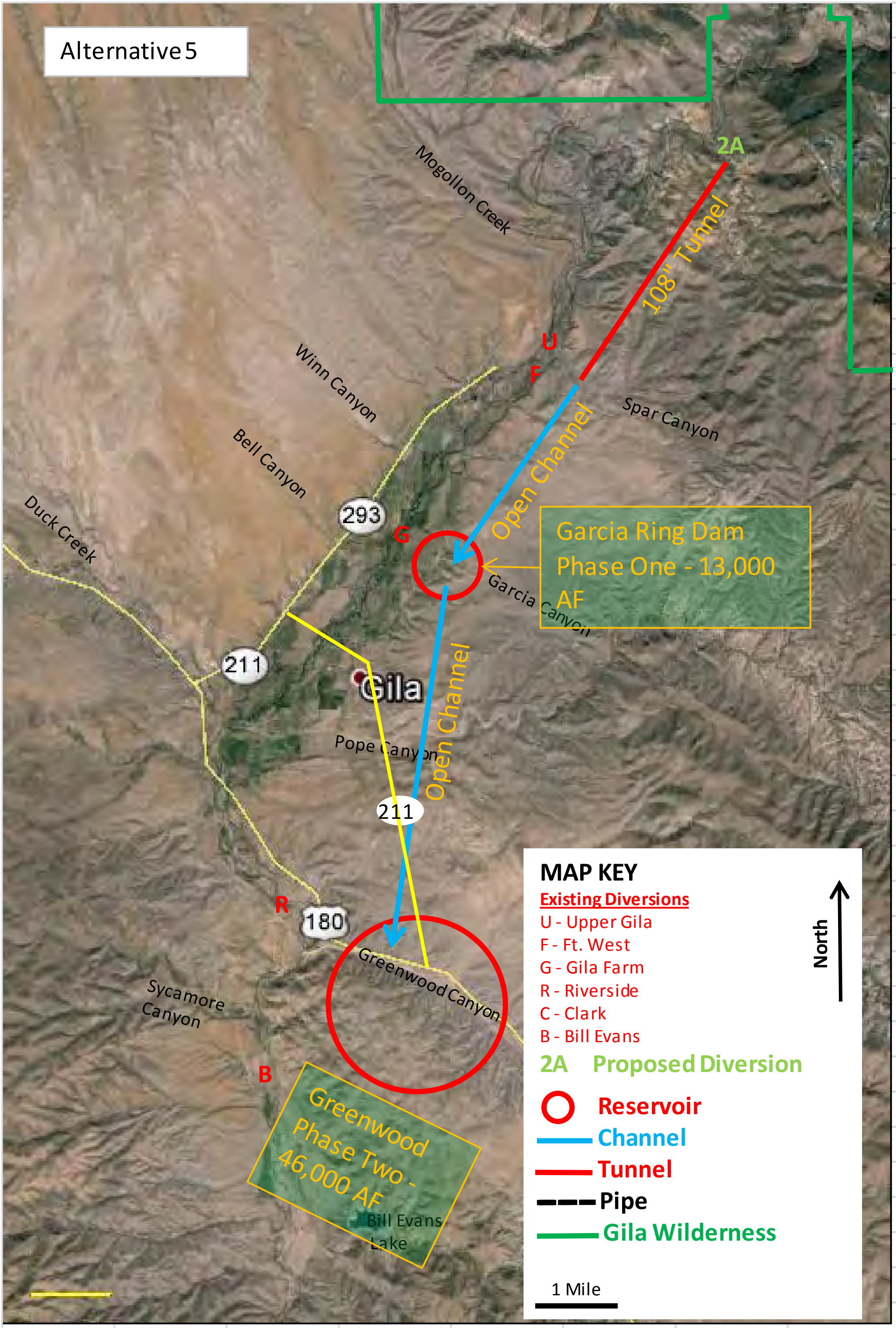

Figure 5-1. Aerial Sketch of Alternative 5. The open channels were drawn as a straight line instead of along the contour.

Alternative 6: Small Spar/Greenwood Reservoirs

Alternative Description:

This alternative diverts 350 cfs of the AWSA water from the Gila River at proposed diversion site 2A, el. 4736 (see Figure 2). The 350 cfs conveyance consists of a 108-inch diameter buried pipe for a length of 1,000-feet and a 108-inch diameter tunnel for a length of 3 miles that outfalls to a small lined storage reservoir in Spar Canyon (1,642 ac-ft) for Phase I.

Phase II consists of an open concrete lined channel conveyance from the Spar Canyon reservoir to a lined water storage reservoir (46,000 ac-ft) in Greenwood Canyon. Phase II also includes a pump station and buried pipe from the outlet works in Greenwood Canyon to the delivery point at Upper Gila. Phase III consists of building a pipeline from the larger Spar reservoir to the City of Deming, NM. See Figure 6-1 for a sketch of this alternative. This alternative is also very similar to an idea (P01-013) developed during the Value Engineering Study by RJH Consultants, Inc. in November 2014.

Water would be released from the Small Spar reservoir outlet works for agricultural and environmental uses in Cliff-Gila and Virden Valleys for Phase I. Phase II deliveries would come from the Greenwood reservoir through buried pipe to a pump station and additional buried pipe to the Upper Gila delivery point. Phase III includes pumping water from Greenwood reservoir over the Continental Divide to the Mimbres Basin for potential future municipal and industrial uses.

Critical Items to Consider:

- Additional evaluation is needed to determine the alignment and cost of the pipeline to Deming, NM from Greenwood.
- About 10 percent of the Small Spar Reservoir would be on US Forest Service land.
- Diversion 2A is on USFS land.
- Additional geologic data are needed for the dam locations, especially depth to bedrock and bedrock properties such as permeability.
- Lining costs are a large percentage of the total costs. Need better seepage and hydrology data to better evaluate the need for lining.

Ways to Implement:

- Phase I includes construction of diversion, tunnel, and a small reservoir in lower Spar Canyon.
- Phase II includes construction of open channel conveyance and siphon from the reservoir in Spar Canyon to a larger reservoir in Greenwood Canyon.
- Phase III includes construction of a pipeline to Deming, NM.

Potential Risks:

The capacity of Small Spar Reservoir most likely will not provide the necessary firm yield to the Cliff-Gila and Virden Valleys under sustained low flow or drought conditions. Under sustained optimal flow conditions, the low reservoir capacity may require release or non-capture of AWSA water when the reservoir is full. After implementation of Phase II, this risk no longer exists.

Advantages:

- The location of Spar canyon is very suitable to release water from the reservoir(s) for agricultural and environmental uses in the Cliff-Gila Valley.
- Greenwood Canyon is on the east side of the valley, which is suitable for pumping to Deming, NM. No additional infrastructure (siphon, etc.) would be needed to cross the Gila River valley.
- Small Spar could be used as a settling basin for the turbulent water that is being diverted from the river.
- The dam abutments and possibly the entire dam at the Greenwood canyon will likely be founded on rhyolite. The rhyolite foundation would be expected to have a lower permeability and provide a better foundation compared to the conglomerate foundation further upstream in the Cliff-Gila Valley.
- The combined capacity of the two reservoirs of 47,642 ac-ft (1,642 ac-ft plus 46,000 ac-ft), provides additional capacity just above the target design capacity of 46,000 ac-ft for all three phases.

Disadvantages:

- Two canyons would be inundated, which is not favorable from a permitting standpoint.
- 1,642 ac-ft capacity of Spar does not meet the target of 13,000 ac-ft for Phase I.
- Requires relocating US Highway 180 around the Greenwood Canyon inundation area at an estimated cost of $55 million.
- Requires relocating an intersection and a small portion State Highway 211 due to the inundation in Greenwood Canyon.
- Requires pumping from Greenwood reservoir to the delivery point at the existing Upper Gila diversion location.

Relative Costs:

Phase I Project Cost ~ $240M
Total for all Three Phases ~ $1,050M

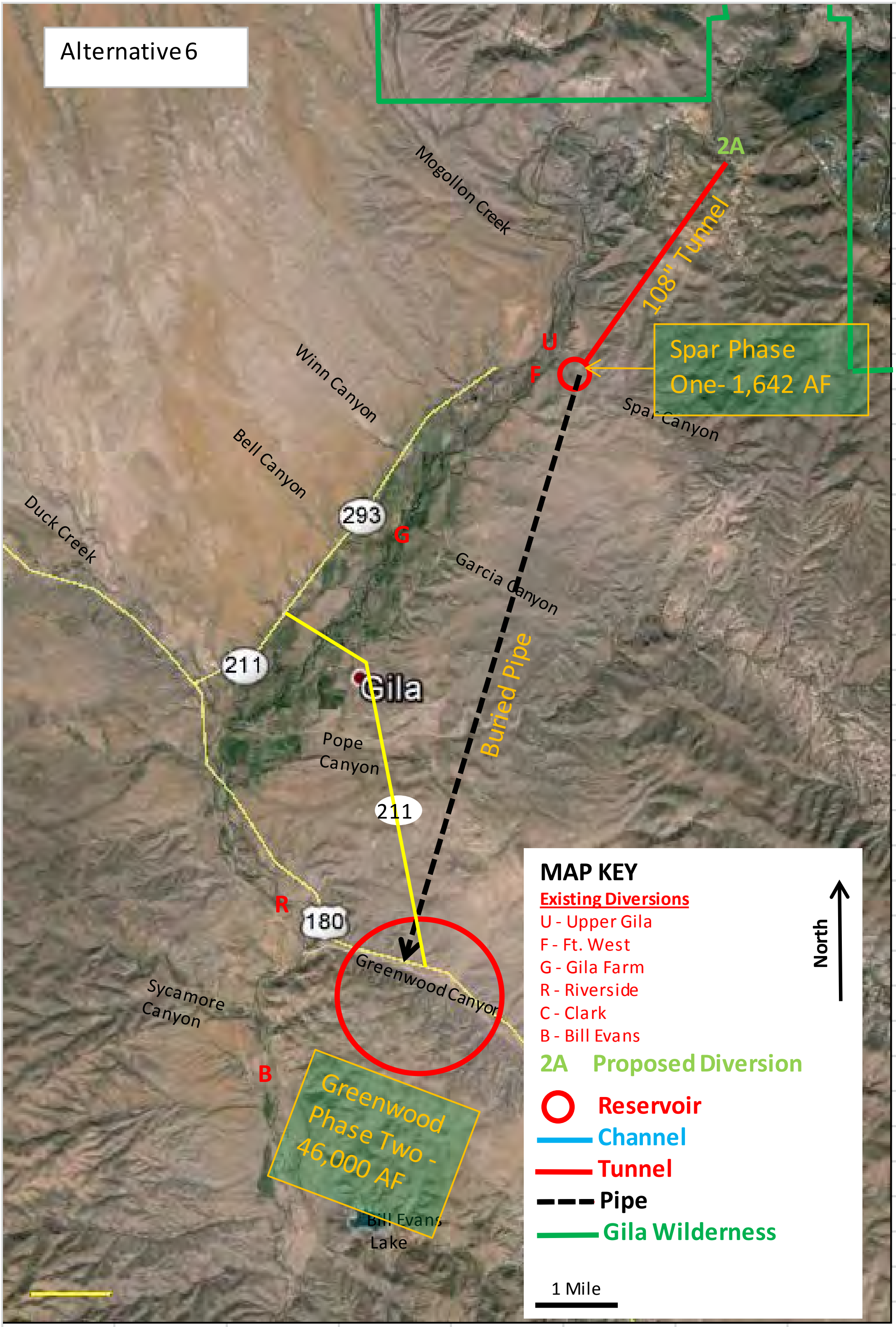

Figure 6-1. Aerial Sketch of Alternative 6. The open channels were drawn as a straight line instead of along the contour.

Alternative 7: Original Winn/Greenwood Reservoirs

Alternative Description:

Under this alternative, up to 350 cfs of the AWSA water would be diverted at Diversion 1, elevation 4668 (see Figure 2), and conveyed through an open concrete-lined channel to Winn Canyon. The capacity of this reservoir would be 2,750 ac-ft. In Phase II, water would be conveyed via open concrete-lined channel to a siphon under the Gila River to Greenwood Canyon with a storage capacity of 26,000 ac-ft. See Figure 7-1 for a sketch of this alternative.

Water would be released from the original Winn reservoir outlet works for agricultural and environmental uses in Cliff-Gila and Virden Valleys for Phase I. Phase II deliveries would come from the Greenwood reservoir through buried pipe to a pump station and additional buried pipe to the Upper Gila delivery point. Phase III includes pumping water from Greenwood reservoir over the Continental Divide to the Mimbres Basin for potential future municipal and industrial uses.

Critical Items to Consider:

- Diversion 1 and part of the upper conveyance line are located on a land that is jointly owned by The Nature Conservancy (TNC) and State of New Mexico, pursuant to the Natural Lands Protection Act (NLPA). The act provided means for a public-private partnership between the State and TNC for the protection of "unique and ecologically significant lands" in New Mexico. The land management plan is part of TNC's "Gila Riparian Preserve" program for education, research, and preservation, which was approved by the State. TNC manages the property, and co-owns an undivided interest in the property with the State.
- Additional geologic data are needed for the dam locations, especially depth to bedrock and bedrock properties such as permeability.
- Lining costs are a large percentage of the total costs. Need better seepage and hydrology data to better define the need for lining.

Ways to Implement:

- Phase I includes construction of diversion, open channel to Winn Canyon, and a small reservoir in Winn Canyon.
- Phase II includes construction of open channel conveyance and siphon from the reservoir in Winn Canyon to a larger reservoir in Greenwood Canyon.
- Phase III includes construction of a pipeline to Deming, NM.

Potential Risks:

The Phase I capacity of Winn Canyon Reservoir most likely will not provide the necessary firm yield to the Cliff-Gila and Virden Valleys under sustained low flow or drought conditions. Under sustained optimal flow conditions, the low / moderate reservoir capacity may require release or non-capture of AWSA water when the reservoir is full. After implementation of Phase II, this risk no longer exists.

Advantages:

- Greenwood Canyon is on the east side of the valley, which is suitable for pumping to Deming, NM. No additional infrastructure (siphon, etc.) would be needed to cross the Gila River Valley.
- The dam abutments and possibly the entire dam at the Greenwood Canyon will likely be founded on rhyolite. The rhyolite foundation would be expected to have a lower permeability and provide a better foundation compared to the conglomerate foundation further upstream in the Cliff-Gila Valley.

Disadvantages:

- Requires crossing the Gila River in two locations: one in Phase I to divert water to Winn Canyon Reservoir and the other in Phase II to deliver water to Greenwood.
- Two canyons would be inundated on both sides of the Gila Valley, which is not favorable from a permitting standpoint.
- 2,750 ac-ft capacity of Winn does not meet the target of 13,000 ac-ft for Phase I.
- 28,750 ac-ft capacity of Winn and Greenwood does not meet the target of 46,000 ac-ft for all three phases.
- Requires relocating US Highway 180 around the Greenwood Canyon inundation area at an estimated cost of $55 million.
- Requires relocating an intersection and a small portion State Highway 211 due to the inundation in Greenwood Canyon.
- Requires pumping from Greenwood reservoir to the delivery point at the existing Upper Gila diversion location.

Relative Costs:

Phase I Project Cost ~ $125M
Total for all Three Phases ~ $700M

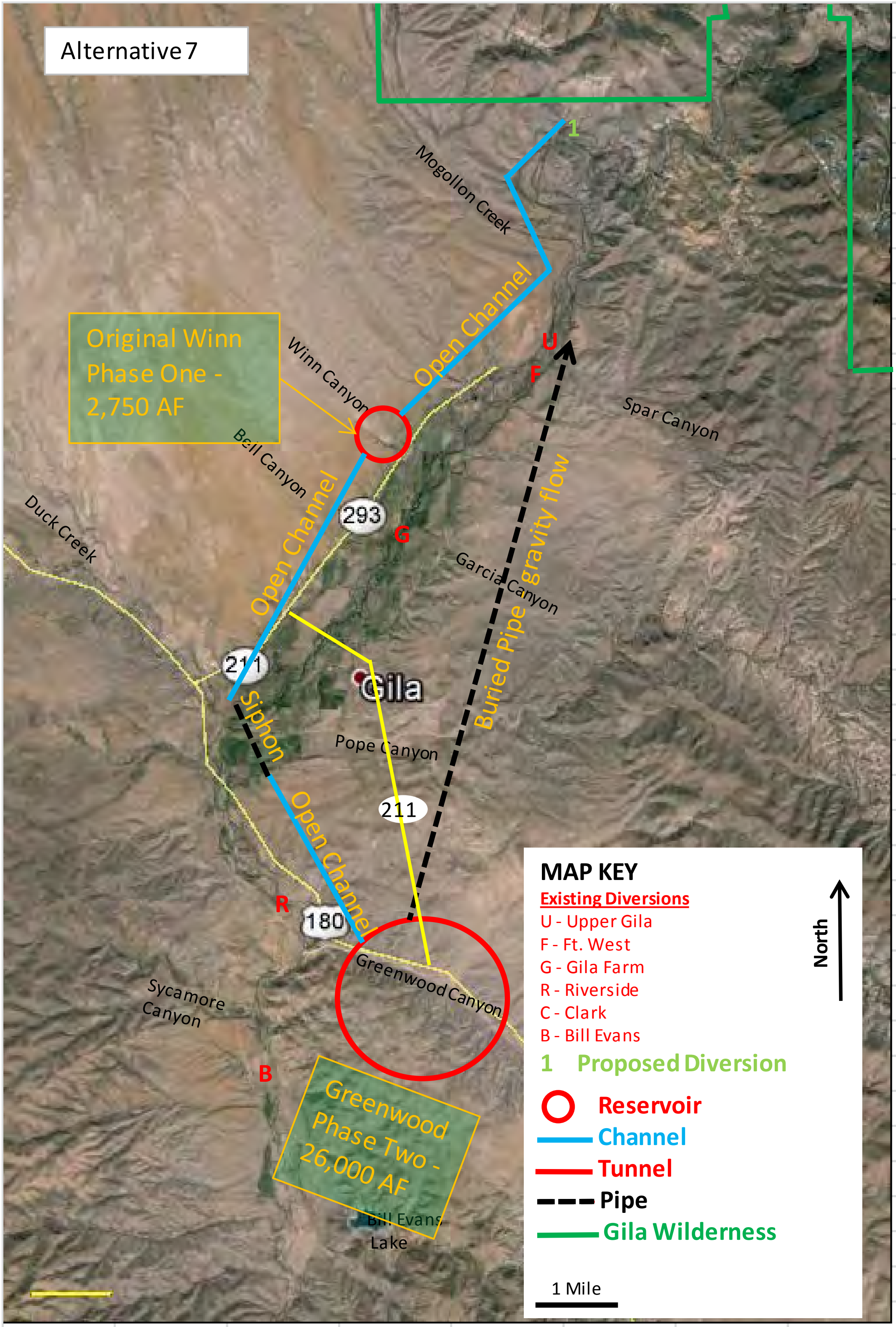

Figure 7-1. Aerial Sketch of Alternative 7. The open channels were drawn as a straight line instead of along the contour.

Alternative 8: Small Greenwood/Greenwood Reservoirs

Alternative Description:

This alternative diverts 350 cfs of the AWSA water from the Gila River at proposed diversion site 2A, el. 4736 (see Figure 2). The 350 cfs conveyance consists of a 108-inch diameter buried pipe for a length of 1,000-feet and a 108-inch diameter tunnel for a length of 3 miles to Spar Canyon.   At Spar Canyon, the conveyance would change from a tunnel to an open concrete lined channel, which would extend to a lined water storage reservoir at Greenwood Canyon (15,000 ac-ft) for Phase I. Phase I also includes a pump station and buried pipe from the outlet works in Greenwood Canyon to the water delivery point at Upper Gila.

Phase II consists of a dam raise, expansion of the outlet works and spillway, and additional lining of the reservoir to get a total of 46,000 ac-ft of storage. Phase III consists of building a pipeline from the Greenwood reservoir to the City of Deming, NM. See Figure 8-1 for a sketch of this Alternative.

Water would be conveyed from the small Greenwood reservoir through a buried pipe to a pump station and more buried pipe for agricultural and environmental uses in Cliff-Gila and Virden Valleys for Phase I. Phase III includes pumping water from Greenwood reservoir over the Continental Divide to the Mimbres Basin for potential future municipal and industrial uses.

The Phase I dam will have a dam crest elevation of about 4605, contain about 1.4 million cubic yards of fill, and will store about 15,000 acre-ft. of water. In Phase I, the outlet works and spillway will be able to accommodate reservoir expansion in Phase II. The dam design will also accommodate a Phase 2 dam raise and reservoir expansion. Raising the dam in Phase II to a crest El. 4660 will contain about 3.2 million yards of fill and will store about 46,000 acre-ft. and provide water to Deming, NM.

Critical Items to Consider:

- Diversion 2A is on USFS land.
- Additional geologic data are needed for the dam location, especially depth to bedrock and bedrock properties such as permeability.
- The dam design can be optimized to reduce costs and accommodate Phase II expansion.
- Lining costs are a large percentage of the total costs. Need better seepage and hydrology data to better define the need for lining.

Ways to Implement:

- Phase I includes construction of diversion, tunnel, open channel and siphon to Greenwood Canyon, and a small reservoir in Greenwood Canyon.
- Phase II includes raising the dam in Greenwood Canyon to create a larger reservoir.
- Phase III includes construction of a pipeline to Deming, NM.

Potential Risks:

The Phase I capacity of the Greenwood Canyon Reservoir may not be sufficient to provide the necessary firm yield to the Cliff-Gila and Virden Valleys under extreme sustained low flow or drought conditions prior to construction of Phase II. Under very long-term sustained optimal flow conditions, the moderate reservoir capacity may require release or non-capture of AWSA water when the reservoir is full. After implementation of Phase II, this risk no longer exists.

More design details are needed to determine the best ways to phase construction of the spillway and outlet works.

Advantages:

- Only one canyon would be inundated, which is favorable from a permitting standpoint.
- Greenwood Canyon is on the east side of the valley, which is suitable for pumping to Deming, NM. No additional infrastructure (siphon, etc.) would be needed to cross the Gila River valley.
- Increased reliability of firm yield in Phase I to the Cliff-Gila Valley when compared to Alternatives 1, 2, 6, and 7, thus decreasing the likelihood of having to forego available AWSA water due to lack of storage.
- The dam abutments and possibly the entire dam at the Greenwood canyon will likely be founded on rhyolite. The rhyolite foundation would be expected to have a lower permeability and provide a better foundation compared to the conglomerate foundation further upstream in the Cliff-Gila Valley.

Disadvantages:

- Additional cost for pumping water deliveries back up the Cliff-Gila Valley.
- Requires relocating US Highway 180 around the Greenwood Canyon inundation area at an estimated cost of $55 million.
- Requires overbuilding the dam and appurtenant structures (outlet works and spillway) to accommodate an expansion for Phase II.
- Requires relocating an intersection and a small portion State Highway 211 due to the inundation in Greenwood Canyon.
- Requires pumping from Greenwood reservoir to the delivery point at the existing Upper Gila diversion location.

Relative Costs:

Phase I Project Cost ~ $490M
Total for all Three Phases ~ $850M

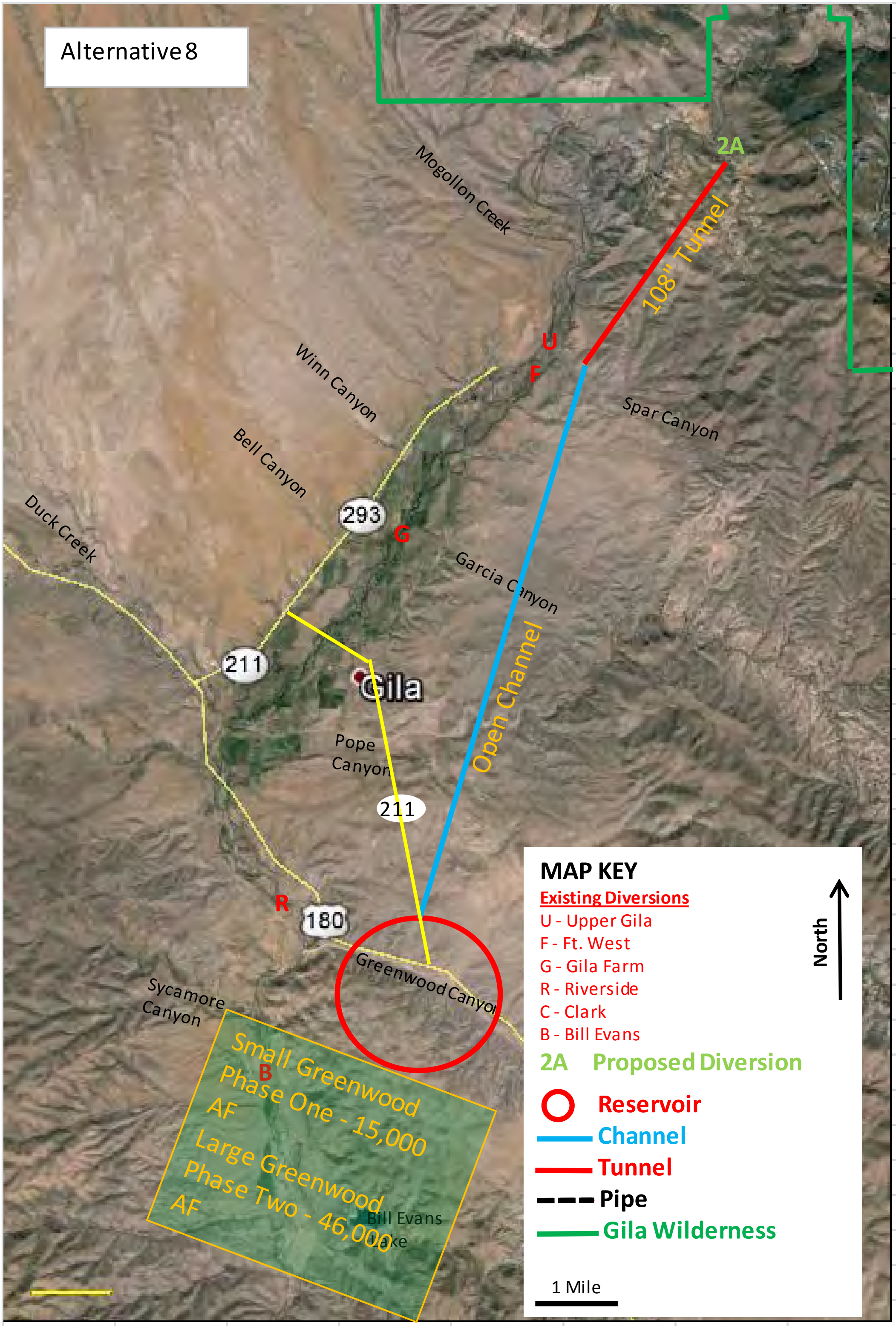

Figure 8-1. Aerial Sketch of Alternative 8. The open channels were drawn as a straight line instead of along the contour.

Alternative 9A: Small Winn/Large Winn Reservoirs

Alternative Description:

This alternative diverts 350 cfs of the AWSA water from the Gila River at proposed diversion site 2A, el. 4736 (see Figure 2). The 350 cfs conveyance consists of a 108-inch diameter buried pipe for a length of 1,000-feet, a 108-inch diameter tunnel for a length of approximately 1.9 miles, 1.4 miles of 108-inch diameter steel lined siphon under the Gila River, and 3.8 miles of open concrete lined channel to Winn Canyon. A longer embankment dam, as compared to the Winn dam proposed in Reclamation's Appraisal Report, would be constructed to obtain 13,000 ac-ft of storage.

Phase II consists of a dam raise, expansion of the outlet works and spillway, and additional lining of the reservoir to obtain 46,000 ac-ft of storage. Phase III consists of building a pipeline, with a siphon across the Gila River, from the Winn reservoir to the City of Deming, NM. See Figure 9A-1 for a sketch of this Alternative.

Water would be delivered from the small and/or large Winn reservoirs for agricultural and environmental uses in Cliff-Gila and Virden Valleys for Phase I and II. Phase III includes pumping water from Winn reservoir over the Continental Divide to the Mimbres Basin for potential future municipal and industrial uses.

Critical Items to Consider:

- Diversion 2A is on USFS land.
- Additional geologic data are needed for the dam location, especially depth to bedrock and bedrock properties such as permeability.
- The dam design can be optimized to reduce costs and accommodate Phase II expansion.
- Lining costs are a large percentage of the total costs. Need better seepage and hydrology data to better evaluate the need for lining.

Ways to Implement:

- Phase I includes construction of diversion, tunnel, siphon, and open channel to Winn Canyon, a longer embankment dam (as compared to the Winn dam proposed in Reclamation's Appraisal Report, for a reservoir in Winn Canyon).
- Phase II includes raising the dam in Winn Canyon to create a larger reservoir.
- Phase III includes construction of a pipeline to Deming, NM.

Potential Risks:

The Phase I capacity of the Winn Canyon Reservoir may not be sufficient to provide the necessary firm yield to the Cliff-Gila and Virden Valleys under extreme sustained low flow or drought conditions prior to construction of Phase II. Under very long-term sustained optimal flow conditions, the moderate reservoir capacity may require release or non-capture of AWSA water when the reservoir is full. After implementation of Phase II, this risk no longer exists.

More design details are needed to determine the best ways to phase construction of the spillway and outlet works.

Advantages:

- Only one canyon would be inundated, which is favorable from a permitting standpoint.
- Increased reliability of firm yield in Phase I to the Cliff-Gila Valley when compared to Alternatives 1, 2, 6, and 7, thus decreasing the likelihood of having to forgo available AWSA water due to lack of storage.

Disadvantages:

- Requires crossing the Gila River in two locations: one in Phase I to divert water to Winn Canyon Reservoir and the other in Phase III to deliver water to Deming, NM.
- Requires overbuilding the dam and appurtenant structures (outlet works and spillway) to accommodate an expansion for Phase II.

Relative Costs:

Phase I Project Cost ~ $360M
Total for all Three Phases ~ $800M

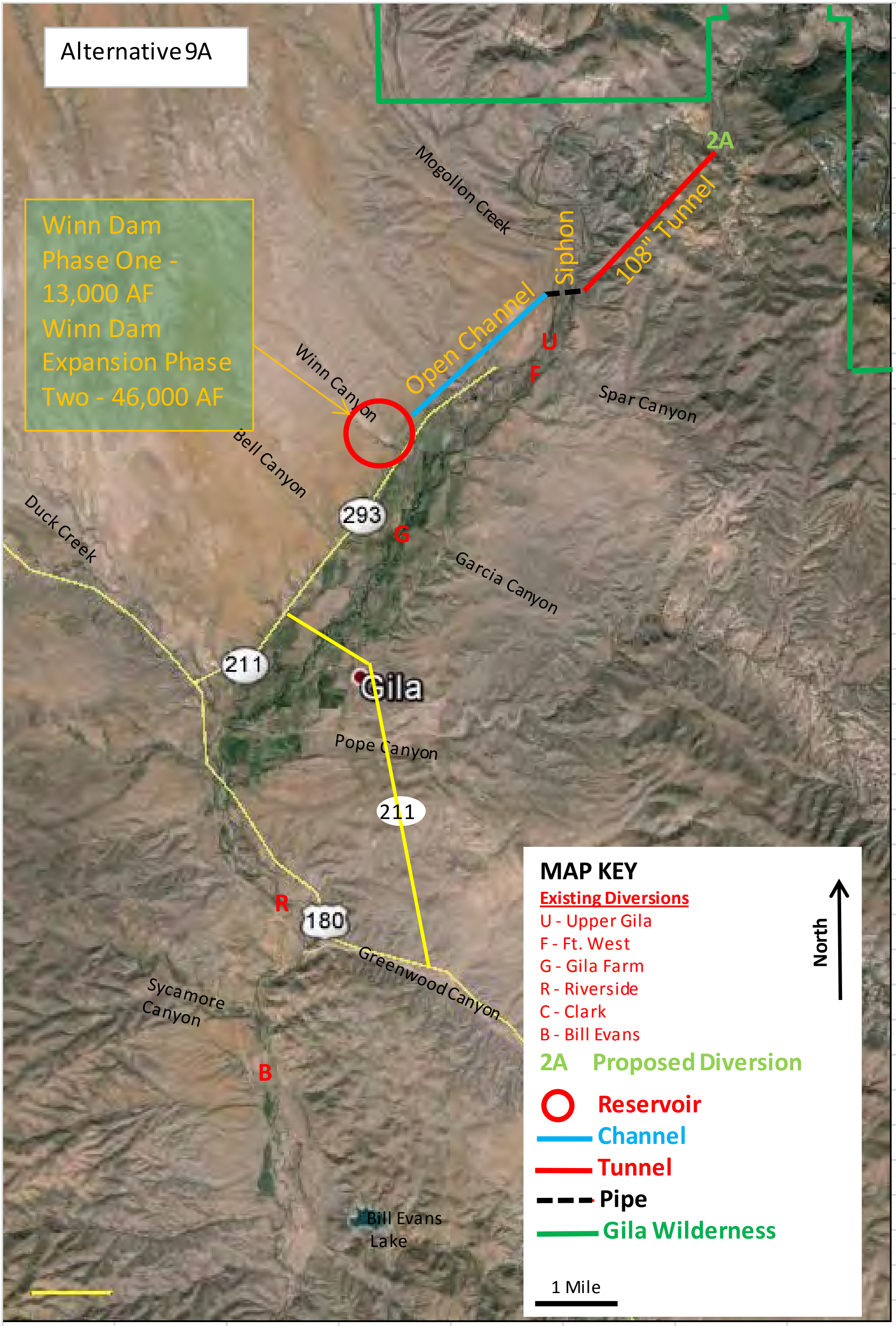

Figure 9A-1. Aerial Sketch of Alternative 9A. The open channels were drawn as a straight line instead of along the contour.

Alternative 9B: Small Bell/Large Bell Reservoirs

Alternative Description:

This alternative diverts 350 cfs of the AWSA water from the Gila River at proposed diversion site 2A, el. 4736 (see Figure 2). The 350 cfs conveyance consists of a 108-inch diameter buried pipe for a length of 1,000-feet, a 108-inch diameter tunnel for a length of approximately 1.9 miles, 1.4 miles of 108-inch diameter steel lined siphon under the Gila River, and 6.1 miles of open concrete lined channel to Bell Canyon. An embankment dam would be constructed to obtain 13,000 ac-ft of storage.

Phase II consists of a dam raise, expansion of the outlet works and spillway, and additional lining of the reservoir to get 46,000 ac-ft of storage. Phase III consists of building a pipeline with a siphon from the Bell reservoir to the City of Deming, NM. The estimated cost of Phase I is approximately $410 million and the estimated cost of all three phases is approximately $910 million. See Figure 9B-1 for a sketch of this Alternative.

Water would be delivered from the small and / or large Bell reservoir for agricultural and environmental uses in Cliff-Gila and Virden Valleys for Phase I and Two. Phase III includes pumping water from Winn reservoir over the Continental Divide to the Mimbres Basin for potential future municipal and industrial uses.

Critical Items to Consider:

- Diversion 2A is on USFS land.
- Additional geologic data are needed for the dam location, especially depth to bedrock and bedrock properties such as permeability.
- The dam design can be optimized to reduce costs and accommodate Phase II expansion.
- Lining costs are a large percentage of the total costs. Need better seepage and hydrology data to better evaluate the need for lining.

Ways to Implement:

- Phase I includes construction of diversion, tunnel, siphon, and open channel to Bell Canyon, and an embankment dam for a reservoir in Bell Canyon.
- Phase II includes raising the dam in Bell Canyon to create a larger reservoir.
- Phase III includes construction of a pipeline to Deming, NM.

Potential Risks:

The Phase I capacity of the Bell Canyon Reservoir may not be sufficient to provide the necessary firm yield to the Cliff-Gila and Virden Valleys under extreme sustained low flow or drought conditions prior to construction of Phase II. Under very long-term sustained optimal flow conditions, the moderate reservoir capacity may require release or non-capture of AWSA water when the reservoir is full. After implementation of Phase II, this risk no longer exists.

More design details are needed to determine the best ways to phase construction of the spillway and outlet works.

May require pumping from Winn reservoir to the delivery point at the existing Upper Gila diversion location.

Advantages:

- Only one canyon would be inundated, which is favorable from a permitting standpoint.
- Increased reliability of firm yield in Phase I to the Cliff-Gila Valley when compared to Alternatives 1, 2, 6, and 7, thus decreasing the likelihood of having to forgo available AWSA water due to lack of storage.

Disadvantages:

- Requires crossing the Gila River in two locations: one in Phase I to divert water to Bell Canyon Reservoir and the other in Phase III to deliver water to Deming, NM.
- Requires overbuilding the dam and appurtenant structures (outlet works and spillway) to accommodate an expansion for Phase II.

Relative Costs:

Phase I Project Cost ~ $410M
Total for all Three Phases ~ $910M

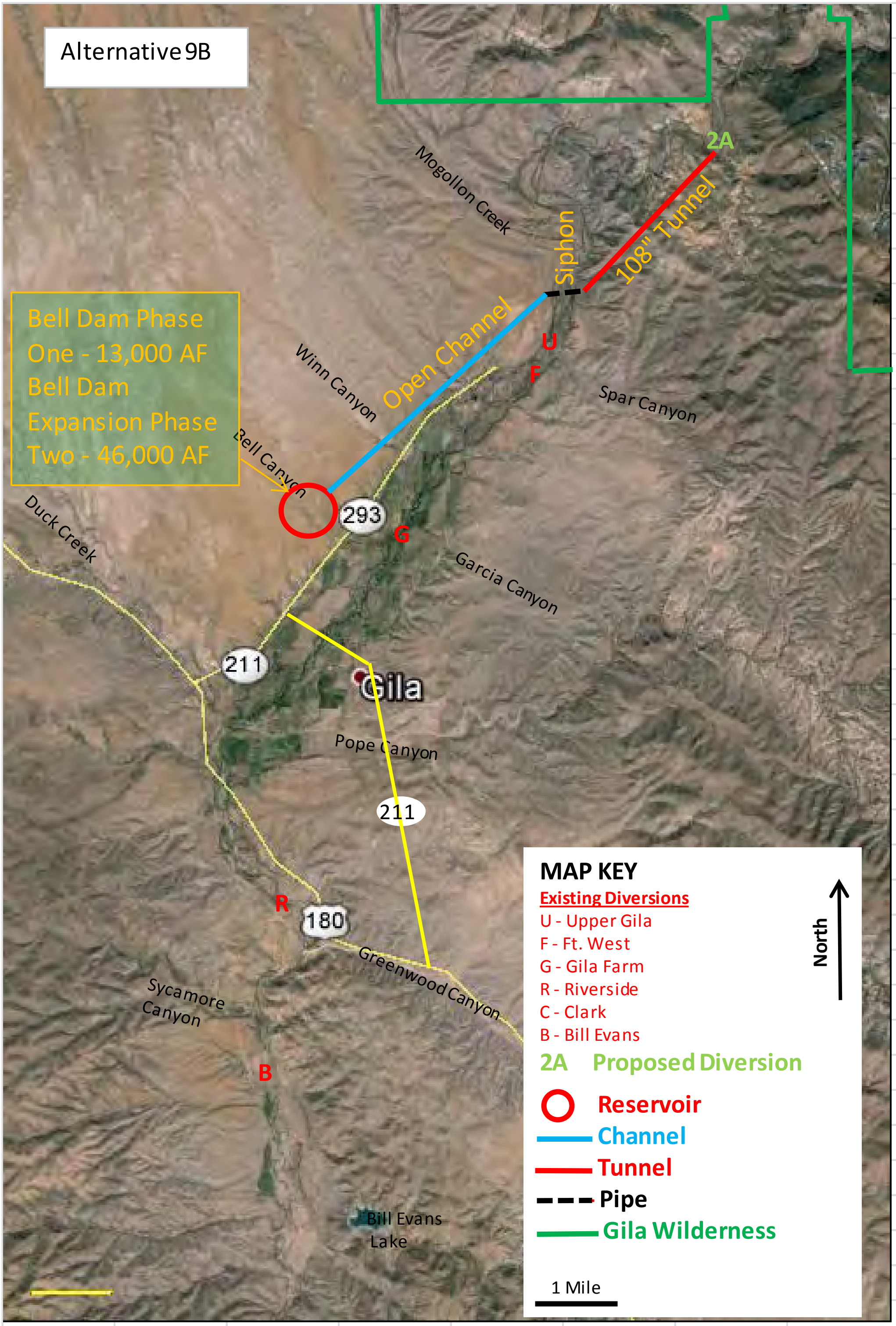

Figure 9B-1. Aerial Sketch of Alternative 9B. The open channels were drawn as a straight line instead of along the contour.

Alternative 9C: Small Winn/Greenwood Reservoirs

Alternative Description:

This alternative diverts 350 cfs of the AWSA water from the Gila River at proposed diversion site 2A, el. 4736 (see Figure 2). The 350 cfs conveyance consists of a 108-inch diameter buried pipe for a length of 1,000-feet, a 108-inch diameter tunnel for a length of 1.9 miles, 1.4 miles of 108-inch diameter steel lined siphon under the Gila River, and 3.8 miles of open concrete lined channel to Winn Canyon. A longer embankment dam, as compared to the Winn Dam proposed in Reclamation's Appraisal Report, would be constructed to obtain 13,000 ac-ft of storage.

Phase II consists of an open concrete lined channel conveyance and siphon to a lined water storage reservoir (46,000 ac-ft) in Greenwood Canyon. Phase II also includes a pump station and buried pipe from the outlet works in Greenwood Canyon to the delivery point at Upper Gila. Phase III consists of building a pipeline with a siphon from the Greenwood reservoir to the City of Deming, NM. See Figure 9C-1 for a sketch of this Alternative.

Water would be released from the small Winn reservoir outlet works for agricultural and environmental uses in Cliff-Gila and Virden Valleys for Phase I. Phase II deliveries would come from the Winn reservoir through buried pipe to a pump station and additional buried pipe to the Upper Gila delivery point. Phase III includes pumping water from Greenwood reservoir over the Continental Divide to the Mimbres Basin for potential future municipal and industrial uses.

Critical Items to Consider:

- Diversion 2A is on USFS land.
- Additional geologic data are needed for the dam locations, especially depth to bedrock and bedrock properties such as permeability.
- Lining costs are a large percentage of the total costs. Need better seepage and hydrology data to better evaluate the need for lining.

Ways to Implement:

- Phase I includes construction of diversion, tunnel, siphon, and open channel to Winn Canyon, and a dam for a reservoir in Winn Canyon.
- Phase II includes construction of open channel conveyance and siphon from the reservoir in Winn Canyon to a larger reservoir in Greenwood Canyon.
- Phase III includes construction of a pipeline to Deming, NM.

Potential Risks:

The Phase I capacity of the Winn Canyon Reservoir may not be sufficient to provide the necessary firm yield to the Cliff-Gila and Virden Valleys under extreme sustained low flow or drought conditions prior to construction of Phase II. Under very long-term sustained optimal flow conditions, the moderate reservoir capacity may require release or non-capture of AWSA water when the reservoir is full. After implementation of Phase II, this risk no longer exists.

Advantages:

- Greenwood Canyon is on the east side of the valley, which is suitable for pumping to Deming, NM. No additional infrastructure (siphon, etc.) would be needed to cross the Gila River Valley.
- Increased reliability of firm yield in Phase I to the Cliff-Gila Valley when compared to Alternatives 1, 2, 6, and 7, thus decreasing the likelihood of having to forgo available AWSA water due to lack of storage.
- The combined capacity of the two reservoirs of 59,000 ac-ft (13,000 ac-ft plus 46,000 ac-ft), provides additional capacity in excess of the target design capacity of 46,000 ac-ft for all three phases.
- The dam abutments and possibly the entire dam at the Greenwood Canyon will likely be founded on rhyolite. The rhyolite foundation would be expected to have a lower permeability and provide a better foundation compared to the conglomerate foundation further upstream in the Cliff-Gila Valley.

Disadvantages:

- Requires crossing the Gila River in two locations: one in Phase I to divert water to Winn Canyon Reservoir and the other in Phase II to deliver water to Greenwood.
- Two canyons would be inundated on both sides of the Gila Valley, which is not favorable from a permitting standpoint.
- Requires relocating US Highway 180 around the Greenwood Canyon inundation area at an estimated cost of $55 million.
- Requires relocating an intersection and a small portion State Highway 211 due to the inundation in Greenwood Canyon.
- Requires pumping from Winn reservoir to the delivery point at the existing Upper Gila diversion location.

Relative Costs:

Phase I Project Cost ~ $360M
Total for all Three Phases ~ $1,050M

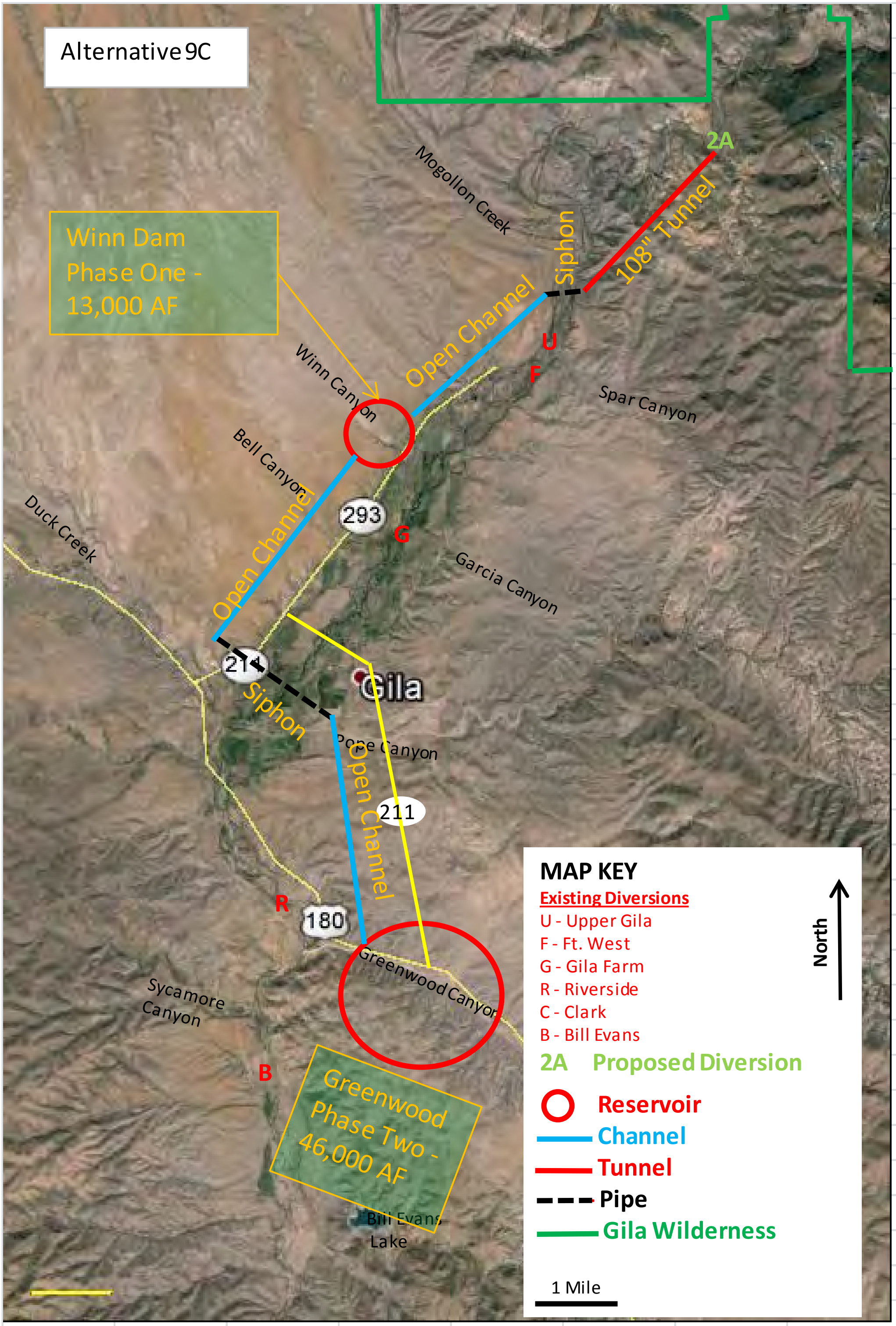

Figure 9C-1. Aerial Sketch of Alternative 9C. The open channels were drawn as a straight line instead of along the contour.

Alternative 9D: Small Bell/Greenwood Reservoirs

Alternative Description:

This alternative diverts 350 cfs of the AWSA water from the Gila River at proposed diversion site 2A, el. 4736 (see Figure 2). The 350 cfs conveyance consists of a 108-inch diameter buried pipe for a length of 1,000-feet, a 108-inch diameter tunnel for a length of 1.9 miles, 1.4 miles of 108-inch diameter steel lined siphon under the Gila River, and 6.1 miles of open concrete lined channel to Bell Canyon. An embankment dam would be constructed to obtain 13,000 ac-ft of storage. Phase II consists of an open concrete lined channel conveyance and siphon to a lined water storage reservoir (46,000 ac-ft) in Greenwood Canyon.

Phase II also includes a pump station and buried pipe from the outlet works in Greenwood Canyon to the delivery point at Upper Gila. Phase III consists of building a pipeline with a siphon from the Greenwood reservoir to the City of Deming, NM. The estimated cost of Phase I is approximately $410 million and the estimated cost of all three phases is approximately $1,100 million. See Figure 9D-1 for a sketch of this Alternative.

Water would be released from the small Bell reservoir outlet works for agricultural and environmental uses in Cliff-Gila and Virden Valleys for Phase I. Phase II deliveries would come from the Bell reservoir through buried pipe to a pump station and additional buried pipe to the Upper Gila delivery point. Phase III includes pumping water from Greenwood reservoir over the Continental Divide to the Mimbres Basin for potential future municipal and industrial uses.

Critical Items to Consider:

- Diversion 2A is on USFS land.
- Additional geologic data are needed for the dam locations, especially depth to bedrock and bedrock properties such as permeability.
- Lining costs are a large percentage of the total costs. Need better seepage and hydrology data to better evaluate the need for lining.

Ways to Implement:

- Phase I includes construction of diversion, tunnel, siphon, and open channel to Bell Canyon, and a dam for a reservoir in Bell Canyon.
- Phase II includes construction of open channel conveyance and siphon from the reservoir in Bell Canyon to a larger reservoir in Greenwood Canyon.
- Phase III includes construction of a pipeline to Deming, NM.

Potential Risks:

The Phase I capacity of the Bell Canyon Reservoir may not be sufficient to provide the necessary firm yield to the Cliff-Gila and Virden Valleys under extreme sustained low flow or drought conditions prior to construction of Phase II. Under very long-term sustained optimal flow conditions, the moderate reservoir capacity may require release or non-capture of AWSA water when the reservoir is full. After implementation of Phase II, this risk no longer exists.

Advantages:

- Greenwood Canyon is on the east side of the valley, which is suitable for pumping to Deming, NM. No additional infrastructure (siphon, etc.) would be needed to cross the Gila River Valley.
- Increased reliability of firm yield in Phase I to the Cliff-Gila Valley when compared to Alternatives 1, 2, 6, and 7, thus decreasing the likelihood of having to forgo available AWSA water due to lack of storage.
- The combined capacity of the two reservoirs of 59,000 ac-ft (13,000 ac-ft plus 46,000 ac-ft), provides additional capacity in excess of the target design capacity of 46,000 ac-ft for all three phases.
- The dam abutments and possibly the entire dam at the Greenwood canyon will likely be founded on rhyolite. The rhyolite foundation would be expected to have a lower permeability and provide a better foundation compared to the conglomerate foundation further upstream in the Cliff-Gila Valley.

Disadvantages:

- Requires crossing the Gila River in two locations: one in Phase I to divert water to Bell Canyon Reservoir and the other in Phase II to deliver water to Greenwood.
- Two canyons would be inundated on both sides of the Gila Valley, which is not favorable from a permitting standpoint.
- Requires relocating US Highway 180 around the Greenwood Canyon inundation area at an estimated cost of $55 million.
- Requires relocating an intersection and a small portion State Highway 211 due to the inundation in Greenwood Canyon.
- Requires pumping from Bell reservoir to the delivery point at the existing Upper Gila diversion location.

Relative Costs:

Phase I Project Cost ~ $410M
Total for all Three Phases ~ $1,100M

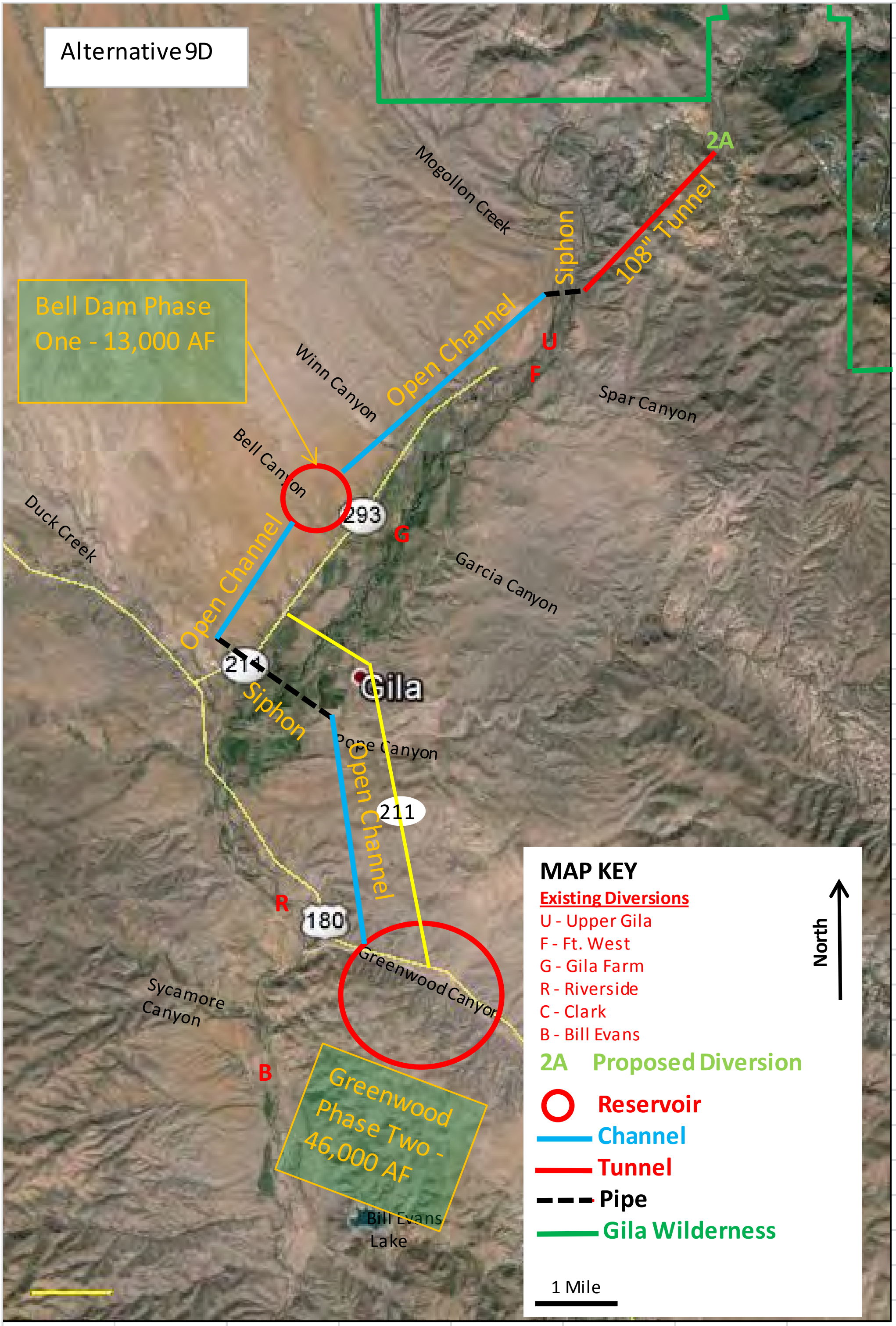

Figure 9D-1. Aerial Sketch of Alternative 9D. The open channels were drawn as a straight line instead of along the contour.

Design Considerations

Design Consideration 1 – Greenwood versus Sycamore for Large Storage Reservoir

The Team evaluated the dam sites at the lower end of both Sycamore Canyon and Greenwood Canyon. Sycamore Canyon has greater potential for environmental impacts related to negative effects on riparian habitat and potentially the yellow-billed cuckoo, which is Federally listed as endangered. The Sycamore Canyon site will also require the relocation of at least one resident in the canyon and longer conveyance from the diversion off the Gila River. If Phase III of the project is completed, the Sycamore Canyon site will require additional infrastructure (siphon, etc.) and a longer conveyance to pump water to Deming, NM. The Greenwood Canyon site has some complexities due to the relocation of US Highway 180 and State Highway 211. However, the Greenwood Canyon site has no residents to relocate, potentially fewer environmental impacts, and results in a more efficient dam site that provides a smaller storage cost per acre-ft. of storage. The Greenwood Canyon site will also provide a better dam foundation in the rhyolite as compared to the Sycamore Canyon site that will likely be founded on conglomerate. Therefore, the Greenwood Canyon site was favored by the Team as compared to the Sycamore Canyon site.

Design Consideration 2 – Dam Safety Issues

The Team assumed that all storage facilities would be designed and constructed according to modern standards and practices. The Team recognizes that all storage facilities should meet the Public Protection Guidelines for facility risk, defined as the total annualized failure probability multiplied by the consequences as a result of dam failure. The Team had the following considerations relative to dam safety when determining which alternatives to pursue in high-level, future studies:

- The main population at risk is located within the Cliff-Gila Valley scattered along the Gila River. Therefore, storage facilities have the potential to result in higher life loss in the event of a dam failure if they are located higher in the Cliff-Gila Valley.
- Storage facilities in the upper half of the Cliff-Gila Valley would likely be founded on conglomerate bedrock. The conglomerate bedrock would likely result in higher seepage quantities, and are expected to require lining, and could result in a higher probability of dam failure due to internal erosion as a result of seepage through the foundation.
- Larger storage reservoirs may generally result in more severe flooding and higher consequences in the event of a dam failure.

Design Consideration 3 – Reservoir Lining

Because of the permeable native soils and bedrock and the high value of the water, storage reservoirs may require lining to reduce seepage to acceptable levels. The Team included lining for all reservoirs as a conservative assumption due to the lack of geotechnical data at the proposed reservoir sites. The liner considered for this study was a 60-mil Linear Low-Density Polyethylene (LLDPE) geomembrane. The geomembrane liner will reduce seepage by 90 to 95 percent and needs to be covered with soil to achieve the desired 50- to 100-year design life. Cost savings could be realized by using an exposed liner (typically 80-mil HDPE), but the expected service life is only 20 years (or less). Side slopes of 3:1 or flatter are needed to keep the soil cover in-place. Steeper slopes up to 2:1 are sometimes used, but the cover is less stable. For this application, cover stability is critical because of the fluctuating water levels as the reservoirs are repeatedly filled and emptied. Soil cement or riprap cover were discussed but deemed too expensive for the large areas involved (see costs below). Cover material and cover stability need to be evaluated in further detail.

Reservoir lining includes several components:

- Excavations of reservoir prism – Unlined reservoirs typically have an irregular shape following the natural topography. Lined reservoirs (including geomembrane liners) require extensive earthwork to provide a relatively flat invert and 3:1 side slopes (typical). Earthwork would include cut and fill to remove reservoir fingers and achieve a relatively simple shape (triangular, rectangular, oval, etc.). The extra earthwork to achieve a simpler shape for lining is justified on a benefit versus cost basis. For this report, the costs for most of this excavation is covered under the cost of obtaining borrow material for construction of the earth dam. Additional earthwork to reach grade is based on $4/cy for excavating the top 3 feet of subgrade that equates to $0.44/sf. This cost does not include any compaction of fill areas.
- Trimming – Final trim to grade plus two passes with a heavy drum roller ($0.77/sf).
- Geomembrane Liner – For 60-millimeter LLDPE, the installed unit cost is approximately $0.60 per square foot. Given the granular soils, a geotextile cushion for puncture protection is included both above and below the geomembrane. Installed cost for each layer of 16-oz. geotextile cushion is $0.15 per square foot. A geotextile cushion is typically more cost effective than additional soil processing or a thicker geomembrane. Total cost ($0.90/sf).
- Cover Material (soil, riprap, soil cement). The geomembrane was considered to be covered with 2 feet of soil cover on 3:1 slopes. Costs for other options (Soil Cement and Rip Rap) are included for comparison.
    - Soil Cover – 2 feet of soil cover at ($12/cy) or ($0.88/sf)
    - Soil Cement – 9-inches-thick at $60/cy equals ($1.66/sf)
    - Rip Rap – $50/cy to $100/cy depending on haul distance, typically 2-feet-thick

Total Cost for Geomembrane liner with 2 feet of Soil Cover ($3/sf)

• Additional Excavation		$0.44
• Trim to Final Grade plus two passes Drum Roller	$0.77	
• Geomembrane with Geotextile Cushion (top and bottom)	$0.90	
• Soil Cover (2 feet thick)	$0.88	
• Total		$2.99

The Team used a cost of $3.15/SF in the cost estimates. The additional $0.15/SF was added because the reservoir area was used to determine the square foot quantity and that does not include the 3:1 side slopes. Therefore, the Team added 5%, or $0.15/SF to the cost of the geomembrane.

Design Consideration 4 – Tunnel Comparison

Two methods are available to move water from Diversion 2A to the top of Spar Reservoir. One method includes constructing an open flow 108-inch diameter pipe along the wall of the lower canyon (for a distance of approximately 22,000 LF) followed by construction of similar open pipe or 108-inch equivalent concrete lined channel on the eastern side of the upper Cliff-Gila Valley (for an additional distance of approximately 20,000 LF). A second method includes constructing approximately 3.2 miles of 108-inch finished diameter tunnel straight through the rock ridge between the diversion and the reservoir.

The all-inclusive cost (excavation, pipe, support, lining, etc.) for constructing the pipe and/or open channel along the wall of the canyon and in the flank of the upper Cliff-Gila Valley is approximately $1,460/LF for a total cost of approximately $61,200,000 (subtotal cost). The all-inclusive cost (excavation, support, lining, etc., including both the portals and tunnel) for constructing the tunnel is approximately $3,500/LF for a total cost of $59,850,000 (subtotal cost). In addition to the aesthetic value of not hanging a pipe on the canyon wall, the cost savings for using a tunnel instead of a pipe or open channel along the canyon wall is approximately $1,400,000 (subtotal cost).

Design Consideration 5 – Direct Pumping/FMI Exchange Concept

The New Mexico Interstate Stream Commission adopted a formal policy to guide its decisions on utilization of the funding and water Congress allocated to New Mexico in the 2004 Arizona Water Settlements Act. That policy has three main tenets: Minimize negative environmental impacts, use the best available science, and provide for present and future water needs. This concept incorporates features that could potentially help meet those policy directives at lower cost and with less environmental impacts than traditional diversion/storage scenarios. In addition, this concept takes into account the recommendation provided in the previous Value Engineering Study (SR01-030) in November 2014.

There are three key features in this concept. First, the element of gravity diversion, necessary to minimize both project energy costs and project carbon footprint, is replaced by direct pumping into a single, medium sized off-stream reservoir (See Figure 10). Second, the need for conveyance to a single large, or number of smaller off-stream reservoirs, to supply Mimbres Basin demands is replaced by an exchange of directly-pumped senior FMI water rights through existing infrastructure (See Figure 11). Lastly, the increased costs and greater carbon footprint of previously discarded direct pumping scenarios is offset by an exchange of income from a remote alternative energy facility used to cover electrical costs of direct pumping and pumping conveyance of water to meet demands in the Mimbres Basin and the Cliff-Gila Valley (See Figure 12).

Water to provide for needs in the Gila Valley is directly pumped from infiltration galleries and stored in an off-stream reservoir located in Spar Canyon. The exchange of 3,000 to 4,000 ac-ft of FMI senior Gila River rights for a like amount of New Mexico's senior 18,000 ac-ft allocation on the Central Arizona Project canal removes the need for 15,000 to 45,000 ac-ft of off-stream storage in the Cliff-Gila Valley. The exchange utilizes current mine-supply infrastructure without any need for significant additional conveyance or diversion infrastructure except for approximately 40 miles of less than 12-inch pipe. The FMI exchange also provides for reduced AWSA diversions needed to meet Cliff-Gila Valley and Mimbres Basin demands. This concept also allows a much lower maximum diversion rate.

Together, the concept elements could potentially eliminate the need for upstream diversions, storage, and most conveyances. Instead of a surface diversion sited in a currently undeveloped river reach, the concept only requires a single off-stream storage reservoir in the currently developed Cliff-Gila Valley (expandable to meet increases in future needs in Grant County), a non-intrusive infiltration gallery or well field sited below Mogollon Creek confluence and a single pumping plant located in an already developed area. Because the remote alternative energy plant can produce and sell energy every day while pumping will occur on only 10 percent of days, the sales of excess energy could be used to pay for project pumping electrical costs. Over time, sales of electrical energy could pay the costs of the alternative energy plant itself.

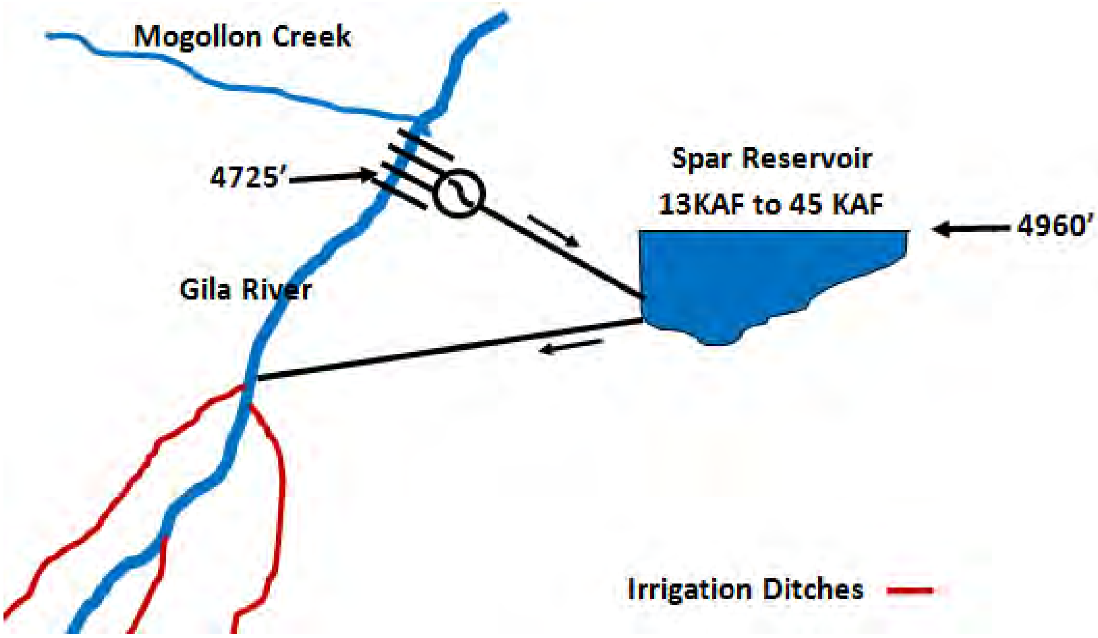

Figure 10. Schematic of conceptual Spar Reservoir with pumping scenario.

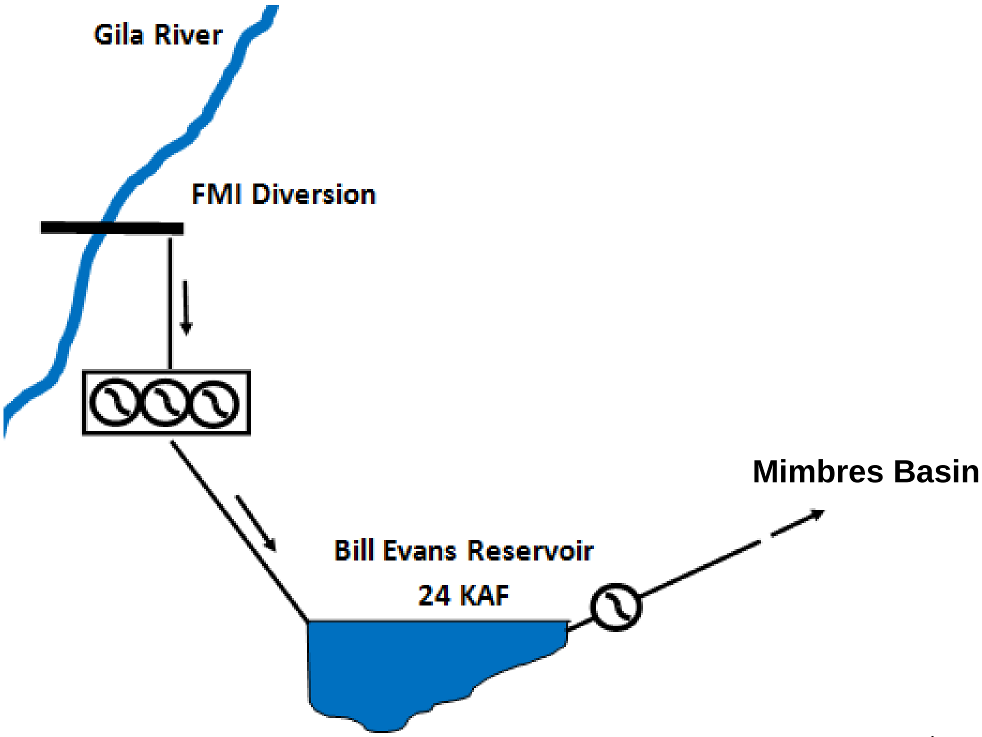

Figure 11. Schematic of diversion and conveyance to Mimbres Basin of 3,000 acre-feet of FMI senior Gila River water right in exchange for 3,000 acre-feet of New Mexico's CAP allocation.

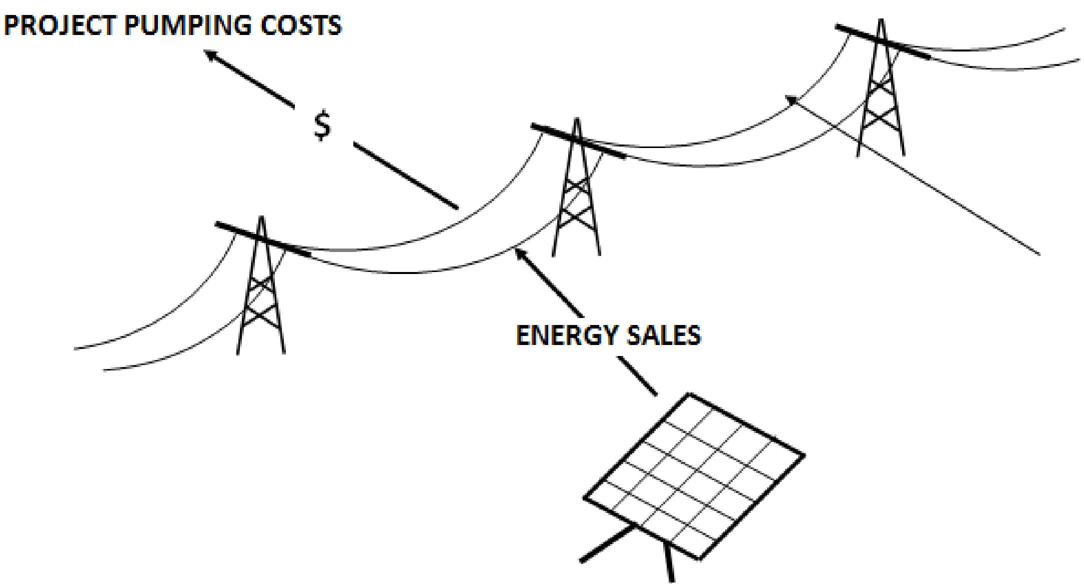

Figure 12. Remote site alternative energy plant (possible combination of wind and passive solar) with tie-in to nearby transmission lines such as Sun-Zia Southwest Transmission project (this project is currently in the development process and anticipated to be in-service by 2020).

Design Consideration 6 – Canal versus Pipeline Conveyance

Water may be conveyed from one point to another by canal or pipeline. Each has advantages and disadvantages. Conservation of head is a significant advantage that canal has over pipeline.

Canal Advantages

- Low flow velocity results in significantly lower head loss. For a 350 cfs canal assumed by Reclamation, the head loss calculated by Manning's Equation is 0.0003 ft./ft. at 4.2 ft./s, which results in a higher storage water surface elevation.
- Relative ease of access for O&M.
- Typically less expensive than pipeline.

Canal Disadvantages

- Undesirable visual impact.
- Interrupts natural surface drainage and can require culverts, siphons, and overchutes.
- Road bridges or other structures required for all road crossings.
- Hazardous to wildlife and livestock.
- Collects debris and sediment.
- Groundwater uplift could be an issue.
- Environmental impacts.
- Requires more maintenance than a pipe, albeit easier.
- Potential losses through evaporation.

Pipeline Advantages

- Relatively little visual impact.
- Passes beneath natural drainages.
- Not a surface hazard.
- Buried pipe has minimal O&M.
- Road crossings are less complicated and do not require a bridge.
- May be shorter than open channel.

Pipeline Disadvantages

- Relatively difficult to clean out debris and sediment.
- Higher flow velocity required for sediment transport results in higher head loss than in a canal. For 108-inch diameter pipe flowing 350 cfs at 8 ft/s, loss is 0.0008 ft./ft.; for 90 inch, loss is 0.0021 ft./ft. This results in a lower storage water surface elevation. For many alternatives in this study, the pipeline option is not viable because of the higher head losses and subsequent reduction in storage capacity at the reservoir.
- Welded steel pipeline requires cathodic protection and periodic interior inspection and reapplication of lining material (paint).

Design Consideration 7 – Diversion Dam Selection

For durability and low O&M, concrete diversion dams with overflow Ogee crests were selected at the appraisal level. Gated sluice bays are provided to divert bed load away from the diversion bay. A gated bay is provided for diversion to the conveyance feature. Suspended sediment that does not settle out in the pool upstream of the diversion dam will be drawn into the diversion. Some issues to be resolved for final design of the diversion dam include:

- Ogee crest widths and elevations determined based on river hydrology.
- Sediment management.
- Native fish passage.
- Non-native fish exclusion.
- Public safety.
- Boat passage.
- Geotechnical considerations.
- Rights-of-way for upstream pool.
- Erosion protection.
- Structure size.
- Diversion rate.
- Flanking protection.

Rock riprap or timber crib diversion dams were not considered because of durability concerns.

Design Consideration 8 – Eliminate Sediment Basins Upstream of Storage Reservoirs

The Team recommends eliminating sediment storage basins upstream of the water storage reservoirs located on Gila River tributaries. Field observations of sediment deposition in the existing sediment control basin located on Winn Canyon and consideration of engineering principles regarding sediment transport indicate the proposed new sediment basins will not be highly effective at reducing fine-grained sediment supply (fine sand & smaller sizes) to the storage reservoirs. Field observations indicate that the tributaries deliver a high percentage of fine-grained sediment that would not be effectively captured by sediment basins. Coarse sediment (gravels, cobbles, boulders) will be deposited at the upstream end of the reservoir, possibly above the normal pool elevation and will have minimal impact on storage volumes. Most water storage reservoirs account for future sedimentation by including dead storage in the designed reservoir volume and do not include separate sediment capture basins.

The benefits of implementing this design consideration include the following:

- Eliminates high costs of construction and maintenance for the sediment basins.
- Allows fine-grained sediment to enter the reservoir, potentially reducing infiltration losses and eliminating the need for expensive liners.
- Allows for capture of tributary runoff, potentially increasing water available to the project.

The disadvantages of implementing this design consideration include the following:

- Loss of potential water storage volume due to periodic sediment deposition.

Design Consideration 9 – Eliminate Upper Greenwood/Sycamore Canyon Reservoirs

The Team considered an alternate location for constructing a reservoir in Greenwood Canyon or Sycamore Canyon at a higher elevation so deliveries to the upper Gila Valley could be by gravity rather than pumping. This alternative was rejected because of the following:

- The dam located higher in Greenwood Canyon with outlet el. of 4595 only provides 18,000 ac-ft of storage. The dam located higher in Sycamore Canyon with outlet el. 4595 only provides 7,000 ac-ft of storage. El. 4595 is the approximate elevation of the upper Gila Valley. Therefore, neither reservoir could be raised high enough to deliver by gravity and still have sufficient storage.
- The higher reservoir would require a higher diversion elevation than that at Diversion 2A.

Design Consideration 10 – Elimination of Mogollon Creek Canyon

At the request of NMISC, the Team did not take into consideration Mogollon Creek Canyon due to CUFA compliance issues.

Design Consideration 11 – Elimination of Bear Creek Canyon

The Team did not take into consideration Bear Creek Canyon because of substantial human development. The canyon is also a critical habitat for loach minnow and spikedace, federally listed fish species.

Design Consideration 12 – Elimination of Mangas Creek Canyon

The Team did not take into consideration Mangas Creek Canyon, as it is a critical habitat for spikedace and loach minnow, two federally listed fish species. In addition, the canyon's location at the lower end of the Cliff-Gila Valley requires pumping for releases at the upper end of the valley.

Design Consideration 13 – Selection of Diversions 2A and 1 Instead of Diversions 2, 3, and 4

Diversion 2A, as proposed by BHI, was preferred for several reasons. First, the river appears to be laterally stable at this location. Review of historical aerial photography of the river from 1953 to 2011 shows the river thalweg (line of lowest elevation corresponding with the river's path) without exception aligned against the rock outcrop, which forms the west bank of the river at this location. This fact eliminates concern that the river would further meander to the west, leaving the diversion structure disconnected from the flow.

In addition, the river appears to be vertically stable at this location for two reasons. First, repeat survey data collected from this location in 2006 and 2014 indicates that the channel geometry at Diversion 2A was relatively unaffected by large floods in 2008 and 2013. Second, the results of BHI's sediment-transport model also indicate that very little change in mean bed elevation occurs at this point. Moreover, because this site is located at a bedrock-controlled hydraulic constriction, relatively high velocities are expected at this site, which would limit sediment deposition in the vicinity of this point.

Finally, the site has good vehicular accessibility from Turkey Creek Road, which will translate to lower construction and O&M costs. The site is closer to Spar Reservoir than the more upstream potential sites, which are only slightly higher in elevation. The more upstream sites would have significantly longer tunnel conveyance requirements with only minimal benefit in terms of higher hydraulic grade line and greater resultant storage in Spar.

Diversion 1 was selected as part of Alternative 7 primarily because the location is the lowest cost diversion option. The site offers good construction access, is situated at a narrow section of the canyon, and conveyance from the diversion structure can be transitioned to standard open channels within a short distance. However, this diversion location has more limited storage options in the upper end of the Cliff-Gila valley than Diversion 2A because of the lower elevation.

Design Consideration 14 – Team Focus on Spar, Garcia, Pope, Greenwood, Winn, and Bell Canyons

In order to identify the preferred canyons in the Cliff-Gila Valley for storage sites, the Team took into account the following criteria:

- Capacity
- Potential for size expansion
- Location in the valley (ability to release stored water at the upper end of the Cliff-Gila Valley)
- Geology
- Width of the canyon
- Critical habitat designation
- Compliance with CUFA
- Habitation

Based on the above criteria, six canyons were selected as follows:

1. Spar
2. Garcia
3. Pope
4. Greenwood
5. Winn
6. Bell

These are all dry ephemeral or intermittent drainages that lack extensive woody riparian habitats, wetlands, and habitat for threatened and endangered species.

Design Consideration 15 – Infiltration Galleries

Infiltration galleries for diversion were not desired for the development of the alternatives because of the following reasons:

- Uncertainty in river bed conditions
- Excessive size required for diverting 350 cfs
- High costs as compared to a surface diversion dam

Design Consideration 16 – Reservoir Impacts to Pump Stations

The water surface in storage reservoirs is expected to fluctuate from full to dead storage. This type of reservoir operation presents more complex pumping challenges than a stable reservoir. These concerns were clarified by Reclamation's pumping plant engineers.

Design Consideration 17 – Pipe or Open Channel Conveyance from the Diversion to the Reservoir and Pumping Requirement

Conveyances must be by canal, except those sections requiring a pipe or tunnel. Pumping is not required from the diversion to the reservoir for any of the alternatives.

Design Consideration 18 – Gravity Flow or Pumping for Water Supply to the Reservoirs

Alternatives that utilize gravity flow (open channel and gravity flow pipe) have many advantages over alternatives that require pumping:

- For the maximum diversion of 350 cfs, large power infrastructure is required to provide pump capability. This infrastructure would only be used for short periods of time (10 percent of the time) during 7 percent of the flows. The rest of the time, pumps and infrastructure would sit idle, with high-cost equipment going unused and creating maintenance issues related to lack of operation.
- For the maximum diversion of 350 cfs, pumping is expensive. The capital cost to build a pumping plant and infrastructure to supply power would be much higher than the cost of gravity supply by canal/pipeline. There would also be higher O&M costs for power and to maintain a pumping plant compared to gravity supply by canal/ pipeline.

Design Consideration 19 – Pipeline from Cliff-Gila Valley to Deming

Additional evaluation is needed to determine the alignment and cost of the pipeline to Deming from Winn, Bell, Spar, and Greenwood canyons. The pipeline to Deming in the BHI report is from Pope Reservoir, and in the Reclamation report is from Mangas Reservoir.

Disposition of Ideas

During the "creativity phase" of the Study, the Team was encouraged to offer any and all ideas, including wild ideas, to solve the identified problems and perform the intended functions. Table 7 below presents a complete list of each idea and the disposition of that idea. The best ideas were developed as alternatives. Several of the ideas that did not rise to the level of an alternative are located in the "Design Considerations and Issues" section of this report.

Table 7. Summary Table of Disposition of Ideas.

Idea		Disposition
Diversion Location		
1.	Diversion 1 (El. 4668)	Owned by State of New Mexico and The Nature Conservancy. Developed as part of Alternative 7. Discussed in Design Consideration 13.
2.	Diversion 2 (El. 4734)	Similar to Diversion 2A, but at a lower elevation, so less favorable than Diversion 2A. Might face some sediment deposition issues. Discussed in Design Consideration 13.
3.	Diversion 2A (El. 4736)	Favorable site as discussed in Design Consideration 13. Developed as part of all Alternatives except Alternative 7.
4.	Diversion 3 (El. 4774)	Estimated to add $24M for a 1.3-mile tunnel, so not included in any alternatives. Discussed in Design Consideration 13.
5.	Diversion 4 (El. 4779)	Estimated to add $24M for a 1.3-mile tunnel, so not included in any alternatives. Discussed in Design Consideration 13.
Conveyance Options		
6.	Open Channel (Canal)	Included in all Alternatives, except 1 and 6. Discussed in Design Consideration 6.
7.	Buried Pipe	Included in all Alternatives from diversion to tunnel, except 7. Also, included as the main conveyance line in Alternative 6. Discussed in Design Consideration 6.
8.	Tunnel	Developed as part of all Alternatives, except 7. Discussed in Design Consideration 4.
Storage Reservoirs		
10.	Spar Canyon (1,642 ac-ft)	Developed as part of Alternatives 1 and 6.
11.	Upper Spar Canyon (46,000 ac-ft with pumping)	Developed as part of Alternative 1.
12.	Pope Canyon (8,700 ac-ft)	Developed as part of Alternative 2 and 3.
13.	Garcia Canyon (4,100 ac-ft)	Developed as part of Alternative 3.
14.	Winn Canyon (2,750 ac-ft)	Developed as part of Alternative 7.
15.	Ring Dam- Garcia, Pope, Winn, or Bell Canyon (target ~13,000 ac-ft)	Developed as part of Alternatives 4, 5, 9A, and 9B.
16.	Greenwood Canyon (26,000 ac-ft to 46,000 ac-ft)	Developed as part of all Alternatives except Alternative 1, 9A, and 9B.
17.	Move Dam location downstream for Winn Canyon and/or Bell Canyon	Developed as part of Alternative 9A and 9B.

Idea		Disposition
18.	Mangas Creek	Reservoir within critical habitat, therefore not considered for an Alternative. Discussed in Design Consideration 12.
19.	Mogollon Creek	Might face compliance issues with CUFA, therefore not considered for an Alternative. Discussed in Design Consideration 10.
20.	Bear Creek	Reservoir within critical habitat, therefore not considered for an Alternative. Discussed in Design Consideration 11.
21.	Upper Greenwood/Sycamore Canyon	Discussed in Design Consideration 9.
Other Ideas		
22.	Upper Greenwood or Upper Sycamore for later phases of project	Discussed in Design Consideration 9.
23.	Dam Safety issues	Discussed in Design Consideration 2.
24.	Reservoir lining	Discussed in Design Consideration 3.
25.	Coordination with FMI and water exchange agreement	Discussed in Design Consideration 5.
26.	Different diversion structure	Discussed in Design Consideration 7.
27.	Eliminate sediment basins upstream of reservoirs	Discussed in Design Consideration 8.
28.	Greenwood Canyon or Sycamore Canyon for Phase II reservoir	Discussed in Design Consideration 1.

Value Method

The Value Method is a decision-making process, originally developed in 1943 by Larry Miles, to creatively develop alternatives that satisfy essential functions at the highest value. It has many applications, but it is most often used as a management or problem-solving tool.

The goal of the Value Method is to achieve the most appropriate and highest value solution for the project. It is only through the effort of a diverse, high-performing Team, in which all members participate, that this goal can be achieved. This Study is the product of such an effort. The purpose of the Study is to make good projects better by focusing on improving value and striving to achieve a return on investment exceeding 5:1.

The Study process follows a job plan that provides a reliable, structured approach to the conclusion. Initially, the Team examined the features of the project to define the critical functions and governing criteria. Then, the Team suggested alternative ideas and solutions to perform those functions, consistent with the identified criteria. The alternatives were then evaluated, analyzed, and prioritized, and the best ideas were developed to a level suitable for comparison, decision-making, and adoption.

This report is the result of a formal Value Planning Study by a Team comprised of people with the diversity, expertise, and independence needed to creatively attack the issues. The Team members bring a depth of experience and understanding of the discipline they represent and an open and independent inquiry of the issues under study, to creatively solve the problems at hand. The Team applied the Value Method to the issues and supporting information and took a "fresh look" at the problems to create alternatives that fulfill the client's needs at the greatest value.

The Team is a diverse group made up of representatives from the State of New Mexico, engineering consultants, and Reclamation. Further policy, regulatory, and/or design evaluations will be required prior to acceptance of any alternative developed during the Study. Alternatives from this Study, in and of themselves, do not indicate the technological, administrative, or policy approval of the agencies represented by the Team. The decision to accept or reject individual alternatives should be made through a combined effort between the New Mexico CAP Entity, Reclamation, and New Mexico Interstate Stream Commission.

Expertise of the Value Study Team

1. Civil engineering
2. Water resources engineering
3. Dam engineering
4. Geotechnical engineering
5. Constructability and costing
6. Ecology and environmental permitting
7. Geomorphology and sediment transport
8. Tunneling
9. Hydrology, water modeling and yield
10. Hydraulic structures and conveyance
11. Materials engineering
12. Geology
13. Value engineering and life-cycle costing

Function Analysis

The Team developed basic functions for the key elements of the project. These functions generally are a two-word pair consisting of an active verb and a measurable noun.

Component	Active Verb	Measurable Noun
Project	Divert	Water
	Store	Water
	Convey	Water
	Secure	Right
	Deliver	Water
	Minimize	Seepage
	Protect	Environment
	Support	Agriculture
	Augment	River Flows
	Ensure	Expandability
	Minimize	Environmental Impacts
	Meet	Multiple Needs
	Maximize	Environmental Benefits
	Spend	Funds
	Minimize	Costs
	Obtain	Funding

Function Analysis System Technique

The Team used the functions to generate a Function Analysis System Technique (FAST) diagram (Figure 13). The diagram was designed to describe the present solution from a function point of view. The FAST diagram helped the Team identify design features that support critical functions. The FAST diagram also helped the Team develop a common understanding of how project objectives are met by the present solution. Some of the functions listed above are not in the FAST diagram because they were not considered critical functions when the diagram was created. In addition, some of the critical functions in the FAST diagram are not listed above because they were not identified until the diagram was created.

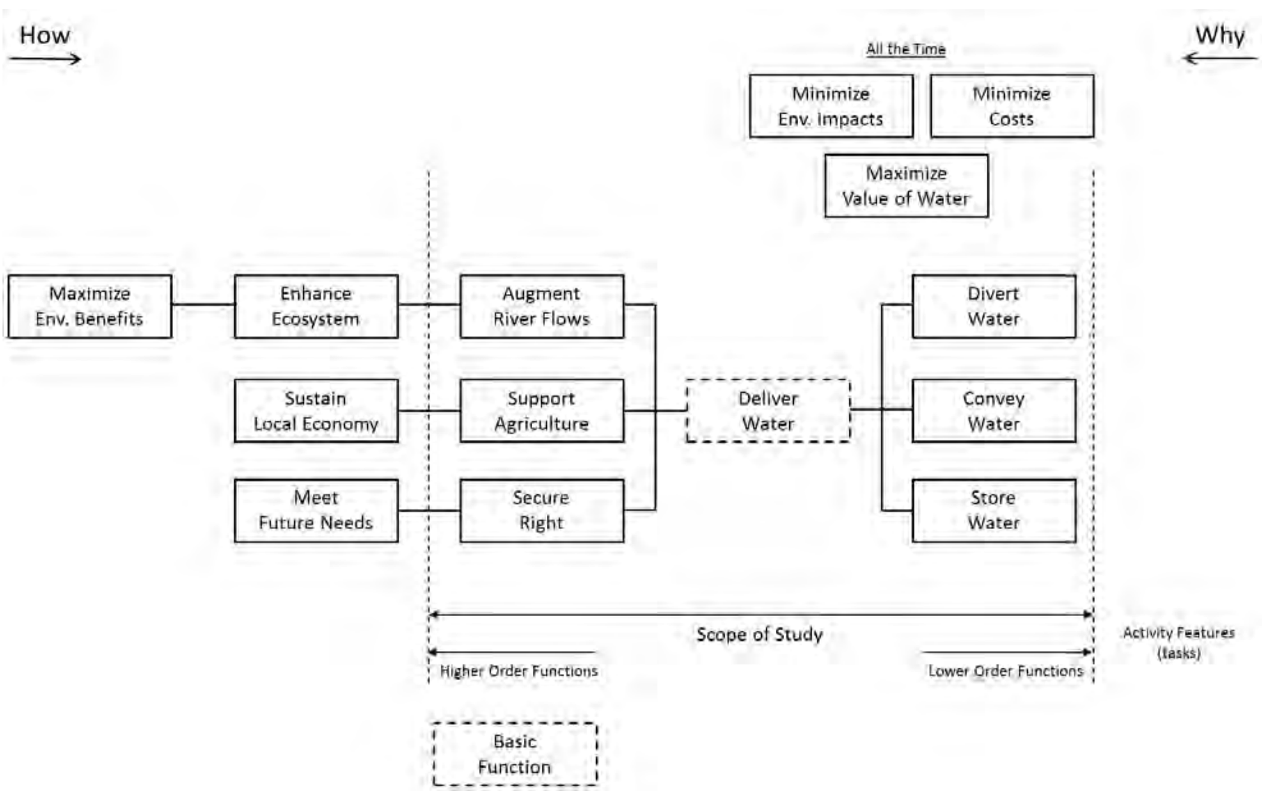

Figure 13. FAST Diagram.

List of Documents Consulted During Study

[1] "Final Report Value Engineering Study: Southwest Regional Water Supply (SWRWS) Project," Prepared for New Mexico Interstate Stream Commission, RJH Consultants, Inc., Solutions Engineering & Facilitating, Inc., November 2014. Web:http://nmawsa.org/ongoing-work/diversion-and-storage-proposals/value-engineering-study-for-the-awsa-diversion-storage-proposals/final-report-value-engineering-study-southwest-regional-water-supply-swrws-project/view

[2] "Preliminary Engineering Report: Gila River Diversion, Conveyance and Storage Alternatives," Prepared for New Mexico Interstate Stream Commission, Bohannan Huston, Inc., April 2014. Web:http://nmawsa.org/ongoing-work/diversion-and-storage-proposals/bhi-final-preliminary-engineering-report-4-11-2014

[3] "Appraisal Level Report on the Arizona Water Settlements Act Tier-2 Proposals and other Diversion and Storage Configurations," Prepared for New Mexico Interstate Stream Commission, Bureau of Reclamation, Phoenix Area Office, July 2014. Web:http://nmawsa.org/ongoing-work/united-states-bureau-of-reclamation/appraisal-level-report-on-the-awsa-tier-2-proposals-and-other-diversion-storage-configurations-july-2014/view

[4] "The 2004 Arizona Water Settlements Act Proposals: Staff Report to the New Mexico Interstate Stream Commission", Prepared for New Mexico Interstate Stream Commission, November 2014. Web:http://nmawsa.org/ongoing-work/interstate-stream-commission/the-2004-arizona-water-settlements-act-proposals-staff-report-to-the-new-mexico-interstate-stream-commission/view

[5] "Preliminary Engineering Report for Phase II Engineering Evaluation of AWSA Diversion and Storage Proposals," Prepared for New Mexico Interstate Stream Commission, Bohannan Huston, Inc., November 2014. Web:http://nmawsa.org/ongoing-work/diversion-and-storage-proposals/bhi-phase-ii-engineering-evaluation-of-the-2004-awsa-diversion-and-storage-proposals

Appendix – Cost Estimates

Alternative 1 - Lower Spar / Upper Spar Reservoirs
Cost Estimate Level: Preliminary
Price Level: 2014 Dollars

Phase One Costs		Size	Quantity	Unit	Unit Cost	Total Cost
A	Diversion	2A	1	LS	$6,000,000	$6,000,000
B	Buried Pipe to Tunnel	108"	1000	LF	$1,600	$1,600,000
C	Tunnel to Spar Canyon	108"	17100	LF	$3,500	$59,850,000
D	Lower Spar Dam	1,642 AF	1	LS	$47,200,000	$47,200,000
E	Lining Lower Spar Reservoir		1	LS	$4,800,000	$4,800,000
					Subtotal	$119,450,000
	Mobilization	5%				$6,000,000
					Phase One Subtotal	$125,450,000
	Design Contingencies	17%				$21,653,017
	New Mexico Gross Receipts Sales Tax	6.2%				$7,896,983
					Phase One Contract Cost	$155,000,000
	Construction Contingencies	25%				$40,000,000
					Phase One Field Cost	$195,000,000
	Non-Contract Costs	25%				$45,000,000
					Phase One Construction Cost	**$240,000,000**

Phases One, Two, and Three Costs		Size	Quantity	Unit	Unit Cost	Total Cost
	Phase One Costs					$119,450,000
F	Upper Spar Dam*	46,000 AF	1	LS	$175,000,000	$175,000,000
G	Lining Upper Spar Reservoir		1	LS	$25,000,000	$25,000,000
H	Deliveries from Upper Spar to Upper Gila		1	LS	$475,000	$475,000
I	Pumping to Deming from Spar		1	LS	$89,000,000	$89,000,000
					SubTotal	$408,925,000
	Mobilization	5%				$20,000,000
					Phases One, Two and Three Subtotal	$428,925,000
	Design Contingencies	17%				$74,063,578
	New Mexico Gross Receipts Sales Tax	6.2%				$27,011,422
					Phases One, Two and Three Contract Cost	$530,000,000
	Construction Contingencies	25%				$130,000,000
					Phases One, Two and Three Field Cost	$660,000,000
	Non-Contract Costs	25%				$170,000,000
					Phases One, Two and Three Construction Cost	**$830,000,000**

*Costs include pumping from Lower Spar to Upper Spar

Alternative 2 - Small Pope / Greenwood Reservoirs
Cost Estimate Level: Preliminary
Price Level: 2014 Dollars

	Phase One Costs	**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
A	Diversion	2A	1	LS	$6,000,000	$6,000,000
B	Buried Pipe to Tunnel	108"	1000	LF	$1,600	$1,600,000
C	Tunnel to Spar Canyon	108"	17100	LF	$3,500	$59,850,000
D	Open Channel (Spar to Pope)	108" eq	94890	LF	$200	$18,978,000
E	Siphon across Bear Creek Canyon	108"	3800	LF	$4,500	$17,100,000
F	Pope Dam	8,732 AF	1	LS	$70,000,000	$70,000,000
G	Lining Pope Reservoir		1	LS	$24,000,000	$24,000,000
H	Relocating County Hwy 211 at Pope		1	LS	$7,500,000	$7,500,000
I	Deliveries from Pope to Upper Gila		1	LS	$7,600,000	$7,600,000
					Subtotal	$212,628,000
	Mobilization	5%				$10,500,000
					Phase One Subtotal	$223,128,000
	Design Contingencies	17%				$34,345,862
	New Mexico Gross Receipts Sales Tax	6.2%				$12,526,138
					Phase One Contract Cost	$270,000,000
	Construction Contingencies	25%				$70,000,000
					Phase One Field Cost	$340,000,000
	Non-Contract Costs	25%				$90,000,000
					Phase One Construction Cost	**$430,000,000**

	Phases One, Two, and Three Costs	**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
	Phase One Costs					$212,628,000
J	Open Channel (Pope to Greenwood)	108" eq	11888	LF	$200	$2,377,600
K	Greenwood Dam	46,000 AF	1	LS	$80,000,000	$80,000,000
L	Lining Greenwood Reservoir		1	LS	$110,000,000	$110,000,000
M	Relocating US Hwy 180 at Greenwood		1	LS	$27,000,000	$27,000,000
N	Deliveries from Greenwood to Upper Gila		1	LS	$8,600,000	$8,600,000
O	Pump Station for Deliveries from Greenwood		1	LS	$1,200,000	$1,200,000
P	Pumping to Deming from Greenwood		1	LS	$81,000,000	$81,000,000
					SubTotal	$522,805,600
	Mobilization	5%				$26,000,000
					Phases One, Two and Three Subtotal	$548,805,600
	Design Contingencies	17%				$96,133,828
	New Mexico Gross Receipts Sales Tax	6.2%				$35,060,572
					Phases One, Two and Three Contract Cost	$680,000,000
	Construction Contingencies	25%				$170,000,000
					Phases One, Two and Three Field Cost	$850,000,000
	Non-Contract Costs	25%				$200,000,000
					Phases One, Two and Three Construction Cost	**$1,050,000,000**

Alternative 3 - Small Garcia and Small Pope / Greenwood Reservoirs
Cost Estimate Level: Preliminary
Price Level: 2014 Dollars

	Phase One Costs	**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
A	Diversion	2A	1	LS	$6,000,000	$6,000,000
B	Buried Pipe to Tunnel	108"	1000	LF	$1,600	$1,600,000
C	Tunnel to Spar Canyon	108"	17100	LF	$3,500	$59,850,000
D	Open Channel (Spar to Garcia)	108" eq	31445	LF	$200	$6,289,000
E	Garcia Dam	4,100 AF	1	LS	$45,000,000	$45,000,000
F	Lining Garcia Reservoir		1	LS	$17,000,000	$17,000,000
G	Open Channel (Garcia to Pope)	108" eq	60108	LF	$200	$12,021,600
H	Siphon across Bear Creek Canyon	108"	3800	LF	$4,500	$17,100,000
I	Pope Dam	8,732 AF	1	LS	$70,000,000	$70,000,000
J	Lining Pope Reservoir		1	LS	$24,000,000	$24,000,000
K	Relocating County Hwy 211 at Pope		1	LS	$7,500,000	$7,500,000
					Subtotal	$266,360,600
	Mobilization	5%				$13,500,000
					Phase One Subtotal	$279,860,600
	Design Contingencies	17%				$44,067,664
	New Mexico Gross Receipts Sales Tax	6.2%				$16,071,736
					Phase One Contract Cost	$340,000,000
	Construction Contingencies	25%				$90,000,000
					Phase One Field Cost	$430,000,000
	Non-Contract Costs	25%				$110,000,000
					Phase One Construction Cost	**$540,000,000**

	Phases One, Two, and Three Costs	**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
	Phase One Costs					$266,360,600
L	Open Channel (Pope to Greenwood)	108" eq	11888	LF	$200	$2,377,600
M	Greenwood Dam	46,000 AF	1	LS	$80,000,000	$80,000,000
N	Lining Greenwood Reservoir		1	LS	$110,000,000	$110,000,000
O	Relocating US Hwy 180 at Greenwood		1	LS	$27,000,000	$27,000,000
P	Deliveries from Greenwood to Upper Gila		1	LS	$8,600,000	$8,600,000
Q	Pump Station for Deliveries from Greenwood		1	LS	$1,200,000	$1,200,000
R	Pumping to Deming from Greenwood		1	LS	$81,000,000	$81,000,000
					SubTotal	$576,538,200
	Mobilization	5%				$29,000,000
					Phases One, Two and Three Subtotal	$605,538,200
	Design Contingencies	17%				$105,855,629
	New Mexico Gross Receipts Sales Tax	6.2%				$38,606,171
					Phases One, Two and Three Contract Cost	$750,000,000
	Construction Contingencies	25%				$190,000,000
					Phases One, Two and Three Field Cost	$940,000,000
	Non-Contract Costs	25%				$240,000,000
					Phases One, Two and Three Construction Cost	**$1,180,000,000**

Alternative 4 - Large Pope / Greenwood Reservoirs
Cost Estimate Level: Preliminary
Price Level: 2014 Dollars

Phase One Costs		**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
A	Diversion	2A	1	LS	$6,000,000	$6,000,000
B	Buried Pipe to Tunnel	108"	1000	LF	$1,600	$1,600,000
C	Tunnel to Spar Canyon	108"	17100	LF	$3,500	$59,850,000
D	Open Channel (Spar to Pope)	108" eq	94890	LF	$200	$18,978,000
E	Siphon across Bear Creek Canyon	108"	3800	LF	$4,500	$17,100,000
F	Large Pope Dam	13,000 AF	1	LS	$90,000,000	$90,000,000
G	Lining Large Pope Reservoir		1	LS	$33,000,000	$33,000,000
H	Deliveries from Pope to Upper Gila		1	LS	$7,600,000	$7,600,000
I	Relocating County Hwy 211 at Pope		1	LS	$7,500,000	$7,500,000
					Subtotal	$241,628,000
	Mobilization	5%				$12,000,000
					Phase One Subtotal	$253,628,000
	Design Contingencies	17%				$41,307,069
	New Mexico Gross Receipts Sales Tax	6.2%				$15,064,931
					Phase One Contract Cost	$310,000,000
	Construction Contingencies	25%				$80,000,000
					Phase One Field Cost	$390,000,000
	Non-Contract Costs	25%				$100,000,000
					Phase One Construction Cost	**$490,000,000**

Phases One, Two, and Three Costs		**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
	Phase One Costs					$241,628,000
J	Open Channel (Pope to Greenwood)	108" eq	11888	LF	$200	$2,377,600
K	Greenwood Dam	46,000 AF	1	LS	$80,000,000	$80,000,000
L	Lining Greenwood Reservoir		1	LS	$110,000,000	$110,000,000
M	Relocating US Hwy 180 at Greenwood		1	LS	$27,000,000	$27,000,000
N	Deliveries from Greenwood to Upper Gila		1	LS	$8,600,000	$8,600,000
O	Pump Station for Deliveries from Greenwood		1	LS	$1,200,000	$1,200,000
P	Pumping to Deming from Greenwood		1	LS	$81,000,000	$81,000,000
					SubTotal	$551,805,600
	Mobilization	5%				$28,000,000
					Phases One, Two and Three Subtotal	$579,805,600
	Design Contingencies	17%				$95,401,069
	New Mexico Gross Receipts Sales Tax	6.2%				$34,793,331
					Phases One, Two and Three Contract Cost	$710,000,000
	Construction Contingencies	25%				$180,000,000
					Phases One, Two and Three Field Cost	$890,000,000
	Non-Contract Costs	25%				$210,000,000
					Phases One, Two and Three Construction Cost	**$1,100,000,000**

Alternative 5 - Large Garcia / Greenwood Reservoirs
Cost Estimate Level: Preliminary
Price Level: 2014 Dollars

	Phase One Costs	**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
A	Diversion	2A	1	LS	$6,000,000	$6,000,000
B	Buried Pipe to Tunnel	108"	1000	LF	$1,600	$1,600,000
C	Tunnel to Spar Canyon	108"	17100	LF	$3,500	$59,850,000
D	Open Channel (Spar to Garcia)	108" eq	80400	LF	$200	$16,080,000
E	Siphon across Bear Creek Canyon	108"	3800	LF	$4,500	$17,100,000
F	Large Garcia Dam	13,000 AF	1	LS	$91,000,000	$91,000,000
G	Lining Large Garcia Reservoir		1	LS	$19,000,000	$19,000,000
H	Deliveries from Garcia to Upper Gila		1	LS	$2,900,000	$2,900,000
					Subtotal	$213,530,000
	Mobilization	5%				$10,500,000
					Phase One Subtotal	$224,030,000
	Design Contingencies	17%				$41,012,500
	New Mexico Gross Receipts Sales Tax	6.2%				$14,957,500
					Phase One Contract Cost	$280,000,000
	Construction Contingencies	25%				$70,000,000
					Phase One Field Cost	$350,000,000
	Non-Contract Costs	25%				$90,000,000
					Phase One Construction Cost	**$440,000,000**

	Phases One, Two, and Three Costs	**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
	Phase One Costs					$213,530,000
I	Open Channel (Garcia to Greenwood)	108" eq	26400	LF	$200	$5,280,000
J	Greenwood Dam	46,000 AF	1	LS	$80,000,000	$80,000,000
K	Lining Greenwood Reservoir		1	LS	$110,000,000	$110,000,000
L	Relocating US Hwy 180 at Greenwood		1	LS	$27,000,000	$27,000,000
M	Deliveries from Greenwood to Upper Gila		1	LS	$8,600,000	$8,600,000
N	Pump Station for Deliveries from Greenwood		1	LS	$1,200,000	$1,200,000
O	Pumping to Deming from Greenwood		1	LS	$81,000,000	$81,000,000
					SubTotal	$526,610,000
	Mobilization	5%				$26,000,000
					Phases One, Two and Three Subtotal	$552,610,000
	Design Contingencies	17%				$93,346,121
	New Mexico Gross Receipts Sales Tax	6.2%				$34,043,879
					Phases One, Two and Three Contract Cost	$680,000,000
	Construction Contingencies	25%				$170,000,000
					Phases One, Two and Three Field Cost	$850,000,000
	Non-Contract Costs	25%				$200,000,000
					Phases One, Two and Three Construction Cost	**$1,050,000,000**

Alternative 6 - Small Spar / Greenwood Reservoirs
Cost Estimate Level: Preliminary
Price Level: 2014 Dollars

	Phase One Costs	**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
A	Diversion	2A	1	LS	$6,000,000	$6,000,000
B	Buried Pipe to Tunnel	108"	1000	LF	$1,600	$1,600,000
C	Tunnel to Spar Canyon	108"	17100	LF	$3,500	$59,850,000
D	Lower Spar Dam	1,642 AF	1	LS	$47,200,000	$47,200,000
E	Lining Lower Spar Reservoir		1	LS	$4,800,000	$4,800,000
					Subtotal	$119,450,000
	Mobilization	5%				$6,000,000
					Phase One Subtotal	$125,450,000
	Design Contingencies	17%				$21,653,017
	New Mexico Gross Receipts Sales Tax	6.2%				$7,896,983
					Phase One Contract Cost	$155,000,000
	Construction Contingencies	25%				$40,000,000
					Phase One Field Cost	$195,000,000
	Non-Contract Costs	25%				$45,000,000
					Phase One Construction Cost	**$240,000,000**

	Phases One, Two, and Three Costs	**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
	Phase One Costs					$119,450,000
F	Buried Pipe from Spar to Greenwood	78''	103479	LF	$800	$82,783,200
G	Siphon across Bear Creek Canyon	108"	3800	LF	$4,500	$17,100,000
H	Greenwood Dam	46,000 AF	1	LS	$80,000,000	$80,000,000
I	Lining Greenwood Reservoir		1	LS	$110,000,000	$110,000,000
J	Relocating US Hwy 180 at Greenwood		1	LS	$27,000,000	$27,000,000
K	Deliveries from Greenwood to Upper Gila		1	LS	$8,600,000	$8,600,000
L	Pump Station for Deliveries from Greenwood		1	LS	$1,200,000	$1,200,000
M	Pumping to Deming from Greenwood		1	LS	$81,000,000	$81,000,000
					SubTotal	$527,133,200
	Mobilization	5%				$26,000,000
					Phases One, Two and Three Subtotal	$553,133,200
	Design Contingencies	17%				$92,962,741
	New Mexico Gross Receipts Sales Tax	6.2%				$33,904,059
					Phases One, Two and Three Contract Cost	$680,000,000
	Construction Contingencies	25%				$170,000,000
					Phases One, Two and Three Field Cost	$850,000,000
	Non-Contract Costs	25%				$200,000,000
					Phases One, Two and Three Construction Cost	**$1,050,000,000**

Alternative 7 - Original Winn / Greenwood Reservoirs
Cost Estimate Level: Preliminary
Price Level: 2014 Dollars

	Phase One Costs	**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
A	Diversion	2A	1	LS	$6,000,000	$6,000,000
B	Open Channel (Tunnel to Winn)	108" eq	29000	LF	$200	$5,800,000
C	Original Winn Dam	2,750 AF	1	LS	$32,000,000	$32,000,000
D	Lining Original Winn Reservoir		1	LS	$15,000,000	$15,000,000
E	Deliveries from Winn to Upper Gila		1	LS	$4,300,000	$4,300,000
					Subtotal	$63,100,000
	Mobilization	5%				$3,200,000
					Phase One Subtotal	$66,300,000
	Design Contingencies	17%				$11,504,310
	New Mexico Gross Receipts Sales Tax	6.2%				$4,195,690
					Phase One Contract Cost	$82,000,000
	Construction Contingencies	25%				$18,000,000
					Phase One Field Cost	$100,000,000
	Non-Contract Costs	25%				$25,000,000
					Phase One Construction Cost	**$125,000,000**

	Phases One, Two, and Three Costs	**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
	Phase One Costs					$63,100,000
F	Open Channel (Winn to Greenwood)	108" eq	43,000	LF	$200	$8,600,000
G	Siphon	108"	8,300	LF	$4,500	$37,350,000
H	Greenwood Dam	26,000 AF	1	LS	$58,000,000	$58,000,000
I	Lining Greenwood Reservoir		1	LS	$66,000,000	$66,000,000
J	Deliveries from Greenwood to Upper Gila		1	LS	$8,600,000	$8,600,000
K	Pump Station for Deliveries from Greenwood		1	LS	$1,200,000	$1,200,000
L	Relocating US Hwy 180 at Greenwood		1	LS	$27,000,000	$27,000,000
M	Pumping to Deming from Greenwood		1	LS	$81,000,000	$81,000,000
					SubTotal	$350,850,000
	Mobilization	5%				$17,500,000
					Phases One, Two and Three Subtotal	$368,350,000
	Design Contingencies	17%				$59,829,741
	New Mexico Gross Receipts Sales Tax	6.2%				$21,820,259
					Phases One, Two and Three Contract Cost	$450,000,000
	Construction Contingencies	25%				$110,000,000
					Phases One, Two and Three Field Cost	$560,000,000
	Non-Contract Costs	25%				$140,000,000
					Phases One, Two and Three Construction Cost	**$700,000,000**

Alternative 8 - Small Greenwood / Large Greenwood Reservoirs
Cost Estimate Level: Preliminary
Price Level: 2014 Dollars

	Phase One Costs	Size	Quantity	Unit	Unit Cost	Total Cost
A	Diversion	2A	1	LS	$6,000,000	$6,000,000
B	Buried Pipe to Tunnel	108"	1000	LF	$1,600	$1,600,000
C	Tunnel to Spar Canyon	108"	17100	LF	$3,500	$59,850,000
D	Open Channel (Spar to Greenwood)	108" eq	142000	LF	$200	$28,400,000
E	Siphon across Bear Creek Canyon	108"	3800	LF	$4,500	$17,100,000
F	Small Greenwood Dam	15,000 AF	1	LS	$40,000,000	$40,000,000
G	Lining Small Greenwood Reservoir		1	LS	$53,000,000	$53,000,000
H	Relocating US Hwy 180 at Greenwood		1	LS	$27,000,000	$27,000,000
I	Deliveries from Greenwood to Upper Gila		1	LS	$8,600,000	$8,600,000
J	Pump Station for Deliveries from Greenwood		1	LS	$1,200,000	$1,200,000
					Subtotal	$242,750,000
	Mobilization	5%				$12,000,000
					Phase One Subtotal	$254,750,000
	Design Contingencies	17%				$40,484,914
	New Mexico Gross Receipts Sales Tax	6.2%				$14,765,086
					Phase One Contract Cost	$310,000,000
	Construction Contingencies	25%				$80,000,000
					Phase One Field Cost	$390,000,000
	Non-Contract Costs	25%				$100,000,000
					Phase One Construction Cost	**$490,000,000**

	Phases One, Two, and Three Costs	Size	Quantity	Unit	Unit Cost	Total Cost
	Phase One Costs					$242,750,000
K	Large Greenwood Dam	46,000 AF	1	LS	$40,000,000	$40,000,000
L	Lining Large Greenwood Reservoir		1	LS	$57,000,000	$57,000,000
M	Pumping to Deming from Greenwood		1	LS	$81,000,000	$81,000,000
					SubTotal	$420,750,000
	Mobilization	5%				$21,000,000
					Phases One, Two and Three Subtotal	$441,750,000
	Design Contingencies	17%				$71,993,534
	New Mexico Gross Receipts Sales Tax	6.2%				$26,256,466
					Phases One, Two and Three Contract Cost	$540,000,000
	Construction Contingencies	25%				$140,000,000
					Phases One, Two and Three Field Cost	$680,000,000
	Non-Contract Costs	25%				$170,000,000
					Phases One, Two and Three Construction Cost	**$850,000,000**

Alternative 9A - Small Winn / Large Winn Reservoirs
Cost Estimate Level: Preliminary
Price Level: 2014 Dollars

Phase One Costs		Size	Quantity	Unit	Unit Cost	Total Cost
A	Diversion	2A	1	LS	$6,000,000	$6,000,000
B	Buried Pipe to Tunnel	108"	1000	LF	$1,600	$1,600,000
C	Tunnel	108"	10200	LF	$3,500	$35,700,000
D	Siphon under Gila River	108"	7600	LF	$4,500	$34,200,000
E	Open Channel (Tunnel to Winn)	108" eq	20000	LF	$200	$4,000,000
F	Small Winn Dam	13,000 AF	1	LS	$40,000,000	$40,000,000
G	Lining Small Winn Reservoir		1	LS	$52,000,000	$52,000,000
H	Deliveries from Winn to Upper Gila		1	LS	$4,300,000	$4,300,000
					Subtotal	$177,800,000
	Mobilization	5%				$8,900,000
					Phase One Subtotal	$186,700,000
	Design Contingencies	17%				$31,728,448
	New Mexico Gross Receipts Sales Tax	6.2%				$11,571,552
					Phase One Contract Cost	$230,000,000
	Construction Contingencies	25%				$60,000,000
					Phase One Field Cost	$290,000,000
	Non-Contract Costs	25%				$70,000,000
					Phase One Construction Cost	**$360,000,000**

Phases One, Two, and Three Costs		Size	Quantity	Unit	Unit Cost	Total Cost
	Phase One Costs					$177,800,000
I	Large Winn Dam	46,000 AF	1	LS	$59,000,000	$59,000,000
J	Lining Large Winn Reservoir		1	LS	$63,000,000	$63,000,000
K	Pumping to Deming from Winn		1	LS	$92,000,000	$92,000,000
					SubTotal	$391,800,000
	Mobilization	5%				$19,500,000
					Phases One, Two and Three Subtotal	$411,300,000
	Design Contingencies	17%				$72,323,276
	New Mexico Gross Receipts Sales Tax	6.2%				$26,376,724
					Phases One, Two and Three Contract Cost	$510,000,000
	Construction Contingencies	25%				$130,000,000
					Phases One, Two and Three Field Cost	$640,000,000
	Non-Contract Costs	25%				$160,000,000
					Phases One, Two and Three Construction Cost	**$800,000,000**

Alternative 9B - Small Bell / Large Bell Reservoirs
Cost Estimate Level: Preliminary
Price Level: 2014 Dollars

	Phase One Costs	**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
A	Diversion	2A	1	LS	$6,000,000	$6,000,000
B	Buried Pipe to Tunnel	108"	1000	LF	$1,600	$1,600,000
C	Tunnel	108"	10200	LF	$3,500	$35,700,000
D	Siphon under Gila River	108"	7600	LF	$4,500	$34,200,000
E	Open Channel (Tunnel to Bell)	108" eq	32000	LF	$200	$6,400,000
F	Small Bell Dam	13,000 AF	1	LS	$42,000,000	$42,000,000
G	Lining Small Bell Reservoir		1	LS	$69,000,000	$69,000,000
H	Deliveries from Bell to Upper Gila		1	LS	$5,200,000	$5,200,000
					Subtotal	$200,100,000
	Mobilization	5%				$10,000,000
					Phase One Subtotal	$210,100,000
	Design Contingencies	17%				$36,564,655
	New Mexico Gross Receipts Sales Tax	6.2%				$13,335,345
					Phase One Contract Cost	$260,000,000
	Construction Contingencies	25%				$70,000,000
					Phase One Field Cost	$330,000,000
	Non-Contract Costs	25%				$80,000,000
					Phase One Construction Cost	**$410,000,000**

	Phases One, Two, and Three Costs	**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
	Phase One Costs					$200,100,000
I	Large Bell Dam	46,000 AF	1	LS	$63,000,000	$63,000,000
J	Lining Large Bell Reservoir		1	LS	$91,000,000	$91,000,000
K	Pumping to Deming from Bell		1	LS	$91,000,000	$91,000,000
					SubTotal	$445,100,000
	Mobilization	5%				$22,000,000
					Phases One, Two and Three Subtotal	$467,100,000
	Design Contingencies	17%				$82,728,448
	New Mexico Gross Receipts Sales Tax	6.2%				$30,171,552
					Phases One, Two and Three Contract Cost	$580,000,000
	Construction Contingencies	25%				$150,000,000
					Phases One, Two and Three Field Cost	$730,000,000
	Non-Contract Costs	25%				$180,000,000
					Phases One, Two and Three Construction Cost	**$910,000,000**

Alternative 9C - Small Winn / Greenwood Reservoirs
Cost Estimate Level: Preliminary
Price Level: 2014 Dollars

Phase One Costs		**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
A	Diversion	2A	1	LS	$6,000,000	$6,000,000
B	Buried Pipe to Tunnel	108"	1000	LF	$1,600	$1,600,000
C	Tunnel	108"	10200	LF	$3,500	$35,700,000
D	Siphon under Gila River	108"	7600	LF	$4,500	$34,200,000
E	Open Channel (Tunnel to Winn)	108" eq	20000	LF	$200	$4,000,000
F	Small Winn Dam	13,000 AF	1	LS	$40,000,000	$40,000,000
G	Lining Small Winn Reservoir		1	LS	$52,000,000	$52,000,000
H	Deliveries from Winn to Upper Gila		1	LS	$4,300,000	$4,300,000
					Subtotal	$177,800,000
	Mobilization	5%				$8,900,000
					Phase One Subtotal	$186,700,000
	Design Contingencies	17%				$31,728,448
	New Mexico Gross Receipts Sales Tax	6.2%				$11,571,552
					Phase One Contract Cost	$230,000,000
	Construction Contingencies	25%				$60,000,000
					Phase One Field Cost	$290,000,000
	Non-Contract Costs	25%				$70,000,000
					Phase One Construction Cost	**$360,000,000**

Phases One, Two, and Three Costs		**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
	Phase One Costs					$177,800,000
I	Open Channel (Winn to Greenwood)	108" eq	19,000	LF	$200	$3,800,000
J	Siphon	108"	8,300	LF	$4,500	$37,350,000
K	Greenwood Dam	46,000 AF	1	LS	$80,000,000	$80,000,000
L	Lining Greenwood Reservoir		1	LS	$110,000,000	$110,000,000
M	Deliveries from Greenwood to Upper Gila		1	LS	$8,600,000	$8,600,000
N	Pump Station for Deliveries from Greenwood		1	LS	$1,200,000	$1,200,000
O	Relocating US Hwy 180 at Greenwood		1	LS	$27,000,000	$27,000,000
P	Pumping to Deming from Greenwood		1	LS	$81,000,000	$81,000,000
					SubTotal	$526,750,000
	Mobilization	5%				$26,000,000
					Phases One, Two and Three Subtotal	$552,750,000
	Design Contingencies	17%				$93,243,534
	New Mexico Gross Receipts Sales Tax	6.2%				$34,006,466
					Phases One, Two and Three Contract Cost	$680,000,000
	Construction Contingencies	25%				$170,000,000
					Phases One, Two and Three Field Cost	$850,000,000
	Non-Contract Costs	25%				$200,000,000
					Phases One, Two and Three Construction Cost	**$1,050,000,000**

Alternative 9D - Small Bell / Greenwood Reservoirs
Cost Estimate Level: Preliminary
Price Level: 2014 Dollars

Phase One Costs		**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
A	Diversion	2A	1	LS	$6,000,000	$6,000,000
B	Buried Pipe to Tunnel	108"	1000	LF	$1,600	$1,600,000
C	Tunnel	108"	10200	LF	$3,500	$35,700,000
D	Siphon under Gila River	108"	7600	LF	$4,500	$34,200,000
E	Open Channel (Tunnel to Bell)	108" eq	32000	LF	$200	$6,400,000
F	Small Bell Dam	13,000 AF	1	LS	$42,000,000	$42,000,000
G	Lining Small Bell Reservoir		1	LS	$69,000,000	$69,000,000
H	Deliveries from Bell to Upper Gila		1	LS	$5,200,000	$5,200,000
					Subtotal	$200,100,000
	Mobilization	5%				$10,000,000
					Phase One Subtotal	$210,100,000
	Design Contingencies	17%				$36,564,655
	New Mexico Gross Receipts Sales Tax	6.2%				$13,335,345
					Phase One Contract Cost	$260,000,000
	Construction Contingencies	25%				$70,000,000
					Phase One Field Cost	$330,000,000
	Non-Contract Costs	25%				$80,000,000
					Phase One Construction Cost	**$410,000,000**

Phases One, Two, and Three Costs		**Size**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
	Phase One Costs					$200,100,000
I	Open Channel (Bell to Greenwood)	108" eq	13,700	LF	$200	$2,740,000
J	Siphon	108"	8,300	LF	$4,500	$37,350,000
K	Greenwood Dam	46,000 AF	1	LS	$80,000,000	$80,000,000
L	Lining Greenwood Reservoir		1	LS	$110,000,000	$110,000,000
M	Deliveries from Greenwood to Upper Gila		1	LS	$8,600,000	$8,600,000
N	Pump Station for Deliveries from Greenwood		1	LS	$1,200,000	$1,200,000
O	Relocating US Hwy 180 at Greenwood		1	LS	$27,000,000	$27,000,000
P	Pumping to Deming from Greenwood		1	LS	$81,000,000	$81,000,000
					SubTotal	$547,990,000
	Mobilization	5%				$27,000,000
					Phases One, Two and Three Subtotal	$574,990,000
	Design Contingencies	17%				$98,929,741
	New Mexico Gross Receipts Sales Tax	6.2%				$36,080,259
					Phases One, Two and Three Contract Cost	$710,000,000
	Construction Contingencies	25%				$180,000,000
					Phases One, Two and Three Field Cost	$890,000,000
	Non-Contract Costs	25%				$210,000,000
					Phases One, Two and Three Construction Cost	**$1,100,000,000**