RECLAMATION

Managing Water in the West

Appraisal Level Report on the Arizona Water Settlements Act Tier-2 Proposals and other Diversion and Storage Configurations

Technical Support Provided to the New Mexico Interstate Stream Commission

U.S. Department of the Interior
Bureau of Reclamation
Phoenix Area Office

July 2014

Mission Statements

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

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.

Appraisal Level Report on the Arizona Water Settlements Act Tier-2 Proposals and Other Diversion and Storage Configurations

Technical Support Provided to the New Mexico Interstate Stream Commission

Prepared By:

U.S. Department of the Interior
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Bureau of Reclamation
Phoenix Area Office

July 2014

Acronym List

Acronym	Phrase
AF	Acre-feet
AIRFA	American Indian Religious Freedom Act
AOI	Area of Interest
ARPA	Archaeological Resources Protection Act of 1979
AWSA	Arizona Water Settlements Act
Reclamation	Bureau of Reclamation
CAP	Central Arizona Project
cfs	Cubic Feet Per Second
CUFA	Consumptive Use and Forbearance Agreement
CY	Cubic Yards
Deming	City of Deming
EIS	Environmental Impact Statement
F°	Fahrenheit
ft.	Feet
GBIC	Gila Basin Irrigation Commission
GCWC	Grant County Water Commission
GIS	Geographic Information System
GSWCD	Grant Soil & Water Conservation District
ISC	Interstate Stream Commission
M&I	Municipal and Industiral
MOU	Memorandum of Understanding
MSL	Mean Sea Level
NAGPRA	Native American Graves Protection and Repatriation Act
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFIA	New Mexico Forest Industry Association
NMISC	New Mexico Interstate Stream Commission
NMOSE	New Mexico Office State Engineer
NMSU	New Mexico State University
NRCS	Natural Resources Conservation Service
O&M	Operations and Maintenance
OM&R	Operations, Maintenance and Replacement
PMF	Probable Maximum Flood
PVC	Polyvinylchloride
RCC	Roller Compacted Concrete
SCADA	Supervisory Control and Data Acquisition
SHPO	State Historic Preservation Office
SSPA	S.S. Papadopulos & Associates, Inc.
TDS	Total Dissolved Solids
TES	Threatened or Endangered Species
TNC	The Nature Conservancy
TSC	Bureau of Reclamation Technical Service Center
USGS	United States Geological Survey

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Executive Summary

The Colorado River Basin Project Act of 1968 authorized the Central Arizona Project (CAP) including authorization of Hooker Dam or alternative to store waters of the Gila and San Francisco Rivers and tributaries diverted in New Mexico in exchange for CAP water delivered to downstream users. The Arizona Water Settlements Act (AWSA) was passed by Congress in 2004, modifying the terms of the CAP exchange and ratifying the Consumptive Use and Forbearance Agreement outlining conditions under which New Mexico may divert these waters. It also authorizes New Mexico to develop other water utilization alternatives in the Southwest Water Planning Region and provides federal funding for both of those options. The New Mexico Interstate Stream Commission (NMISC) is in charge of the planning process to provide alternatives to the State of New Mexico for use of the federal funding made available and must notify the Secretary of the Interior by December 31, 2014 if the State of New Mexico intends to build a New Mexico Unit of the CAP (Unit).

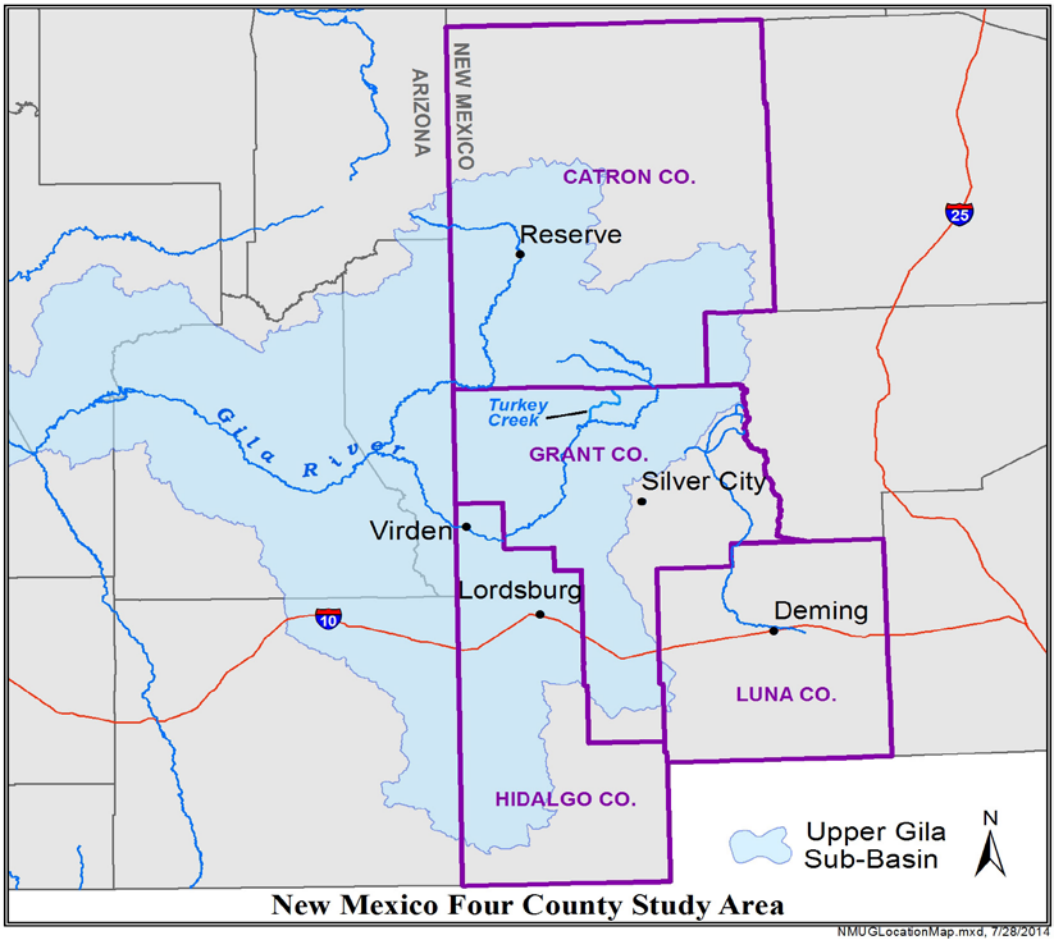

Figure ES-1. - Area of Interest

The NMISC entered into a Memorandum of Understanding (MOU) dated May 7, 2013 with the Bureau of Reclamation (Reclamation) to collaboratively develop technical information to assist in New Mexico's decision-making process for the AWSA. The primary purpose is to do an economic analysis of all proposals, an engineering assessment of the three Tier-2 diversion proposals, identify other potential diversion and storage configurations and an environmental review of potential impacts from diversion and storage proposals.

Since this is New Mexico's process, Reclamation completed the tasks outlined in the MOU between Reclamation and the NMISC. Because this report was conducted at an appraisal level, stated assumptions in the proposals were taken at face-value and available existing data were used. Subsequently, there are uncertainties associated with the analyses provided and only a brief discussion of them could be provided at this appraisal level. Reclamation performed similar analyses on each proposal to allow for comparisons between them; however, Reclamation makes no recommendations as to a preferred proposal.

A. Background

Reclamation's role in the implementation of the AWSA is to provide oversight for the Secretary of Interior, manage the Lower Colorado River Basin Development Fund (Fund) and assure environmental compliance of a Unit.

The AWSA provides $66 million in funding to be paid in 10 equal annual amounts beginning in 2012 for paying costs of a Unit or other water utilization alternatives to meet water supply demands in southwestern New Mexico. Indexed payments of approximately 9.04 million a year from the Fund have been transferred to a New Mexico Unit Fund, now totaling over 27 million. There is up to an additional amount of $62 million available if New Mexico chooses to build a Unit, which is also subject to indexing.

Through the NMISC'sTier-2 Planning Process, fifteen water-related projects submitted by stakeholders from the Southwestern Water Planning Region were selected for their further consideration.

Table ES-1. - Tier 2 Diversion Proposals

AWSA Tier-2 Non-Diversion Proposals
Grant County Water Commission Infrastructure and Reuse
Grant County Recharge and Reservoir
City of Deming Wastewater Reuse
Municipal Conservation
Pleasanton Ditch Improvements
Luna Ditch Improvements
Sunset/New Mexico New Model Pipeline

AWSA Tier-2 Non-Diversion Proposals
San Francisco Watershed Restoration
New Mexico Forest Industry Association Watershed Restoration
New Mexico State University Watershed Restoration
Grant Soil & Water Conservation District Forest Restoration
U.S. Forest Service Watershed Restoration
Southwest New Mexico Regional Water Supply (Deming Surface Water Diversion)
Gila Basin Irrigation Commission Diversion and Storage
Hidalgo County Off-Stream

B. Tasks Performed

1. Engineering Assessment

An appraisal level engineering assessment of the three AWSA Tier-2 diversion proposals was completed to identify data gaps and provide necessary technical information so that the proposals can be considered in a uniform fashion. Proposals were generally evaluated at face-value although in places technical data was generated to fill in gaps to allow for full analyses.

Table ES-2. - Tier-2 Diversion Proposals Costs

AWSA Tier-2 Diversion Proposal	Construction Cost ($)
GBIC	41,800,000
City of Deming	503,100,000
Hidalgo County	235,000,000

Based on our extensive agency experience, Reclamation provided other diversion, storage and conveyance options for NMISC's consideration. Reclamation initially identified 4 diversion sites and 24 side canyon storage locations. Of these, a total of 8 Other Diversion and Storage Configuration Options were developed for further evaluation.

Table ES-3. - Single and Multiple Storage Configuration Options: Costs & Storage Volume

Single Storage Configuration Options (Alternatives)		
Single Storage Site	**Construction Cost ($)**	**Storage Volume (AF)**
Spar Canyon from Diversion 4	161,583,000	3,100
Winn Canyon from Diversion 1	83,291,200	2,750

Single Storage Configuration Options (Alternatives)		
Single Storage Site	**Construction Cost ($)**	**Storage Volume (AF)**
Pope Canyon from Diversion 1	234,011,200	7,900
Greenwood Canyon from Diversion 1	280,511,200	26,000
Dam Canyon from Diversion 2	307,223,000	9,400
Multiple Storage Configuration Options (Alternatives)		
Multiple Storage Site	**Construction Cost ($)**	**Storage Volume (AF)**
Greenwood Canyon & Sycamore Canyon from Diversion 1	598,450,000	62,900
Mogollon Canyon & Wynn Canyon from Diversion 4	307,303,000	14,250
Spar Canyon & Garcia Canyon from Diversion 4	294,373,000	10,600

2. Economic Analyses

An appraisal level analysis of the economic benefits, costs and regional impacts was conducted for all the AWSA Tier-2 Proposals and Other Diversion and Storage Configuration Options. Information provided in the project proposals and supplemental engineering reports commissioned by the NMISC, as well as information from engineering assessments provided by the Reclamation Phoenix Area Office were used to evaluate potential water supplies and costs associated with each proposal and diversion option. The evaluation of benefits is based on values derived from existing data and previous studies that reflect conditions similar to the study area.

The cost and benefit analyses indicates the costs exceed benefits for all of the diversion proposals and the other diversion and storage options. The potential benefits may exceed costs for the Grant County Recharge and Reservoir, Deming Wastewater Reuse, GCC Municipal Conservation, Pleasanton Ditch Improvements, and San Francisco Watershed Restoration proposals. Additional analyses beyond the appraisal level would be needed to more conclusively evaluate the proposals.

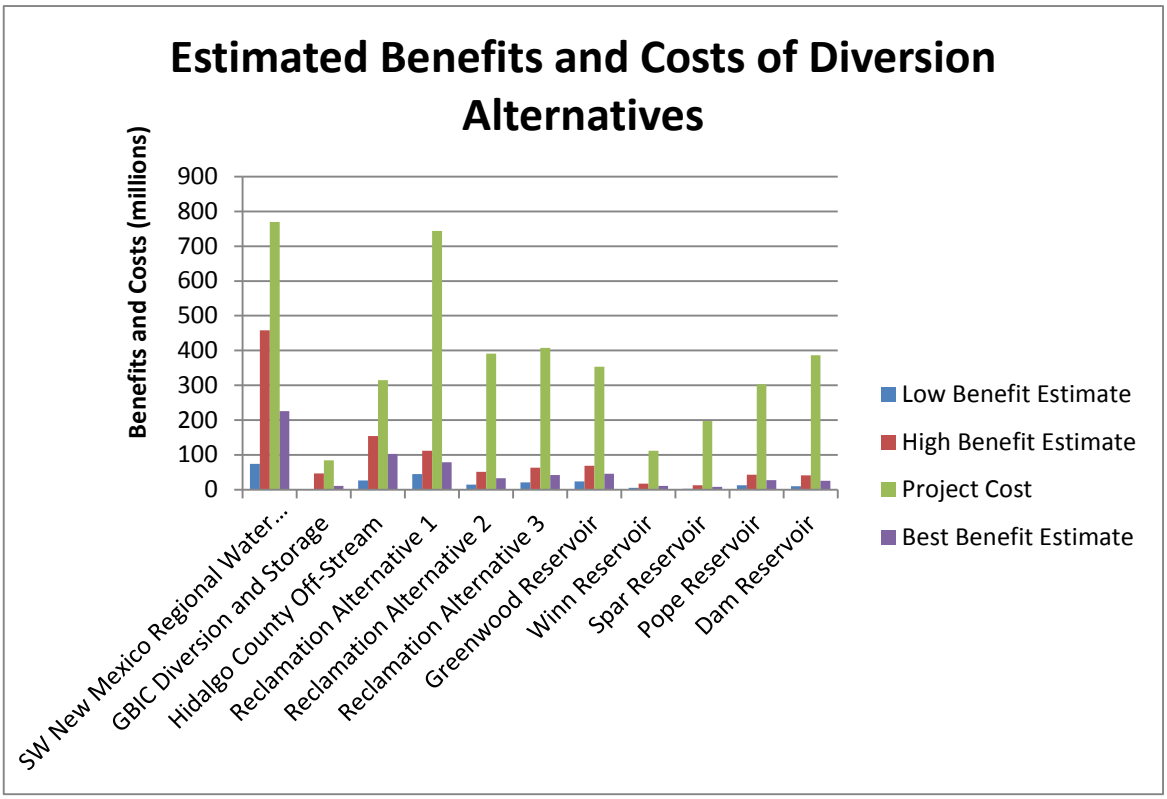

Figure ES-2. - Estimated Benefits and Costs of Diversion Alternatives

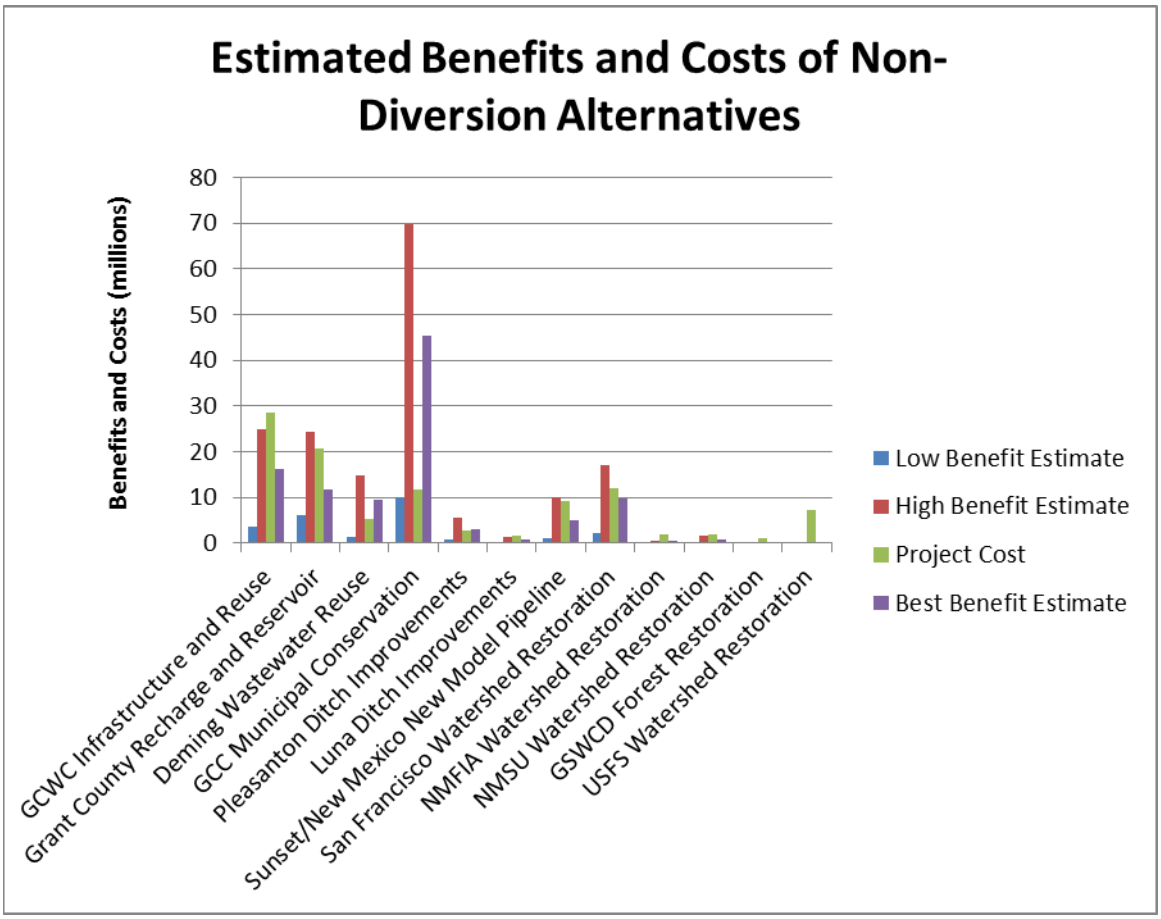

Figure ES-3. - Estimated Benefits and Costs of Non-Diversion Alternatives

Regional impacts represent changes in the value of goods and services produced in a region, changes in income, and changes in employment that are directly related to construction and operation of a project. Short-term impacts are created by project construction while longer term impacts are generated by ongoing OM&R expenditures, restoration activities, and project output (such as agricultural production from irrigation supplies) associated with water supplies. Regional impacts are separate and distinct from economic benefits and the two cannot be added together. The regional impact analysis indicates that construction associated with the more costly diversion alternatives will have a significant short-term impact on the regional economy. However, the long term impacts of the proposed projects would be very small relative to the overall economy.

3. Environmental Review

National Environmental Policy Act (NEPA) compliance is driven by what the NMISC choses as its preferred projects. If New Mexico choses construction of a Unit, Reclamation will be the lead agency to complete the Environmental Impact Statement (EIS) and New Mexico will be the joint-lead agency. If New Mexico chooses to pursue a non-diversion project, then NEPA will apply only if the project requires federal permitting or approval. And NEPA will be completed by the federal agency approving that project.

The appraisal level environmental review included an overview of possible impacts to the cultural resources and biological communities. The gray vireo, loach minnow, spikedace, southwestern willow flycatcher, narrow-headed gartersnake, northern Mexican gartersnake and yellow-billed cuckoo were some of the species identified as possibly being impacted. A more detailed investigation will be completed if appropriate once a project is selected.

C. Conclusions

The engineering assessment provides the NMISC with a more complete and consistent description of the three Tier-2 proposals to evaluate along with 4 diversion sites and 24 canyon storage sites, of which Reclamation analyzed 8 alternatives more in-depth. Diversion alternatives range from over 1,000 to 62,000 AF of storage and $41 to $598 million in construction costs. The outcome of the economics cost and benefit analyses show that diversion and seven non-diversion proposals' estimated costs exceed estimated benefits. Five non-diversion proposals reflect potential positive net benefits. The environmental review identified some of the biological and cultural resources potentially impacted by the proposals. The extent to which federal agencies are involved in the NEPA process will be determined by New Mexico's project selection. Reclamation will be the lead federal agency for this process if New Mexico chooses to build a Unit. If a non-diversion alternative is chosen, the federal agency approving that project will be the agency in charge of NEPA, if there is federal involvement in the project.

Appraisal Level Report on the Arizona Water Settlements Act Tier-2 Proposals and Other Diversion and Storage Configurations

Technical Support Provided to the New Mexico Interstate Stream Commission

I. Introduction

A. Overall project and scope of study

New Mexico is leading the decision making process on whether to build a Unit, including how to utilize funding provided to them by the AWSA. On May 7th, 2013, Reclamation and the NMISC entered into a MOU stating that Reclamation will provide technical assistance in assessing diversion and non-diversion proposals to meet water supply demands in southwestern New Mexico. The primary purpose of this assessment is to provide appraisal level engineering, economic, and environmental analyses of the stakeholder's Tier-2 proposals and of other diversion and storage configurations Reclamation provided NMISC for consideration. Reclamation has been tasked within the MOU with the following:

- Complete an engineering assessment of the 3 existing Tier-2 diversion and storage proposals (Deming Diversion, Gila Basin Irrigation Commission Diversion and Storage, and Hidalgo County Diversion and Storage).
- Identify other diversion, conveyance, and storage options suitable for consideration by the NMISC.
- Conduct an economic analysis for each of the Tier-2 proposals being evaluated and for the other diversion, storage, and conveyance options Reclamation has provided for NMISC's consideration.
- Assess potential effects of the diversion, storage, and conveyance proposals on water-related resources, fish, wildlife and endangered species.
- Provide an appraisal level report to be made available for a public review before the final report to be delivered to the NMISC on July 31, 2014.

This is not a Reclamation appraisal study. However, all analyses provided were completed at the appraisal level. An appraisal level analysis is a preliminary assessment and relies on available existing data and information. The analyses completed in this report are to simply compare the magnitude of costs and resources of each proposal, one to another, which will be general in nature.

Reclamation realizes that, at this level of analysis, there are data gaps and results which are qualitative in nature rather than quantitative. If a New Mexico Unit is selected, further studies will be conducted in greater detail.

Where necessary, assumptions for unavailable data were made based on experience in similar cases. Levels of uncertainty associated with lack of information are noted where possible. Appraisal level costs and benefits are best guesses based on the information available for this level of analysis. However, they are not to be construed as actual costs of implementing any of the proposals. Specific costs to implement any of the proposals will only be known after the equivalent of a feasibility level of analysis is complete.

B. Background

The 2004 AWSA modified the terms of New Mexico's use of Gila River water and tributaries authorized as part of the CAP in the Colorado River Basin Projects Act of 1968. The State of New Mexico must decide if they wish to build a New Mexico Unit to divert waters from the Gila and San Francisco Rivers in exchange for delivering Colorado River Water via the CAP to downstream users in Arizona and, if so, notify the Secretary of their decision by no later than December 31, 2014. $66 million (indexed) will be transferred from the Lower Colorado River Basin Development Fund to a State of New Mexico fund over a 10-year period starting in 2012 to pay the costs of a New Mexico Unit to divert these waters, or to develop other water utilization alternatives in the 4-county Southwest Water Planning Region of New Mexico. Expenditure of these funds is at the discretion of the NMISC.

If New Mexico opts to build a Unit, the Secretary is required to issue a Record of Decision by December 31, 2019, approving the project based on an environmental analysis and on a demonstration that Unit costs for construction of a project designed to deliver more than 10,000 acre feet per year do not exceed the 10,000 acre feet per year cost threshold. Reclamation is the lead Federal agency for environmental compliance. "Upon request by the State of New Mexico to the Secretary, the State of New Mexico shall be designated as joint lead agency with respect to environmental compliance." New Mexico is authorized to receive up to an additional $62 million (indexed to the construction costs of the Unit) in non-reimbursable funds if they choose to build the Unit. Diversion of water must be in accordance with rules agreed to by downstream parties in the Consumptive Use and Forbearance Agreement (CUFA) ratified by the AWSA.

The NMISC initiated planning efforts shortly after the AWSA was passed in 2004. Since then, NMISC has created and collaborated with planning groups, modeling teams, science forums, stakeholder groups, contractors and Reclamation to work through the planning process and provide research and analyses to investigate ways to utilize benefits of the AWSA.

C. Study authority

The study authorities are the Colorado River Basin Projects Act of 1968 and the Arizona Water Settlements Act of 2004.

D. Study area description

The area of interest covers approximately 1200 square miles in the Southwest Water Planning Region, which is located in the southwest corner of New Mexico and is comprised of four counties: Hidalgo, Luna, Grant, and Catron. The area of interest boundaries are the confluence of Turkey Creek and Gila River to the north, Virden, NM to the southwest and the City of Deming, NM to the southeast.

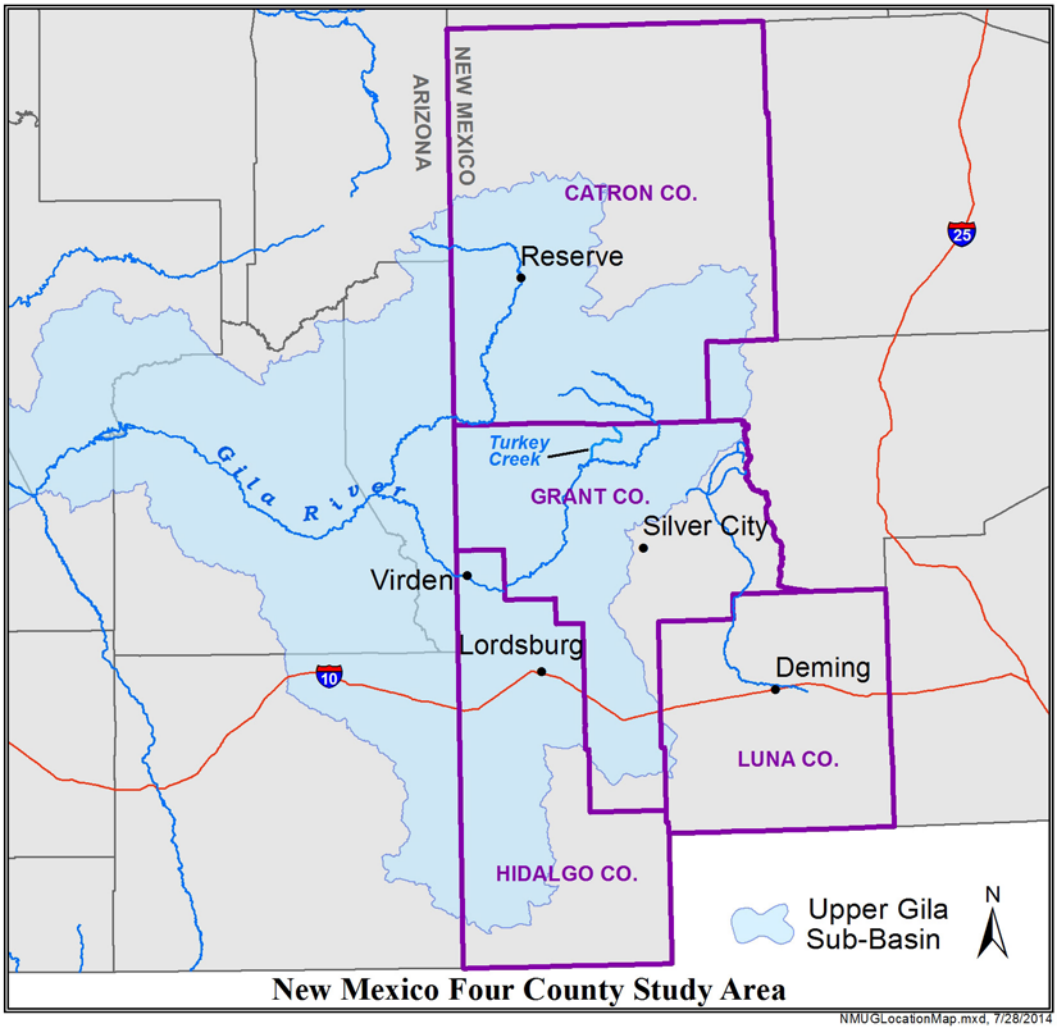

Figure I-1. - Study area map

1. Climate

In the southwest Region, terrain varies from the continental divide to the Chihuahuan Desert, resulting in significant climate variations. Elevation is the single most influential factor, with temperatures varying from below 0° Fahrenheit (°F) in the mountains to more than 100°F in the basins. The average annual temperatures across the four counties range from 46°F in the higher elevations to 61°F in the lower elevations. Average annual precipitation also varies from 11 inches in the lower elevations to 17 inches in the higher elevations. A range of 16-25 percent of the precipitation in the region falls during the winter months.

2. Topography

Most of the area in this appraisal level investigation is located in the Upper Gila Sub-Basin. Elevations range from approximately 3,700 feet above sea level near the village of Virden to 6,200 feet near the continental divide.

E. Public involvement

The ISC holds quarterly meetings to discuss the current status of review of stakeholder proposals. Reclamation attends these meetings to provide outreach on our activities and receive stakeholder input on an ongoing basis. These meetings are generally held at least quarterly, and are open to the general public who is encouraged to attend and ask questions. The times and locations of these meetings are advertised in advance, and the various proposals that are being considered, along with supplemental information as it is developed, are available on the New Mexico AWSA website. This includes information presented by Reclamation at each meeting so the information is publicly available for those unable to attend.[1]

[1] **New Mexico Unit –Central Arizona Project**, ***Questions Reclamation is Frequently Asked Regarding Technical Support for New Mexic"*****NM AWSA Input and Public Meeting 4.14.14**

II. Proposal Overview and Background

A. AWSA Tier 2 Proposals

"At the November 22, 2010 ISC meeting, various stakeholders from southwest New Mexico presented proposals for developing water and accessing funding available under the 2004 AWSA. Stakeholders were invited to submit their proposals to the Evaluation Panel. Stakeholders submitted forty-five applications in the Tier-1 process. Twenty-one of those applications qualified for Tier-2 consideration. Applicants submitted twenty applications for Tier-2 evaluation." [2] In February 2012, following the two-tiered evaluation process, the ISC selected sixteen water-related projects proposed by stakeholders for further consideration which has become fifteen proposals due to one withdrawing their proposal.

Table II-1. - Tier-2 Proposals

Proposal	Proponents
Grant County Water Commission Infrastructure and Reuse	Grant County Water Commission (GCWC)
Grant County Recharge and Reservoir	Grant County (GC)
City of Deming Wastewater Reuse	City of Deming
Southwest New Mexico Regional Water Supply (Deming Surface Water Diversion)	City of Deming
Gila Basin Irrigation Commission Diversion and Storage	Gila Basin Irrigation Commission (GBIC)
Hidalgo County Off-Stream	Hidalgo County
Municipal Conservation	Gila Conservation Coalition (GCC)
Pleasanton Ditch Improvements	Pleasanton East-side Ditch Company (PEDCo)
Luna Ditch Improvements	1892 Luna Irrigation Ditch Association
Sunset/New Mexico New Model Pipeline	Sunset and New Mexico New Model Canals
San Francisco Watershed Restoration	Catron County
New Mexico Forest Industry Association Watershed Restoration	NM Forest Industries Association (NMFIA)
New Mexico State University Watershed Restoration	NM State University (NMSU)
Grant Soil & Water Conservation District Forest Restoration	Grant Soil & Water Conservation District (GSWCD)
U.S. Forest Service Watershed Restoration	Gila National Forest (US Forest Service)

[2] Memorandum dated 2/6/2012, Arizona Water Settlement Act Project Proposals – Final Tier-2 Evaluation Panel review and ranking os stakeholder proposals.

B. Other diversion and storage configuration options

Reclamation identified four diversion sites, 24 side canyon storage sites and conveyance system options for the NMISC's consideration. Reclamation developed criteria based on our agency's extensive experience with similar facilities and with input from NMISC and other Input Group members. Reclamation identified 7 storage sites with efficient storage (accounting for cost of dam, storage volume, conveyance costs) then considered the following criteria:

1. Reservoir site(s) to store 64,000 AF – Maximum allowable single year AWSA diversion.
2. Reservoir site(s) to store 14,000 AF – Average allowable yearly AWSA diversion over 10-year period.
3. Reservoir site(s) to store 10,000 AF – Average allowable yearly AWSA diversion over 10-year period minus San Francisco River allocation of 4,000 AF.
4. Diversion, conveyance and storage costing less than $128,000,000
5. Best single storage site (based on $/AF)
6. Best combination, two storage sites (based on $/AF)
7. Best combination, two storage sites east side of river, 10,000 AF minimum (based on $/AF).
8. Best combination, two storage sites west side of river, 10,000 AF minimum (based on $/AF).
9. Best combination, two storage sites & connecting siphon across river (based on $/AF)
10. Additional storage sites evaluated by Reclamation.

Table II-2. - Diversion & storage configuration options

Diversion & Storage Configuration Options	Met Criteria
Greenwood Canyon and Sycamore Canyon (62,900 AF, Diversion 1)	1, 6, 9
Mogollon Canyon and Winn Canyon (14,250 AF, Diversion 4)	2, 8
Spar Canyon and Garcia Canyon (10,600 AF, Diversion 4)	3, 7
Greenwood Canyon (26,000 AF, Diversion 1)	5
Spar Canyon (3,100 AF, Diversion 4)	10
Winn Canyon (2,750 AF, Diversion 1)	4
Pope Canyon (7,900 AF, Diversion 1)	10
Dam Canyon (4,400 AF, Diversion 1)	10

C. Planning scope

The appraisal level investigation is based on a 50-year planning timeframe with construction of the "New Mexico Unit" estimated to begin after 2020. All appraisal level cost estimates and assessed land and property values are based on 2013 values and should be indexed accordingly. Operation and Maintenance values and frequencies will be specified according to the activity within the report.

D. Cost estimating information

Cost estimates within this report have appraisal level contingencies factored in to account for the preliminary status of the evaluations.

Cost estimates include the cost for construction, mobilization/demobilization, New Mexico Gross Receipts Tax, design contingencies, construction contingencies, and non-contract costs. A brief description of the cost and special allowances are described below:

A 5% surcharge for mobilization and demobilization was assessed toward the cost of construction. Mobilization includes all activities and costs for transportation of Contractor's personnel, equipment, and supplies to the site. Demobilization includes costs for redeploying personnel, equipment, and supplies not required at the site including a site cleanup.

A 6.2% New Mexico Gross Receipts Tax was assessed toward the cost of construction. The gross receipts tax is a tax on persons engaged in business in New Mexico for the privilege of doing business in New Mexico. The tax is imposed on the gross receipts of persons who perform services in New Mexico; Service includes construction activities and all construction materials that will become part of the construction project.[3]

A 17% surcharge for design contingencies was assessed toward the cost of construction. Design contingencies are allowances intended to account for three types of uncertainties inherent as a project advances from the planning stage through final design which directly affects the estimated cost of a project. These include: (i) unlisted items, (ii) design and scope changes, and (iii) cost estimating refinements.

A 25% surcharge for construction contingencies was assessed toward the cost of construction. Constructions contingencies are allowances for minor differences in

[3] New Mexico Taxation and Revenue Department, "FYI-105 Gross Receipts and Compensating Taxes: An Overview", (New Mexico, 2013)

actual and estimated quantities, unforeseeable difficulties at the site, changed site conditions, minor changes in plans, and other uncertainties.

A 25% surcharge for non-contract cost was assessed toward the cost of construction. Non-contract costs refer to the costs of work or services provided in support of the project, some of which can be expensed against a specific plant account, and other work which is of such a broad non-specific nature that it can only be attributed to the project as a whole. These costs include design data investigations, engineering and design, lands and rights-of-way, contracting administration, construction management and inspection, and contract close-out.

Distributive costs refer to that portion of the non-contract costs which is of such a broad non-specific nature that it can only be attributed to the project as a whole.[4]

Land costs for the proposals were derived from the respective County Assessor's Office appraisals.

Estimates for Operation and Maintenance are projected average annual costs for operations, maintenance, replacements, and additions.

E. Diversion volumes

The quantity of water available for an AWSA diversion project has been the source of considerable discussion. The terms most often used are "safe yield" and "firm yield". Safe yield is considered the quantity of water that can be diverted without impacting water rights holders and river functionality. Reclamation defines firm yield as the maximum amount of water that can be consistently withdrawn from a reservoir on an annual basis without completely depleting the reservoir during a drought period equivalent to the historical drought of record.

For the purposes of this study, Reclamation used historical river flow data obtained from USGS. River flows that could potentially be diverted as part of an AWSA project in conformance with CUFA requirements were provided by the ISC.

Gila River flows that could potentially be diverted on a yearly basis under CUFA constraints are shown in Figure II-1.

[4] Reclamation Manual, "FAC-09-01 Cost Estimating", (Denver, 2007)

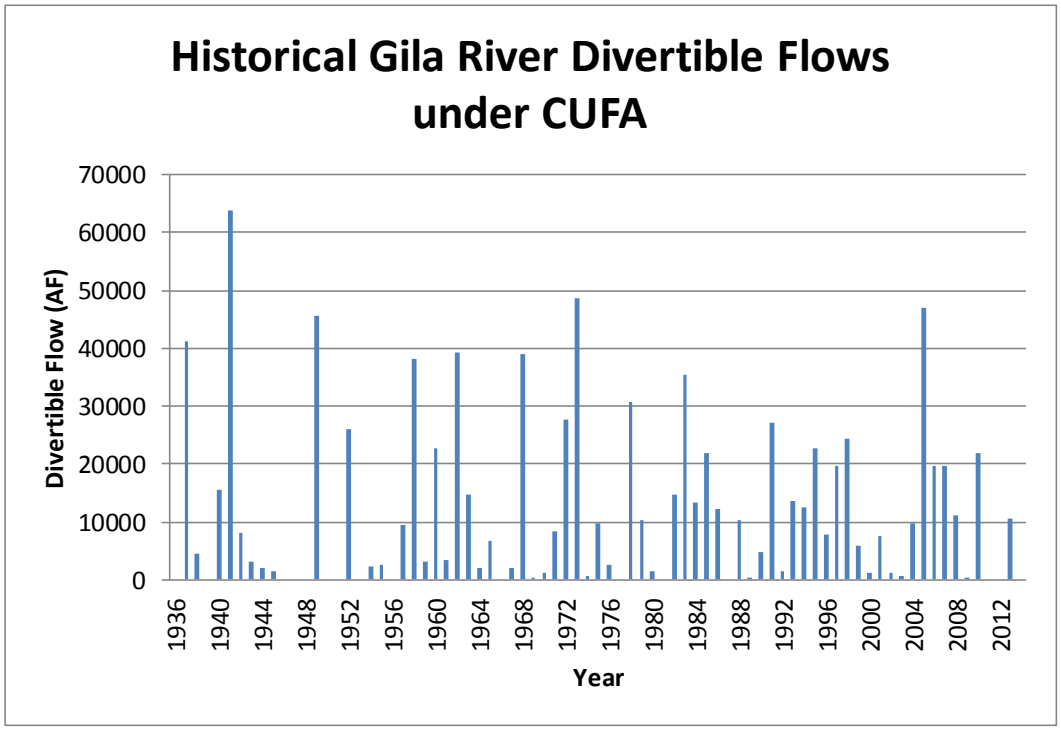

Figure II-1. - Historical Gila River divertible flows under CUFA

A progressive moving average of yearly divertible flows is shown in Figure II-2. Taking the entire period from 1937 to 2013 into account, these figures indicate an average of about 12,000 AF of water could be diverted on an average yearly basis. For the purposes of this study, 12,000 AF is considered the average safe yield for AWSA purposes. The historical data in Figure II-1 shows that some years, for example 1946-1948, there is no safe yield for AWSA purposes.

Firm yield is dependant on specific storage reservoir sites, factoring in reservoir volume, diversions, sedimentation, precipitation, losses from evaporation, seepage, and spills, and intended use and timing of uses.

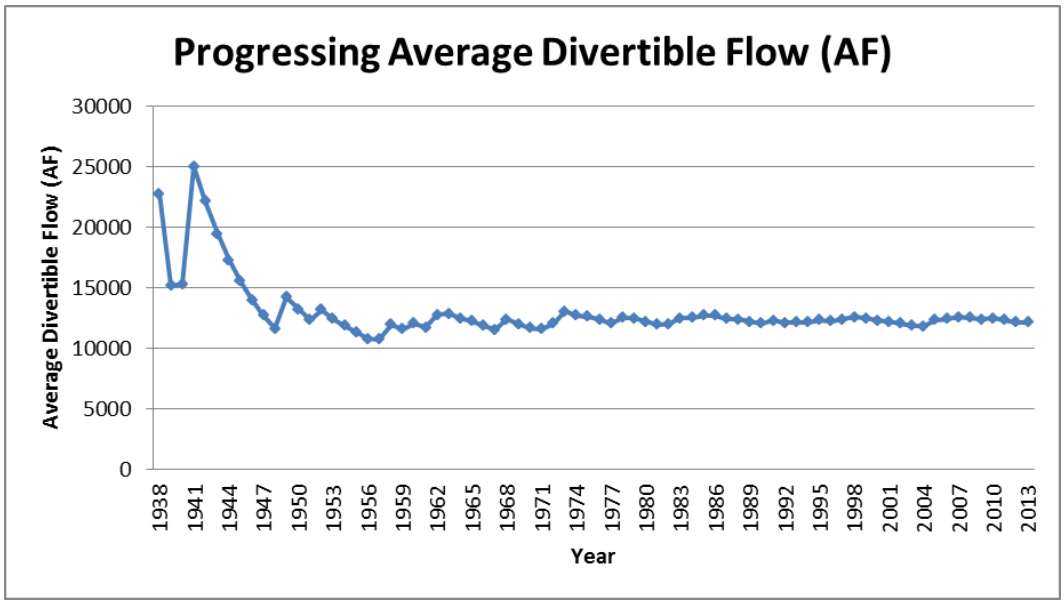

Figure II-2. - Progressing average divertible flow (AF)

The average divertible yearly flows are also broken down into 11-year increments in Figure II-3. Eleven-year increments were selected because the period of record can be divided into nearly equal blocks. Interestingly, the block from 2003 through 2013 does not reflect the current drought conditions in the southwest as one would expect, probably the result of large, but inconsistent runoff events. However, the previous period from 1992 to 2002 captures the drought impacts, showing the lowest flows of any of the 11-year periods.

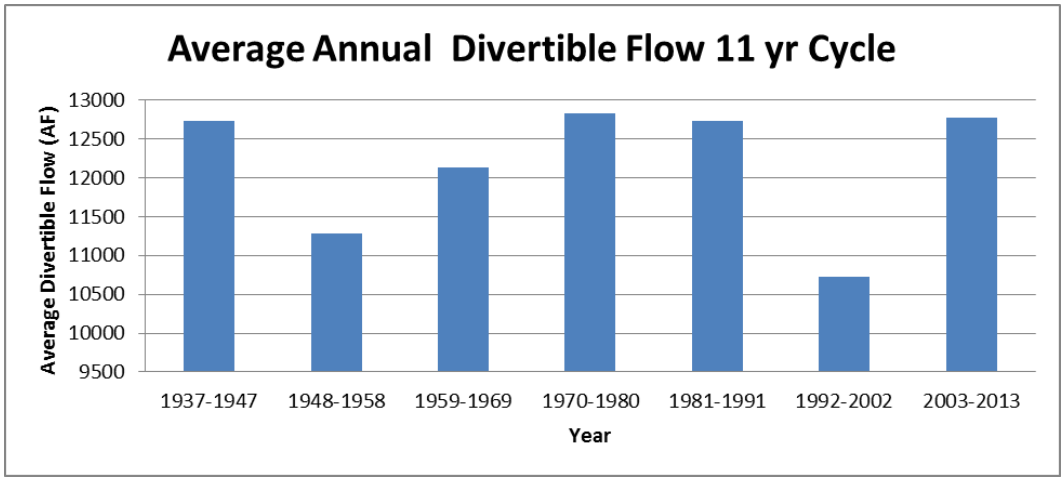

Figure II-3. - Average annual divertible flow 11 year cycle

F. Climate Change

Climate change analysis and quantification is outside the scope of this study. Reclamation acknowledges climate change challenges and defers to specific studies associated with the issue. For the purpose of this study, Gila River flows are based on historical USGS data for the period of record. ISC provided data on flows that could potentially be diverted from the Gila River in accordance with CUFA requirements from years 1936-2014.

G. Economics

The economic analysis is an appraisal level evaluation of the benefits, costs, and regional economic impacts of the 15 AWSA Tier-2 proposals that are currently under consideration by the NMISC as well as three possible combined diversion and storage alternatives and five individual storage alternatives evaluated by the Bureau of Reclamation. The cost-effectiveness of each of the proposals and alternatives in terms of cost per AF of water provided or saved are provided to enable comparison of one to another. A summary of net benefits, costs, and regional impacts are presented in the economic section of this report.

H. National Environmental Policy Act

The National Environmental Policy Act was passed in 1969 and became effective January 1, 1970. It established a policy that would "encourage projective and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment; and enrich the understanding of ecological systems and natural resources important to the Nation".[5] The Act requires that all people making decisions that involve the federal government understand the consequences of their decision on the human and natural environment and consider those consequences before making a final decision.

Reclamation acknowledges the rich asthetic and unique values that could be affected by implementation of some of the Tier-2 Proposals, specifically diversion and storage projects. Ecosystem disruptions have the potential for both adverse and positive impacts on the areas. All changes would need to be examined carefully, methodically, and throroughly during the NEPA process should a diversion and storage project be chosen for analysis by the NMISC.

Further, Reclamation is aware that there are areas thoughout the basin that have been designated as mitigation properties for previous projects developed in the basin. Changes to these established mitigation areas could effect the species they were originally created to protect and preserve. The cost associated with

[5] National Environmental Policy Act of 1969, Section 2

creating and mainting new mitigation areas could be substantial. Therefore, the NEPA process would need to intensively study all impacts icluding direct, indirect, and cumulative and remain vigilent to ensure the requirement to take a "hard look" at all available alternatives is met. Reclamation would be responsible for the systematic interdisciplinary study of these impacts should the NMISC choose to move forward with a diversion and storage project.

Reclamation can provide an overview of species, and ecocolgical resources common in the Gila basin as part of this level report, however, we must emphasize that until the Interstate Stream Commission issues its final decision regarding which projects they would like to submit for further consideration and analysis it is impossible to predict exactly how the basin would be affected.

Reclamation reviewed all 15 Tier-2 Proposals as well as the Other Diversion and Storage Options Reclamation would be the lead Federal agency on any proposed diversion and storage projects and an EIS would be required to obtain the Secretary's approval.

Reclamation is responsible for ensuring the quality of the NEPA document. An EIS evaluates the impacts to the human environment; therefore the EIS would include analysis on all resources including how climate change would effect all resources, using an interdisciplinary approach. All these analyses would need to conform to the President's Council on Environmental Quality and Reclamation regulatory requirements.

Some of the presented proposals other than diversion and storage are located on federal lands controlled by agencies other than Reclamation. Since some of these proposals require the approval by a federal agency, proponents would be required to comply with the NEPA requirements of the entity who manages the land. Proponents may need to examine the time and cost considerations associated with NEPA compliance, whether the proposal is for a diversion, or a non-diversion proposal.

I. Biology

Reclamation biologists primarily reviewed the diversion proposals, since these are the proposals that would, if chosen, be a major part of the required Environmental Impact Statement. However, our biologist developed a biological overview of possible impacts that would apply to all the proposals. First, impacts to biological resources can be either positive or negative. It should be noted that these are an overview of possible impacts and do not necessarily apply to any one project in particular. More specific review of diversion proposals are addressed within the individual proposal analysis.

Based on potential impacts to hydrologic conditions of groundwater and surface water systems from proposed water development alternatives, the following environmental/biologic impacts may be anticipated.

1. Impacts to Vegetation
    a. Increase/decrease of riparian vegetation
    b. Increase/decrease of wetland vegetation
    c. Increase/decrease of native vegetation
    d. Increase/decrease in upland vegetation
    e. Non-native vegetation establishment

2. Impact to Riparian-obligate Species
    a. Habitat quality (loss, degradation, conversion)
    b. Habitat size/distribution
    c. Habitat integrity (e.g. fragmentation)
    d. Trophic interactions (food web impacts or food availability)
    e. Species viability in the affected area

3. Impacts to Fish/Aquatic Species
    a. Habitat quality (loss, degradation, conversion)
    b. Habitat quantity
    c. Stream channel fragmentation
    d. Non-native species introduction/increases
    e. Introduction of disease, pathogens, parasites
    f. Food availability
    g. Viability in the affected area

4. Impacts to Terrestrial Species
    a. Habitat quality (loss, degradation, conversion)
    b. Habitat quantity
    c. Non-native species introduction/increases
    d. Introduction of disease, pathogens, parasites
    e. Food availability
    f. Viability in the affected area

It is also important to note that all Federal, State, and local laws need to be considered for all proposals. The proposals on federal lands, as well as private and state lands are subject to compliance with the Endangered Species Act, Migratory Bird Treaty Act, and other Federal and State legislation and requirements. Further, there may be other impacts not listed in this overview. The proposals that would occur on federal lands would also require that the proponent coordinate with the agency that manages the land and fulfill their specific requirements. Further detail of the basic biological analysis for the diversion proposals is provided in subsequent sections of this document.

J. Cultural resources

The National Historic Preservation Act (NHPA), 1966, was passed into law in order to protect the Nations' historic properties. The NHPA defines historic properties as districts, sites, buildings, structures, and objects that may be eligible for the National Register of Historic Places.

Section 106 of the NHPA states: "The head of any federal agency having direct or indirect jurisdiction over a proposed federal or federally assisted undertaking in any State and the head of any Federal department or independent agency having authority to license any undertaking shall, prior to the approval of the expenditure of any federal funds on the undertaking or prior to the issuance of any license, as the case may be, take into account the effect of the undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register. The head of any such federal agency shall afford the Advisory Council on Historic Preservation established under Title II of this Act a reasonable opportunity to comment with regard to such undertaking."

Other relevant federal cultural resource legislation and direction include, among others:

The Native American Graves Protection and Repatriation Act (NAGPRA*)*
The NAGPRA provides a process for returning Native American cultural items. These items can include human remains, and cultural patrimony, funerary, or sacred objects. Items are returned to lineal descendants and culturally affiliated Indian tribes found on federal lands. There are also penalties for illegal trafficking of those items.

The Archaeological Resources Protection Act (ARPA) prohibits the excavation of archeological resources on federal or Indian lands without a permit from the land manager

Executive Order 13007 requires that agencies try not to damage "Indian sacred sites" on federal land and avoid blocking access to such sites by traditional religious practitioners

The American Indian Religious Freedom Act (AIRFA) says that the U.S. Government will respect and protect the rights of Indian tribes to the free exercise of their traditional religions; the courts have interpreted this as requiring agencies to consider the effects of their actions on traditional religious practices.

Reclamation primarily reviewed the proposed diversion projects, using a desktop survey of Grant County provided by the New Mexico Interstate Stream Commission. There was very limited data available.

There are few archaeological or cultural resource surveys completed within the proposed project areas. However, based on archaeological site densities in other parts of the desert southwest, and especially in New Mexico and along riparian areas, it is very likely that there would be a high density of archeological sites. Therefore, should any one of the projects be chosen, extensive survey work and consultation with the New Mexico State Historic Preservation Office would be required. Further, all the proposals that use federal funding require compliance with the NHPA, and those projects that occur on federal land would need to be coordinated with the agency that manages the property in order to fulfill that agency's particular requirements.

K. Listed species or species of concern and critical habitat

All of the proposed diversion projects would require consultation with the United States Fish and Wildlife Service (USFWS) under Section 7 of the Endangered Species Act. The first step in the consultation process is to create a list of potentially affected threatened or endangered species (TES). Reclamation did a very basic review of the areas, and identified some of the potential TES in the proposed project areas. The following information on the potential species affected by the proposed diversion projects would be required in order to begin consultation with the USFWS should any of the diversion projects be chosen by the NMISC. This list is representative of a very basic review and more information would be required if NMISC decides to pursue a UnitUnit.

It will be necessary for all of the project proponents regardless if the project is on Federal, State, or private property to comply with the Endangered Species Act. It is recommended that the technical information that follows be reviewed and integrated into the planning process of all the proposals to help determine whether a formal or informal consultation would need to occur.
This review pertains to federally listed species and state of New Mexico listed species.

Any possible species impacts would be those that are riparian obligates. Habitats are water and vegetation dependent. Mogollon Creek contains speckled dace *(Rhinichthys osculus)*, and longfinned dace *(Agosia chrysogoster)* but no listed fish. The upper portion of Mogollon Creek supports the Endangered Gila Trout *(Oncorhynchus gilae)*. This area is within the Gila Wilderness boundary where the Gila trouttrout have been reintroduced into the West Fork of Mogollon Creek, along a 6 mile stretch of creek. Reservoir storage downstream on the Gila River will not impact the Gila trout.

There is little riparian vegetation along Mogollon Creek which is mostly a sycamore complex up to the forest boundary. Surveys for southwestern willow flycatchers have not been done and they are not likely to be in the area. Yellow-billed cuckoo may be in the area. The western yellow-billed cuckoo *(Coccyzus*

americanus occidentalis) has been proposed for listing as a threatened distinct population segment. Systematic surveys have not been carried out on the Gila, San Francisco, and San Juan rivers. The extent of habitat in these areas is limited, and much is fragmented. Based on available habitat, a maximum of 35 yellow-billed cuckoo pairs could breed on the Gila River, while no more than 15 and 5 pairs could breed on the San Juan and San Francisco Rivers, respectively (USFWS (2013c) estimated that 100 to 155 yellow-billed cuckoo pairs currently breed in western New Mexico.

Mangas Creek contains the endangered loach minnow *(Tiaroga cobitis)*, and possibly the endangered spikedace *(Meda fulgida)*. This creek is isolated from other creeks that contain non-native fish and bull frogs *(Litobates catesbeianus)* , and is unique in that respect. This isolation has likely aided in the persistence of both listed species. The drop off of spring flow from snowpack is critical to spawning as this provides water in the side channels and backwater habitat. This habitat maintains larval fish mid to late April. In addition, temperature and photoperiod contributes to maintaining larval fish.

The southwestern willow flycatcher *(Empidonax trailli extimus)* is an endangered species that has been recorded on private lands along the drainages to the Gila River and on the Gila River. For the first time in 2013, 1 pair was detected during the third census south on Mogollon Creek on TNC land. Near Iron Bridge West, near Cliff, New Mexico there have been few pairs detected over the past 5 years. In 2010 there were as many as 12 adult birds with 6 territories, but in 2013 there were 5 adult birds with only 3 territories. Territories were detected at Bill Evans Road and at U Bar on private land. U Bar had the highest number of territories at 162 in 2013, with 121 pairs. The Gila Cliff Valley above bear Creek has the highest number of flycatcher territories at 178 in 2013. There have been no detections on Mangas Creek.

The threatened northern Mexican gartersnake *(Thamnophis eques)* has proposed critical habitat along the Gila River up to the split east and west at Beaver Canyon, which is above the diversion projects. Historic populations were in Mule Creek in northwestern Grant County in the San Francisco River drainage. This species is tied to shallow, slow moving and partially vegetated areas such as springs, stock tanks, cienegas, streams and rivers. They can be found between 40 – 2590 meter elevation. Their diet is fish and other animals. Recent findings detected the snake along the Gila River below Iron Bridge.

The threatened narrow-headed gartersnake *(Thamnophis rufipunctatus)* has critical habitat proposed and overlaps the Mexican gartersnake along the Gila River, and can also be found in the upper Gila at Little Creek, Turkey Creek, Black Canyon and Beaver Canyon. This species typically inhabits cool rocky streams and ranges down the Gila River to the Arizona border between 700-2500

meters elevation. The diet of this snake is mostly fish. Bullfrogs and crayfish are predators of both these snakes.

L. Listed species considered but removed from consideration

The newly listed as endangered New Mexico meadow jumping mouse *(Zapus hudsonius luteus)* is not within the project area.

The Jaguar *(Panthera onca*) is proposed for listing as Endangered this year and critical habitat was proposed for the Peloncillo Mountains and the San Luis Mountains along the southwest corner of Hidalgo County, New Mexico. This area is outside the project areas for the diversion projects .

The Mexican wolf *(Canis lupus baileyi)* was extricated from the US by 1970. From 1977-1980 a captive breeding program was developed with the 5 last remaining wolves taken from the wild in Mexico. A recovery plan was finalized in 1982 and on March 29, 1998 the first wolves were released into the wild within the blue range wolf recovery area. All wolves within the recovery area were designated as a non-essential experimental population under Section 10(j) of the Endangered Species Act. The recovery area encompasses the Gila Wilderness and Gila National Forest. Wolves are not within the area of the proposed diversion projects as of this time. Wolves could move through the area of the projects, but are not expected to be affected by the projects.

The endangered Chiricahua leopard frog *(Lithobates chiricahensis)* occurs between 1000 and 2600 meters elevation in New Mexico. In 1995 only 2 known sites still supported populations and both were in relatively deep and steep sided, well-fed streams. They have persisted in spring and stream sites that are inaccessible and in wilderness areas of the Gila National Forest.[6] None are known to occur within the project areas.

Bald eagles (*Haliaeetus leucocephalus*) are a rare winter visitor in Hidalgo and Luna counties. In summer and also winter they can be found in Catron and Grant counties. They utilize rock faces to nest along the Arizona/New Mexico border in the White Mountains and the Mogollan plateau. No nesting occurs within the project locations

[6] Jennings 1995

III. Tier-2 diversion analyses

The New Mexico Interstate Stream Commission identified 15 AWSA proposals to be evaluated and considered as candidate projects for AWSA funding. Of these 15 proposals, four incorporated diversions from the Gila River. These proposals are:

1. Gila Basin Irrigation Commission
2. Southwest New Mexico Regional Water Supply Project (City of Deming)
3. Hidalgo County Off-Stream Project

Reclamation evaluated the Tier 2 diversion proposals and prepared costs estimates based on the actual proposal language and information provided. Reclamation did not alter the proposals, but concerns and potential problems are discussed, and improvements are suggested where applicable.

All Tier 2 evaluations were done at an "appraisal" level. Reclamation uses appraisal level analyses to compare alternatives to each other. Existing information is used to develop cost estimates, which have high contingency percentages to account for unknowns and small cost items that are not appropriate to define at the appraisal level stage. Appraisal level cost estimates should not be considered construction cost estimates, but instead a way to compare alternatives.

Reclamation considers geology related to proposed reservoirs to be the most significant unknown associated with all alternatives in this report. Geotechnical data on dam foundation and abutment stability, water tightness of the dam foundation, landslide potential, faulting, sinkhole potential, and alluvial depth to bedrock are some of the critical characteristics that would need to be thoroughly investigated for development of dam projects. Geologic investigations would require extensive drilling programs and geotechnical analyses before a dam site is considered acceptable and engineering can proceed.

Although appraisal level work typically limited to existing data, Reclamation performed some geophysics testing at three dam sites identified in Tier 2 proposals (Mogollon Creek, Mangas Creek, and Schoolhouse Canyon), one diversion site (Diversion 1), and one dam site associated with additional alternatives (Winn Canyon). The non-ground disturbing testing involved tracking seismic shock waves to obtain data on the depth of alluvium over bedrock in order to better quantify excavation and foundation treatments for dam construction.

A. Gila Basin Irrigation Commission proposal

Overview - Excerpts from the Gila Basin Irrigation Commission proposal

The Gila Basin Irrigation Commission (GBIC) is made up of surface and ground water irrigators in the Gila River Basin and includes members representing livestock producers, domestic well owners, realtors, habitat interests, landowners along the Gila River, and other parties affected or concerned about current and future availability of water in or from the Gila River.

GBIC has created a plan to identify needs, uses, and implementation options for water available under the Arizona Water Settlement Act (AWSA). Top ranking components were selected in the broad categories of diversion, conveyance, and storage resulting in the Project. Because diversion is necessary to accomplish all categories, GBIC is focusing their attention in this funding request to diversion structures related to existing acequias.

GBIC proposes the replacement of earthen diversions with two permanent concrete diversion structures. One diversion would be located at or upstream of the Upper Gila and Fort West Ditch diversions (See figure III-1. - Conceptual Project Components) The second diversion would be located where it can provide water to the Gila Farm Ditch. The diversions would be non-storage structures that would cross the main channel of the Gila River and the over-bank zone, to contain future channel migration.

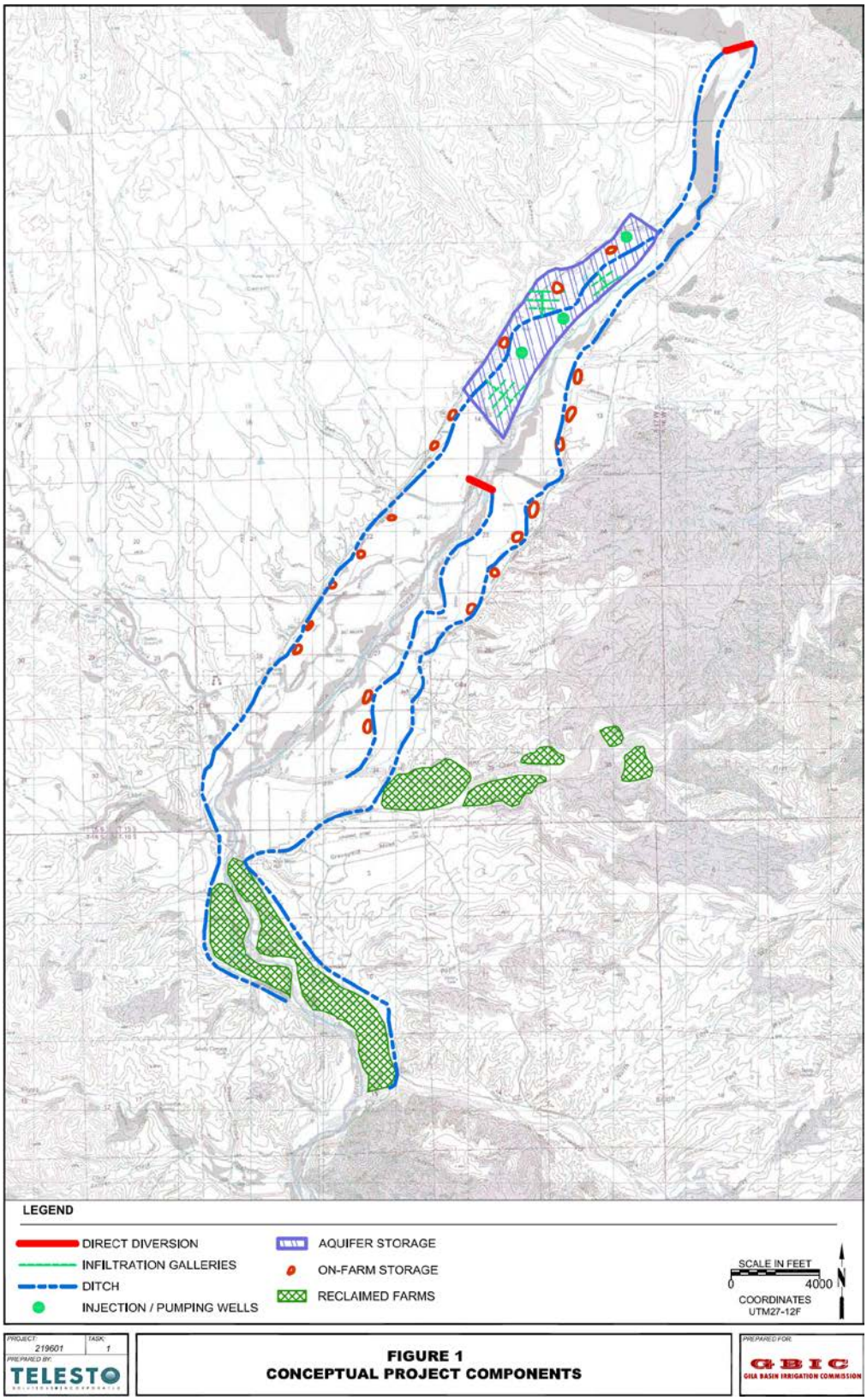

Figure III-1. - Conceptual project components (Figure 1 of GBIC Proposal)

Water diverted during times of adequate flow would be conveyed by unlined ditches to beneficial uses downstream. The existing Upper Gila and Fort West Ditches would likely distribute water from the northern diversion, while the Gila Farm Ditch would receive water from the southern diversion. Within the overall project, these ditches may be repaired or enhanced to accommodate flow as needed and/or new conveyance structures constructed in order to transport sufficient flow to use locations.

The overall Project also contains storage components of aquifer storage and "onfarm" surface storage. Aquifer storage involves the placement of diverted water into the unsaturated portion of the Gila River alluvium by a variety of possible means, including ditch and pond seepage, infiltration galleries, and injection wells. This storage can be recovered by wells and river return flows. The other storage component, "on-farm" storage, refers to the use of small- scale reservoirs to store diverted water on property owners' land. These may be in the form of stock ponds, small reservoirs, and even wetlands.[7]

Gila Basin Irrigation Commission (GBIC) - The GBIC proposal is comprised of three components: diversion, conveyance, and storage. Each component of the proposal is evaluated below using information contained within the proposal and additional information from GBIC personnel.

The principle components of the GBIC proposal are:

1. Divert surface flows from the Gila River at new or improved diversion structures.
2. Convey diverted flows in new canals/ditches to tie into existing ditches.
3. Store diverted Gila River water in unsaturated Gila Valley alluvium for later use at the Gila Farms Diversion.
4. Store diverted Gila River water in on-farm storage ponds for later use at the Gila River Diversion and/or farm fields served by the Upper Gila ditch and Fort West Ditch.

1. Diversion from the Gila River

GBIC proposes two new diversion structures. The upstream diversion would be located on the Gila River near the mouth of Mogollon Creek, just downstream of the Mogollon Box Campground. The other would replace the existing Gila Farm Diversion.

New diversion downstream of Mogollon Creek - The width of the active river channel at this point is roughly 600 feet wide. To ensure the river does not erode

[7] GBIC Proposal

around the end of the diversion, the structure would need to extend into the low terraces, requiring a total structural length of 950 feet. The structure can be located such that there is no impact to the Mogollon Box Campground

It may be less costly to build the diversion where the canyon is narrow, despite the additional conveyance distances; an estimated $1,000,000 less. However, the GBIC proposed diversion location ensures the use of flows generated within the Mogollon Creek watershed. Ditches originating from this diversion structure would run on each side of the river.

600 feet of the diversion would be structural concrete with a 7-foot tall crest to check up the water depth for the intake to the conveyance ditch. The intake inlet would be controlled with gates. Debris would be kept from entering the conveyance system with a trash rack/screen.

The remaining 350 feet of the structure to the canyon walls would be constructed of sheet piling driven 25 feet into the alluvium to prevent lateral movement of the river. 11 feet of the sheet piling would extend above original ground and would be hidden within a compacted embankment.

Diversion structures would be engineered to withstand the design flood, which would likely be the in the range of 100- to 250-year flood.

The cost to construct a diversion immediately downstream of Mogollon Creek is estimated at $9,300,000.

Replace Gila Farms Diversion – GBIC proposed replacing this diversion with a permanent concrete structure. A permanent structure would significantly reduce O&M costs since the current structure is unstable during runoff events and needs frequent repair. However, since the floodplain at this site is roughly 5,000 feet across, significant work would need to be done to ensure the river doesn't erode around an end of the structure and bypass the diversion. In order to ensure a stable structure, approximately 4,400 feet of wing wall would need to be constructed from the structure to the edge of the floodplain. The cost of replacing the Gila Farms Diversion with a structure that could withstand extreme runoff events would likely cost more to build than the upper diversion. Reclamation estimates the cost of such a structure to replace the Gila Farms Diversion to be $10,900,000. However, whether the cost of a structure of this magnitude is justifiable could be argued.

It is our understanding that a new Gila Farms Diversion would need to divert only about 12 cfs, as the existing structure currently does. If a new structure is not intended to divert AWSA diversions up to 350 cfs, there may be economic justification to install a smaller, less costly structure. Such an approach may require similar O&M effort as the existing structure, but could significantly

reduce up-front capital costs. Depending on the level of risk GBIC would accept for maintenance following runoff events, the cost of a new structure could be less than $1,000,000. This study shows the highest cost option of $10,900,000, which can be adjusted to reflect future decisions regarding the Gila Farms diversion structure.

To avoid the expense of constructing a second diversion entirely, GBIC may want to consider eliminating the Gila Farms Diversion and supply the Gila Farm Ditch from the Fort West Ditch. A half-mile long cross-cut canal or pipe could transport water from an up-sized Fort West Ditch to the existing Gila Farms Ditch. However, since the Gila Farms Diversion currently captures and diverts agricultural return flow, a structure may still be needed.**Diversion Comments - Scour** – Scour analyses need to be performed during the design phase for both the structural concrete section and the sheet piling wing wall to ensure the various types of scour do not undercut the structure.

Wing walls – Non-erodible wing walls, such as the proposed sheet piling, is essential to prevent the river from rerouting during runoff events and bypassing the structure. The initial capital investment in a stable structure with solid abutment tie-ins will significantly reduce long-term maintenance costs. Materials used to construct wing walls should be evaluated for cost effectiveness and ease of construction.

Sheet Pile Wall - Sheet piles can be used to create cost effective cutoff walls. Boulders in the alluvium can increase driving difficulties. Test pit investigations should be performed to determine how the boulder content of the underlying alluvium would affect construction bid prices. Steel sheet piling may have corrosion issues over time. Plastic sheet piling will resist corrosion, but the ability to be driven into rocky alluvium is limited.

Earth Materials – Concrete and riprap armored earth embankment could be constructed above existing ground to ensure all flows are directed over the structural concrete section of the diversion. Assuming a 300-foot structural concrete section, the embankment may need to be roughly 15 feet in height in order to contain the historical high flood flows.

Secant piles or slurry wall – These methods create a cementitious cutoff wall below ground. Low-strength concrete slurry mix of 1000 to 1500 pound/square inch compressive strength could be used. A reinforced wall would need to be extended above ground to roughly the height of the diversion structure's outer walls.

Sediment and debris – Since a significant amount of diversions will take place during higher flows, the intake to the conveyance system will need to be designed to handle sediment and debris. Trash racks will prevent larger debris, such as

trees and branches, and floating vegetation like grasses from entering the conveyance intake.

Sands and gravels can be settled quickly with a wider, slower velocity section at the upper end of the conveyance system. These settled materials would be sluiced back to the river downstream of the diversion structure. A second sluice gate further downstream would provide a mechanism to flush the conveyance system of any materials making it past the first sluice gate. There may be a need for additional sluice gates further down the canal.

2. Conveyance

New Canal/Ditch - Flows will be conveyed from the new upper diversion structure by means of two new open channel connection canals which will connect to existing ditches. The new canal on the west side of the Gila River will be about 0.8 miles long before connecting to the existing Upper Gila ditch. The new east-side canal will be roughly 1.5 miles long and connect to the Ft. West Ditch.

The new canals could each be sized to carry the maximum allowable flow of 350 cfs, which would provide the highest level of operational flexibility. However, in the interest of cost effectiveness, the ditches could be designed to carry a combined 350 cfs or some other flow, depending on final needs. Assuming 2 new canals, each with 350 cfs capacity at $400 per linear foot, the connection canals would cost an estimated $4,860,000.

If the capacities of the new ditches exceed that of the existing ditches, the existing ditches will require modification to carry the higher flow.

New ditches will need to be protected from runoff events associated with the Gila River and side drainages.

Existing Ditch Improvements – Depending on the capacity of the new ditches, portions of the existing Upper Gila and Ft. West Ditches may need to be upsized. If GBIC intends to convey 350 cfs, all existing ditches will need to be upsized. For cost estimating purposes, ditch sections requiring increased capacity should be considered as needing a total rebuild.

Sizing new ditches and expanding existing ditches is dependent on several factors:

- Rate at which water can be stored in the unsaturated alluvium.
- Time required to fill the on-farm storage reservoirs.
- Number of on-farm storage reservoirs.
- Size of on-farm storage reservoirs.

- Optimization of the relationship between capital costs and operational flexibility.

In order to generate firm cost estimates and to optimize costs, the sizing of ditches requires much more discussion to be able to quantify accurately. For a placeholder, existing ditch improvements are estimated to cost $1,000,000.

The existing Upper Gila, Ft. West, and Gila Farm Ditches will require the installation of new gates to allow the release of water into infiltration galleries and on-farm storage ponds. A short section of ditch will need to be concrete lined for each gate structure. Slide gates provide an inexpensive means for low pressure applications. The cost of installing slide gates in existing ditches is included in the cost estimates for constructing infiltration galleries and on-farm storage ponds.

3. Storage

Infiltration Galleries: An infiltration gallery is essentially a horizontal well or subsurface pipe that intercepts underground flow within permeable materials. Depending on the intended purpose and design, an infiltration gallery can either drain saturated soils (See Figure III-5. - Collection System) or deliver water to unsaturated soils similar to a leach field (See Figure III-4. - Recharge System). Infiltration galleries are usually constructed to discharge water into a pumped sump. The gallery can be placed below or adjacent to a river. The gallery needs to be placed in permeable soils and the collector pipelines should always be enveloped with gravel.

Infiltration galleries come in two basic configurations – bed-mounted galleries and on-shore galleries. In a bed-mounted gallery, intake screens are buried beneath the water body in a constructed trench that is backfilled with a suitably sized filter pack material. In an on-shore gallery, the intake screen is buried in a trench constructed parallel to the water body shoreline, and is also backfilled with a suitable filter pack material.

For the purposes of this report, the delivery of water to the unsaturated alluvium through an array of piping will be called the “recharge system”. The infiltration gallery concept for draining saturated soils will be called the “collection system”.

The GBIC proposal describes using infiltration galleries or injection wells to store water in unsaturated Gila River alluvium. GBIC further clarified in a subsequent conversation that water stored in the alluvium would be used to increase the duration of seepage flow from the alluvial aquifer to the Gila River. This seepage flow would supplement normal river flows at the Gila Farms Diversion since

there are times during the irrigation season when river flows do not meet the water needs for the Gila Farm Ditch. The concept would be intended to provide approximately 90 days of flow during the dry season.

Estimates of the aquifer storage capacity in this project consist of determining the fillable capacity of the vadose zone, or the partially saturated to unsaturated zone above the water table. The fillable capacity of the vadose zone is dependent on the thickness of this zone, which is defined by the depth to water both spatially and temporally, the lateral area of the storage zone in question, and on the material characteristics of the vadose soil zone. The material characteristics include the estimated specific yield, specific retention, in-place density and cementation of the soil matrix, and in-situ saturation from previous percolation events.

Reclamation made a number of simplifying assumptions to derive an estimate of the volume of water which could be stored (neglecting time dependent recharge and discharge), and certain land use restrictions (e.g., that waterlogging is acceptable); that with the exception of some thin but unconsolidated surface or near-surface silt layers, there are no obvious clay layers, caliche seams (aquitards), or impeding layers in the soil profile from an inspection of fifteen NMOSE WATERS Drillers' Logs or S.S. Papadopulus & Associates, Inc. surface water-groundwater interaction piezometer boring logs; that the saturated zone in the alluvial aquifer is hydraulically connected to and continuous with depth into the full saturated thickness of the underlying Gila Conglomerate; that the average depth to water for the alluvial aquifer over the project focus area throughout the year is 18 feet bgl (from the 13 wells of the NMOSE WATERS database), and a range of specific yield is used to calculate the range of potential alluvial storage capacity (Table III-1. - Estimated Vadose Zone). It is also assumed there will be no additional storage in the Gila Conglomerate. The 350 acre storage area (shown on Figure III-2 is assumed as a unit block of alluvial aquifer without considering that lateral storage increases elsewhere (e.g., under residences, roads, etc.) would in reality increase any potential estimates of storage volumes.

The storage capacity of the unconfined alluvial aquifer system (water table aquifer) is dependent on the specific yield. Specific yield is the physical drainage or dewatering (or filling of) of the water in the pore spaces by gravity in the alluvial matrix. Not all of the water filling the pore spaces can be drained or recovered due to some retention of water in the pores – specific retention. Specific yield plus specific retention of a porous medium equals the porosity.

The specific yield is defined as the ratio of the volume of soil voids that can be drained by gravity to the total volume of the saturated soil, or:

$$S_y = V_D/V_T$$

where:

V_D = volume of water drained by gravity, and

V_T = volume of saturated soil

The instantaneous storage capacity volume is then the product of specific yield, aquifer area, and addition in vadose zone head (ft.) or:

$$\Delta V = S_y A \Delta h$$

The proposed recharge area shown on Figure III-1: Conceptual Project Components(Figure 1 of GBIC Proposal) was estimated in GIS at about 560 acres. However, using only the five preferred soil groups (#43, #32, #33, #44, and #69) shown on Figure III-3 NRCS National Cooperative Soil Survey Web Soil Map for Focus Study Area west of the river in the focus area of study, primarily sections 11-14, the total acreage for all five soil groups in the AOI is 725 acres, but not all that area is useable.

For instance, soil group #67 accounts for 40 acres but it is a silty clay loam and would not be expected to be a favorable soil for infiltration. The other five soil groups (#43, #32, #33, #44, and #69) have more favorable infiltration and storage properties. Table 1 in Appendix D summarizes the soil characteristics and estimated infiltration properties.

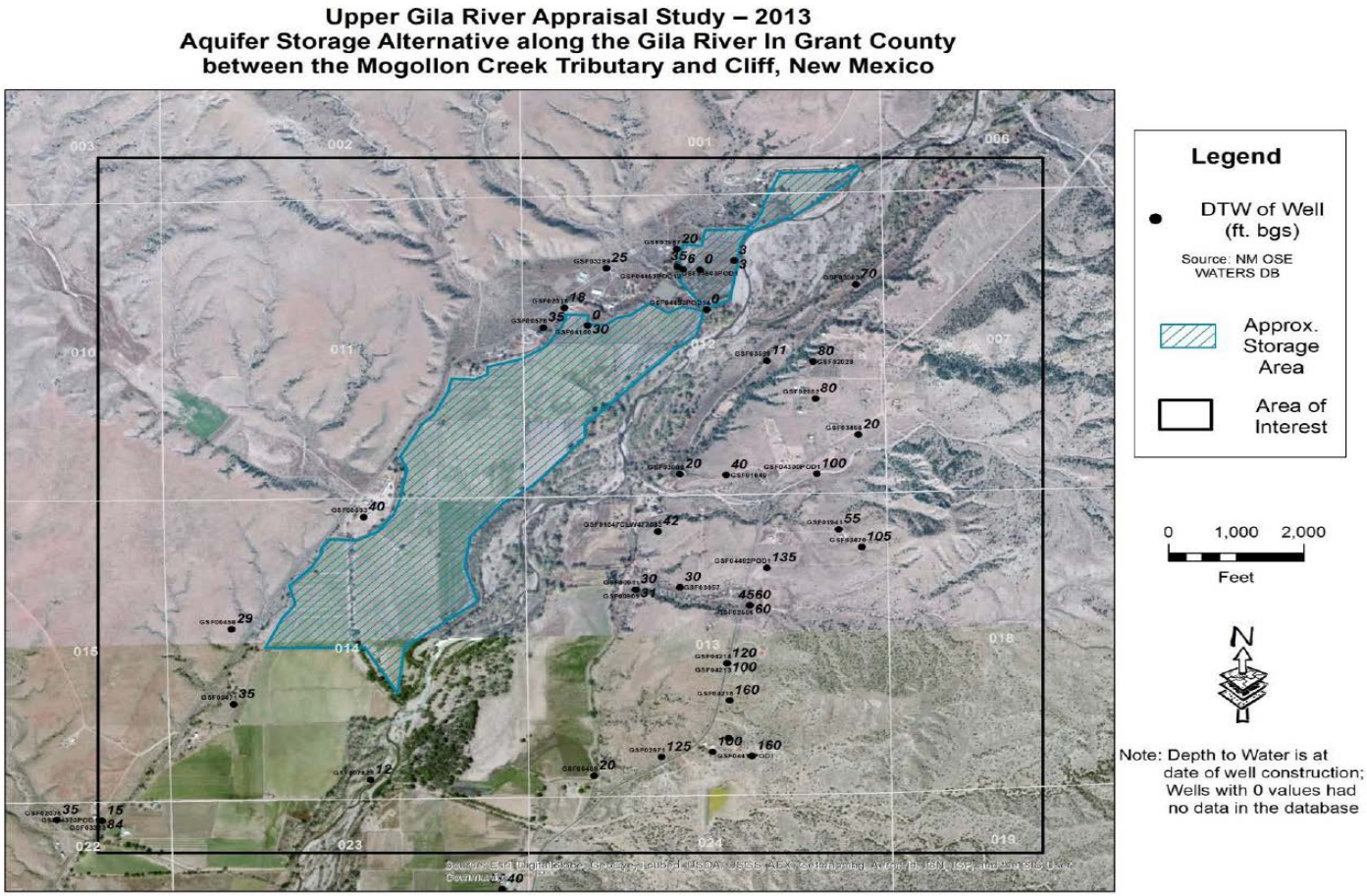

Figure III-2. Study area showing wells and recharge area used in analysis

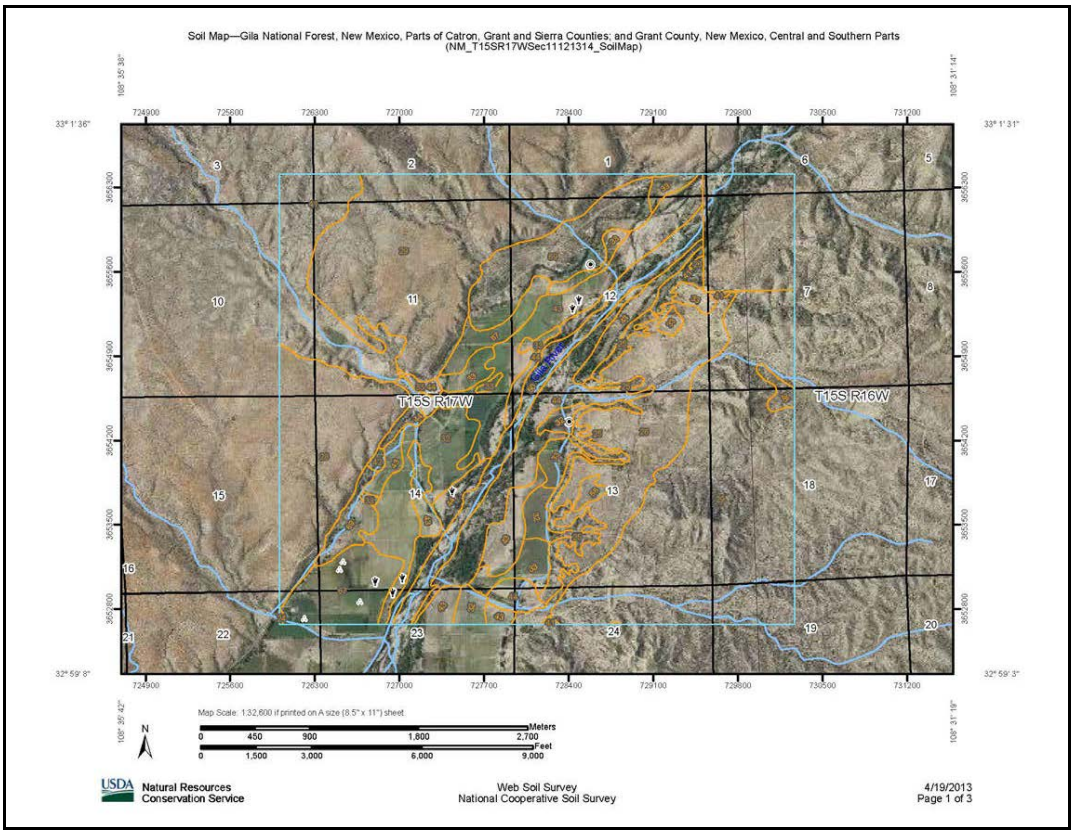

Figure III-3. - NRCS National Cooperative Soil Survey web soil map for focus study area

Figure III-2 shows three polygons defining the extents of the farm/open fields where infiltration gallery/collection infrastructure could be buried below the fields. These areas are estimated in GIS at 18 acres, 22 acres, and 305 acres. This gives approximately 350 acres available for infiltration recharge of surplus water. Using a typical range of specific yield values, the following appraisal level estimated storage volumes are presented in Table III-1. The 0.05 specific yield is based on S.S. Papadopulos & Associates, Inc. (SSPA) calibrated Reach 1 riparian model value for the layer 1 channel alluvium. A typical sandy, gravely, cobbly alluvium with some silty fines should have a specific yield of 0.2, or 20 percent.

Table III-1. - Estimated vadose zone
Storage under Farm/Open Fields West of the River in the Project Study Area (AOI) Sections 11 - 14 using a Range of Specific Yield and Average Annual Depth-to-Water of 18 feet bgl.

Specific Yield	Acre-feet of Potential Storage (based on 350 acres)
0.05	315
0.10	630
0.20	1260

SSPA (2004) used an on-farm percolation rate in their riparian models of a recharge rate of 0.00415 feet per day over a 241 day typical irrigation season (0.00415 ft./day * 350 acres * 241 days). At such a constant infiltration rate, and assuming all the soil groups have similar percolation rates to the farm fields, applying that rate over 350 acres would equate to a recharge rate of about 1.45 AF per day or 350 AF per 241 day irrigation cycle.

The range of expected aquifer storage might then be roughly 350 to 1000 AF at any given snapshot of time.

These estimates don't factor in transient (time-dependant) seepage outflows or other inflows into the 350 acre unit block of aquifer. Static water levels within the proposed approximately 350 acre groundwater storage area (the cross-hatched region shown on Figure III-2), fluctuate seasonally in response to natural and artificial recharge (flood/storm water, agricultural return flows, stock tank seepage, river losses, etc.) and any diversions, pumping, or evapo-transpiration taking water out of groundwater storage.

This fluctuation in groundwater levels translate into corresponding changes in the available, seasonal vadose zone thickness available for storage of Gila River flood waters. The soil moisture content within the vadose zone will also vary, which also affects the amount and the rate at which the diverted flood waters can be recharged in the 350 acre farm field area. These hydrologic processes are dynamic and the groundwater flow system (and thus potential aquifer storage capacity) is constantly in motion, moving from areas of recharge to areas of discharge. This is true whether some portion of Gila River flood flow is being diverted and recharged under the farm fields, or not. Additional flood flow recharge will cause static water levels to rise and a groundwater mound to form, which will increase hydraulic heads, changing groundwater gradients and increasing the rate at which groundwater will flow and migrate down-gradient, and laterally as baseflow discharge to the river, from the storage area. Thus, the potential aquifer storage volume will not be constant over a given year and the rate at which the aquifer storage area can accept recharge will vary throughout the year based on both natural and anthropogenic factors.

The aquifer and aquifer storage area is not analogous to a bathtub. Short of constructing a positive cut-off engineered barrier such as a slurry cut-off wall, secant pile or sheet-pile type cellular barrier wall around the 350 acre farm fields to a lower permeability formation (such as the underlying Gila Conglomerate, or deeper volcanic rocks), or by using hydrodynamic controls (pumping/injection wells), there is no practicable way to isolate the aquifer storage area as would occur if one could construct an underground storage tank.

The range of expected aquifer storage might then be roughly 350 to 1000 AF at any given snapshot of time.

These estimates don't factor in transient (time-dependant) seepage outflows or other inflows into the 350 acre unit block of aquifer. Static water levels within the proposed approximately 350 acre groundwater storage area (the cross-hatched region shown on Figure III-4), fluctuate seasonally in response to natural and artificial recharge (flood/storm water, agricultural return flows, stock tank seepage, river losses, etc.) and any diversions, pumping, or evapo-transpiration taking water out of groundwater storage.

This fluctuation in groundwater levels translate into corresponding changes in the available, seasonal vadose zone thickness available for storage of Gila River flood waters. The soil moisture content within the vadose zone will also vary, which also affects the amount and the rate at which the diverted flood waters can be recharged in the 350 acre farm field area. These hydrologic processes are dynamic and the groundwater flow system (and thus potential aquifer storage capacity) is constantly in motion, moving from areas of recharge to areas of discharge. This is true whether some portion of Gila River flood flow is being diverted and recharged under the farm fields, or not. Additional flood flow recharge will cause static water levels to rise and a groundwater mound to form, which will increase hydraulic heads, changing groundwater gradients and increasing the rate at which groundwater will flow and migrate down-gradient, and laterally as baseflow discharge to the river, from the storage area. Thus, the potential aquifer storage volume will not be constant over a given year and the rate at which the aquifer storage area can accept recharge will vary throughout the year based on both natural and anthropogenic factors.

4. Recharge system

Injections wells: Injection wells have the potential to introduce lower quality water (surface water) into the alluvial aquifer, which could prohibit their use. In addition, the unsaturated alluvial zone is a relatively thin layer, which doesn't lend itself to efficient recharge from point sources like injection wells. For these reasons, injections wells were not evaluated further in this study.

Recharge Basins: Although recharge basins would provide efficient and cost effective storage of water in the unsaturated alluvium, this concept is not addressed in this report because recharge basins were not part of the GBIC Tier 2 proposal, and because basins would take up cultivated land. A brief discussion of recharge resulting from unlined on-farm storage ponds is included in Section III.6.

Slotted pipe: Reclamation evaluated a recharge system consisting of an array of below-ground slotted pipes, similar to a large scale leach field. The average thickness of unsaturated alluvium within the area identified in the GBIC proposal is 18 feet. This unsaturated "vadose" zone is similar throughout the Cliff-Gila valley. Because the unsaturated alluvium thickness averages only 18 feet, a recharge system needs to apply water evenly over as much area as possible. An array of slotted piping would meet this criterion and satisfy the intent of the GBIC proposal.

Four-inch diameter slotted polyvinylchloride (PVC) pipe would be spaced at 10-foot intervals to perform the recharging function(see Figure III-4: Recharge System). Further evaluation should be done to optimize the exact spacing, but 10 feet is reasonable based on the geologic information available. Recharge piping should be as close to the ground surface as possible to maximize storage and reduce installation costs. However, since most of the piping array would be in farmed fields, the piping needs to be below the plow zone, and below ripping depth (if applicable).

Reclamation set the recharge piping 4 feet below the ground surface, leaving an average of 14 feet (18 feet – 4 feet) of unsaturated alluvium water storage.

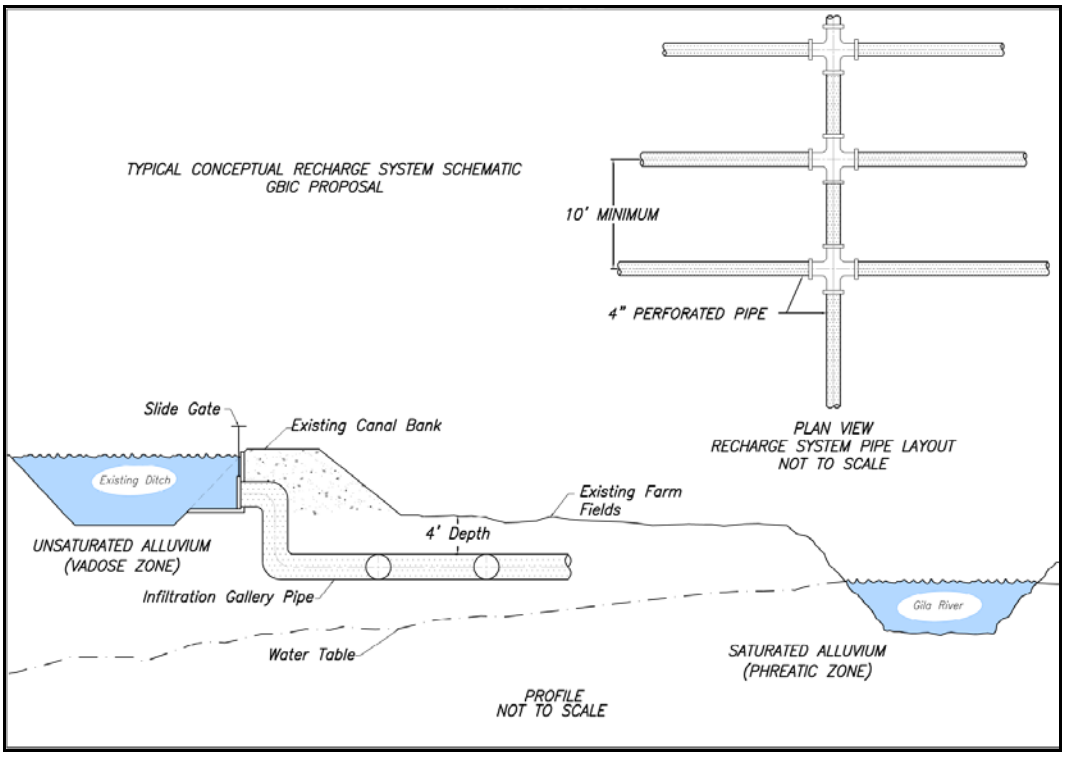

Figure III-4. - Recharge system

The area identified in GBIC's proposal for aquifer storage covers approximately 560 acres (about 2 miles of floodplain). Roughly half of this acreage is not conducive to pipe placement because of development, such as residences, yards, farm buildings, roads, ditches, and other improvements, leaving about 350 acres of land for the installation of a recharge system.

Calculating the amount of pipeline at 10-foot spacing over 350 acres, the maximum flow rate that can be taken into the system and effectively recharged is approximately 5.3 cfs.

As described in the Aquifer Storage paragraph III.2, the total alluvial storage available in the 350-acre area is estimated to range from 500 to 1,000 AF. Recharging 5.3 cfs equates to 10.6 ac-ft/day. Recharging at this rate to achieve a stored volume of water of 500 to 1,000 AF would require roughly 50 to 95 days. In order to supply a recharge system for extended periods of 50 to 95 days, storage would be necessary; for example on-farm storage ponds, side canyon storage.

The estimated alluvial storage capacity of 500 to 1,000 AF is probably conservative in that the recharge area of 350 acres will spread throughout the total study area's 560 acres and into permeable substrates outside of the study acreage, resulting in more potential storage. Additionally, the alluvial storage capacity will cycle several times per year as runoff events occur and diversion

opportunities arise and terminate. If an alluvial recharge project is considered, definitive groundwater modeling and geologic investigations are advised to assess benefit/cost ratio and thoroughly quantify aquifer storage, groundwater movement, and soil permeability.

Clogging: Because the water to be used in the recharge system is surface water, the system will likely have to cope with clogging issues. Floating debris will be carried into the pipe array, reducing the ability for the slotted pipe to deliver water to the ground. Suspended fines will be introduced into the alluvium along each pipe, reducing soil permeability and recharge rates. Since diversions off the Gila River will generally take place during higher flows, suspended sediments will have to be dealt with. These items are significant O&M issues. The larger debris may be able to be flushed through the system. There are references to using pressurized air to break up the silt blockage in the soils around the slotted pipes. Reclamation cannot comment on the effectiveness of this approach.

In Reclamation's opinion, these clogging concerns, particularly the silt sealing, are significant enough to warrant further study and possible testing before identifying piped recharge as a viable alternative. Recharge basins experience the same problems, but wet/dry cycles and periodic ripping are used to break up the silt and schmutzdecke clogging (a biological layer that forms on the bottom of water bodies). These mitigative actions are probably not applicable or cost effective with an underground piping system. At this time, with the information available, there are too many O&M questions with an underground recharge system to be considered as a vetted, workable alternative.

Raise water table: Recharge operations will raise the water table in the immediate area. Although the average depth of unsaturated alluvium is 18 feet, the depth to groundwater is not uniform throughout the proposed recharge area. There are already boggy areas which would be expected to increase in size, and new waterlogged areas would likely appear, possibly affecting farming operations. The higher water table may negatively impact residences, leach fields, septic tanks, and other structures and development.

Groundwater quality: Higher water table elevations resulting from recharge operations may affect the quality of water in existing wells. The residences receive water for domestic use from wells that primarily rely on the alluvial aquifer. Although the source remains the same (Gila River), the project recharge locations and quantities may alter water quality in wells.

Lost water: The unsaturated alluvium storage reserve is an unconfined system. Depending on recovery methods, there may be a volume of water lost to the surrounding substrates that may not be recoverable. The economics of paying for AWSA water may force pumped recovery from new or existing wells as opposed to passive recovery methods.

5. Recovery of stored water in alluvial aquifer

Water stored in the unsaturated alluvium is intended for use at the Gila Farm Diversion, which experiences insufficient flows at certain times of the year. The recovery of the stored water and its delivery to the Gila River upstream of the Gila Farms Diversion (or directly into the Gila Farms Ditch) can be accomplished by several means. The desired flow to be delivered is 12 cfs[ ].

Recovery Wells – Stored water can be recovered using existing or new wells. Existing wells may not have the combined capability to produce 12 cfs, so new wells may be necessary. A new well capable of producing 300 gallons per minute (0.6 cfs) would cost an estimated $84,000. Pumping O&M costs would be significant. A rough estimate of pumping costs to produce 12 cfs from a depth of 11 feet below ground for 90 days per year is $62,000. The advantage to pumping is that the case can be made that the wells are recovering only diverted and stored water, and no water is lost to natural lateral migration. A well field capable of producing 12 cfs is estimated to cost $1,600,000.

Infiltration Gallery Collection System – The infiltration gallery concept shown in Figure III-5 is a simple, passive recovery method capable of delivering 12 cfs. If positioned within saturated alluvium, water will fill the slotted pipe and be conveyed back to the river. Discharges are controlled with valves to adjust flows. The concept consists of three parallel runs of optimally sized slotted collection pipe, ranging from 4-inch to 12-inch diameter. Each pipe run is roughly 1,500 feet long and the runs are spaced about 1,200 feet apart. The collection pipes feed into a 15-inch diameter solid pipe for gravity transport to the river.

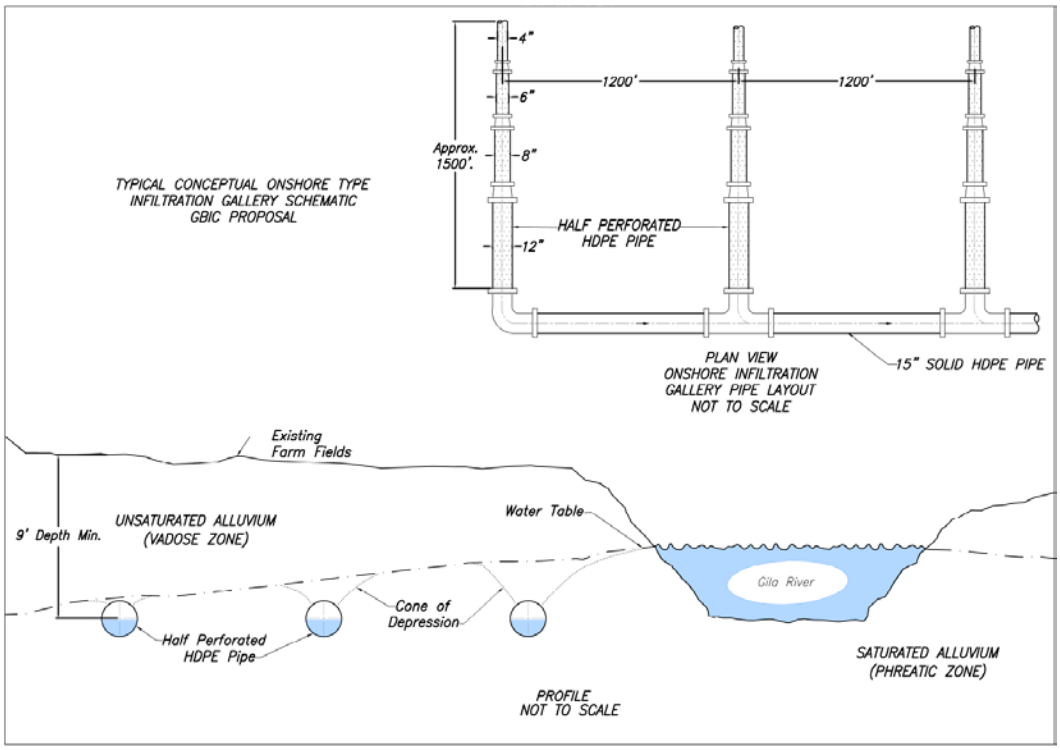

Figure III-5. - Collection system

The infiltration gallery would be situated about 9 feet below ground surface to capture water from a constructed recharge system or natural groundwater fed by the river. The transport pipe would gradually daylight at a slope flatter than the general slope of the land.

Power needs for an infiltration gallery are insignificant, required only for flow monitoring, SCADA, valve operations, and vault lighting and ventilation.

The primary concern with an infiltration gallery is that not all the water diverted and stored in the alluvium will be recoverable. The unsaturated alluvium is an unconfined storage system. Some percentage of the stored water will sink below the elevation of the infiltration gallery, and an additional amount will migrate outside the area of influence of the infiltration gallery.

An infiltration gallery capable of producing 12 cfs is estimated to cost $1,100,000.

Lateral Migration of Stored Groundwater – After being stored in the vadose zone, a percentage of the mounded water will move laterally in all directions. The portion moving back toward the Gila River will replenish river flows, to be used downstream at the Gila Farm Diversion. The rate at which these return flows add

to the streamflow would be difficult to predict and is dependent on underground water mounding height, alluvial permeability, distance from recharge points, flow depth in the river, and other local impacts.

Similar to the infiltration gallery, not all the water diverted and stored in the alluvium will be recoverable. The unsaturated alluvium is an unconfined storage system. Some percentage of the stored water will sink below the elevation of the riverbed profile, and an additional amount will migrate away from the river.

Advantages of the migration approach are no power costs, and no collection system required. After water is recharged, there are no capital costs or operating costs.

Disadvantages are lack of flow control and non-recoverable water that migrates away from the river.

There is no cost associated with relying on return flows from the recharge system to replenish the river.

6. Injection wells

Because the unsaturated alluvium is limited to about 18 vertical feet, injection wells are not a good choice for putting water into the alluvial aquifer. The soils would accept the water at a similar unit rate as the recharge system described in Section III A.4., but with far less pipe area. Exceeding that rate would result in water boiling up at the the well. Injecting into deeper aquifers would need to address permitting issues associated with potentially poorer quality surface water affecting higher quality groundwater.

7. On-farm storage ponds

Figure III-1: Conceptual Project Components shows 19 on-farm storage ponds fed by existing ditches. During a discussion with GBIC, Reclamation was told that 19 storage ponds were more than would be pursued, and a more likely number would be 8-10 storage ponds. The storage ponds would be approximately 2 acres in size and 15-foot deep maximum water depth.

Reclamation estimated costs for 10 storage ponds with a total storage volume of 300 acre-ft. Storage ponds would be located adjacent to the existing Upper Gila and Fort West Ditches to utilize the ditch embankment for one side of the ponds. Conceptually, the storage ponds would include 5 feet of excavation for both storage space and to obtain borrow material. Excavated material would then be used for compacted embankment to contain the stored water. Slide gates would be installed in the exiting ditches to release water into storage ponds. A second slide gate would release water from the storage pond into a pipe that will gravity

feed into the farm fields below. The conceptual design is shown in Figure III-6. Erosion control features will need to be incorporated at pipe outlets into and from the storage ponds.

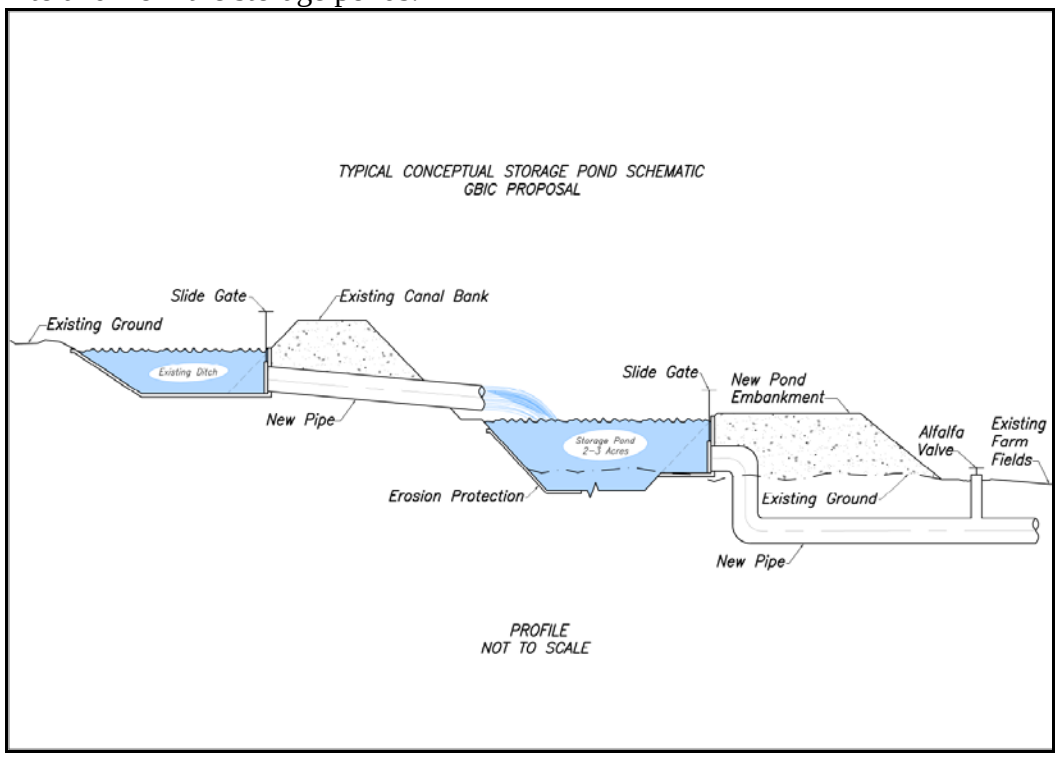

Figure III-6. - Typical conceptual storage pond schematic

Even though a portion of the pond storage is below ground, the entire contents of the ponds could be emptied with a 500-foot long pipeline due to the natural slope of the valley floor. Above-ground storage volume can be released to farm ditches and fields adjacent to the ponds.

Storage Pond Seepage - Significant seepage losses are expected from the storage ponds into the ground. Initially the seepage rate could be as high as 3 to 5 feet per day[x3], but would slow within days as fines begin to clog the seepage paths. Once the schmutzdecke (a biological layer that forms on the bottom of water bodies) develops, the seepage rate will drop even further, to an estimated 0.2 feet per day. Seepage could be put to beneficial use as a recharge method, or prevented entirely with liners, as discussed below.

Storage Pond Recharge – Since seepage is expected from on-farm storage ponds, the ponds could function as recharge basins, with the water being stored in the unsaturated alluvium. Water would then be recovered from wells when needed. Open basins are considered the most cost effective method of recharging when land is available. Recharge rates decline quickly as fines are introduced into the alluvium and as the schmutzdecke forms. Open basin recharge operations

mitigate these issues with yearly wet/dry cycles and disking or ripping of the basin invert. Wet/dry cycles alone significantly improve recharge rates by eliminating the schmutzdecke layer.

Reclamation anticipates the pond inverts would undergo dry periods during normal operations, thereby keeping recharge rates at an effective level. Fines would continue to be deposited in the ponds, slowing recharge rates. Disking or ripping may become necessary if the ponds are to be kept functioning as recharge features.

Storage Pond Liners – If recharge from on-farm storage ponds is not pursued, liners can be installed to eliminate seepage entirely. Liners can be covered with soil for a more natural appearance. The cost to line one storage ponds is estimated at $163,000.

8. Operation and maintenance

Operation, Maintenance, and Replacement (OM&R) costs are difficult to estimate without a defined project. For the GBIC proposal, the yearly OM&R costs are assumed to run 1.4% of the total project cost. The replacement component is included in this percentage as an average cost per year, but in reality replacement needs would increase as the system ages.

OM&R is estimated to average $585,000 per year.

9. GBIC proposal evaluation summary

1. A new structural concrete diversion structure downstream of Mogollon Creek can be constructed without unreasonable engineering and construction issues. But the width of the floodplain at this location requires significant wing wall protection to prevent runoff damage and keep O&M costs low, resulting in an estimated cost of $9,300,000 for a reliable, stable structure. A new diversion for Gila Farm would be located in a wider floodplain and would likely cost more than the Mogollon Creek location.

2. Conveyance canal capacity from the diversion structure to existing ditches is dependent on final uses, which is not defined at this time. A rough estimate for two 2-mile concrete lined ditches, one on each side of the river, with capacities of 20 cfs at $100 per linear foot, would cost an estimated $2,100,000.

   For the purpose of this study, costs were estimated for two 350 cfs connection canals; total cost $4,860,000.

3. Available storage capacity of the unsaturated alluvium within the 560-acre area identified in the GBIC proposal is estimated to range from 500 to 1,000 AF. The cost to construct a recharging system to store this quantity of water is estimated at $10,900,000. Problems associated with leaching-type systems include:

    - Slow recharge rates as fines infiltrate the alluvium

    - Maintenance issues with a buried system.

4. Recovery of water from floodplain alluvium could be done with wells (existing or new), a passive system like an infiltration gallery, or reliance on movement of stored water through the alluvium to replenish the river. Since existing well capacity is not quantified, Reclamation developed cost estimates for a controllable discharge infiltration gallery, $1,100,000.

5. On-farm storage ponds can be constructed for an estimated $380,000 per pond. The ponds can be lined to prevent seepage losses for an estimated $163,000 per pond. Unlined ponds could double as storage reservoirs and as recharge basins.

10. Engineering Conclusions GBIC proposal

1. Reclamation did not identify critical concerns associated with diversion structures, although the wide floodplain locations require significant wing wall components which result in additional costs. The downstream diversion (Gila Farms) may never be required to divert more than 12 cfs, so less expensive options may be appropriate.

2. Water conveyance structures are relatively straightforward. Sizing new and modified ditches to optimize costs versus operational flexibility is the principle challenge.

3. Storage in unsaturated alluvium provides limited storage potential, estimated from 500 to 1,000 AF. The estimated cost per AF is high compared with other storage alternatives, about $15,000/AF. Fines carried into a leach-type recharge system will negatively impact recharge rates and pressure jetting may not adequately mitigate the problem. This is not a good application for injection wells because of the limited 18-foot thick unsaturated storage zone. The on-farm storage ponds are probably the best and least expensive recharge method, although farm land is sacrificed by the ponds' footprints.

Storage in unsaturated alluvium presents a number of significant concerns and unknowns for such limited storage. In Reclamation's opinion, alluvial storage does not appear to be economically viable.

4. Recovery of alluvial storage can be accomplished with new or existing wells, infiltration galleries, or reliance on lateral water movement though permeable soils to replenish river flows. Each option has its pros and cons, but all are reasonable approaches to recovery.

5. On-farm storage ponds present no major engineering, construction, or O&M concerns. If unlined, the ponds may function as recharge basins.

6. **Overall** – Reclamation's biggest concern with the GBIC proposal involves water storage in unsaturated alluvium. Considering the limited storage, initial capital cost for recharge, and expected clogging problems associated with the underground recharge system, the concept presents enough concerns to justify reconsideration. Open basin recharge and recovery using wells could deliver more dependable water at a lower cost.

The diversion, conveyance, and recovery features of the GBIC proposal are reasonable, and in Reclamation's opinion, exhibit no fatal flaws.

11. Project cost

The total project cost is estimated at $41,800,000

Upper diversion structure	$9,300,000
Gila Farms diversion structure	$10,800,000
Connection ditches (2 @ 350 cfs)	$4,860,000
Upsize existing ditches	$1,000,000
Storage ponds (10)	$3,800,000
Pipeline recharge system	$10,900,000
Infiltration Gallery	$1,100,000
	$41,800,000
OM&R	$585,000/yr

12. Environmental

Biology - Gila Basin Irrigation Commission Diversion and Storage.
No records for listed fish exist within Mogollon Creek that would be impacted by the diversion. There are native long-finned dace in this creek.The creek is comprised of a sycamore vegetation complex and it is possible that habitat for the yellow-billed cuckoo is along the drainage.

The creek has habitat fornorthern narrow-headed gartersnakegartersnakegartersnake and the northern Mexican gartersnakegartersnakegartersnake.

Cultural - Gila Basin Irrigation Commission Diversion and Storage.
The location of the proposed diversions associated with this project is about ½ a mile from where the Gila River and Mogollon Creek join in Grant County. Earthen dams currently exist, but a permanent diversion structure would be built. Storage would be within and along the river. The Interstate Stream Commission did a basic desktop study of the Grant County area for Cultural Resources. A one-hundred percent cultural resources survey in all areas of ground disturbance is necessary, as well as less intensive surveys as developed in consultation under the NHPA, Section 106 process with the New Mexico SHPO, Native American groups and other interested parties. The intensive survey is especially important due to the project's proximity to the river. Avoidance of all cultural resources is recommended if possible as testing and excavation can be a very costly undertaking. It is recommended that if planning proceeds, an analysis that includes costs of acquiring the private land needed, the cultural surveys and possible mitigation be included as part of the overall project cost.

B. Southwest New Mexico regional water supply project (City of Deming)

Overview - Excerpts from the Southwest New Mexico Regional Water Supply Project proposal

This New Mexico Unit project, entitled the Southwest New Mexico Regional Water Supply Project, amends the City of Deming's Surface Water Diversion Project application by providing significant additional feasibility and cost analysis and further defining the conceptual approach outlined in the original application. This proposal addresses and annual use of up to 10,000 ac-ft. of Gila River Arizona Water Settlement Act (AWSA) water, and it supports full development of the 4,000 AF allocated to the San Francisco River in Catron County, although the latter is not specifically covered in the proposed project.

This proposal includes a 5000-AF capacity reservoir that is currently proposed to be located at Mogollon Creek. Farther downstream, on the Gila River, a subsurface diversion structure would be constructed and water conveyed to a side channel reservoir with an approximately 30,000-ac-ft storage capacity that would be constructed on the Mangas Creek.

Water from the Mogollon reservoir would be released to the Gila River for downstream agricultural use and during low flows for environmental mitigation purposes. Water stored in the Mangas reservoir would be piped to the Silver City

area and mining district communities and would gravity flow through a pipeline to the City of Deming.

For both reservoirs, water would be diverted from the Gila River during the flow regimes allowed by the Consumptive Use and Forbearance Agreement (CUFA) rules under the Arizona Water Settlement Act (AWSA). The Mogollon surface diversion would be capable of diverting up to the maximum rate of 350 cubic feet per second (cfs) from Mogollon Creek, and the subsurface diversion from the Gila River would be capable of diverting up to 115 cfs.

The Mogollon reservoir would capture flows from the creek that could be released to the Gila River. A series of five, subsurface horizontal collector wells would be needed at the Mangas diversion site. Water diverted through these wells would be conveyed to a side canyon surface reservoir prior to being pumped up to the elevation divide through a series of booster station and into a pipeline where it would then gravity flow down to Grant and Luna County users (Figure III-7.). Water can also be released from the Mangas reservoir for use in the Virden area and elsewhere in Hidalgo County.

The Southwest New Mexico Regional Water Supply Project proposal involves five components: capture, storage, diversion, pumping, and conveyance. Each component of the proposal is evaluated below using information contained within the proposal.

The principle components of the Southwest New Mexico Regional Water Supply Project proposal are:

1. Construct dam to capture natural flows in Mogollon Creek.
2. Release stored flows from the Mogollon reservoir for agriculture and environmental purposes.
3. Divert water from Gila River using subsurface diversion.
4. Pump diverted Gila River water to a reservoir on Mangas Creek.
5. Convey diverted water from Mangas Creek reservoir to Silver City, Bayard, Santa Clara, Hurley, and Deming.

1. Diversion from the Gila River

The City of Deming's proposal consists of two diversion components. The first is capturing and storing natural flows in Mogollon Creek, essentially diverting Gila Basin water before it reaches the Gila River. The second diversion consists of subsurface diversion, pumping, and storage of up to 30,000 ac-ft. of water in a Mangas Creek reservoir.

2. Mogollon Creek diversion and dam

This concept relies entirely on the capture and storage of 5,000 AF of natural flows generated in the Mogollon Creek watershed. The average annual runoff at the Mogollon Creek stream gauge (Gauge No. 09430600) is 21,880 AF per year, from years 1967 to 2013. The gauge is located about 13 miles upstream of the Gila River and the proposed dam site. The yearly runoff fluctuates greatly; for example 42,180 AF were recorded in 2013, but only 4,010 AF in 2012.

A dam placed near the mouth of Mogollon Creek could potentially hold 11,600 AF. The actual watershed yield combined with reservoir seepage and evaporative losses needs to be evaluated to correctly size the reservoir.

Runoff events generated within the Mogollon Creek watershed usually exceed 350 cfs on a yearly basis, with the high flow of record being 10,800 cfs (USGS). According to AWSA restrictions, diversions are limited to 350 cfs, which implies that natural runoff entering a reservoir exceeding 350 cfs would be released from the reservoir at the same rate. This could be achieved if reservoir levels were high enough to utilize the spillway. However, the majority of time the outlet works would be the only way to release stored water. Outlet works are sized for downstream use and to meet reservoir evacuation criteria. For economic reasons, outlet works would not normally be sized to spill high flow flood events. Reservoir levels below spillway initiation require temporary storage of flood flows. Stored flood volumes are then released per legal requirements or for downstream use. The AWSA does not specifically address this flood storage issue. Legal review is recommended to define flood storage policy.

Reclamation developed cost estimates for the 5,000 AF reservoir and dam described in the Deming proposal. The site characteristics (relatively wide, sloping abutments, deep alluvial foundation) lend themselves to an earthen dam, roughly 1600 feet across the stream with a structural height of 80 feet. The dam site is roughly 1.2 miles upstream from the confluence with the Gila River. Conceptual plan view and cross-sections for a dam at this site are shown in Figure III-7. The conceptual dam would be a zoned structure, with an impermeable clay core, filters, drains, outer general earth-fill zones, riprap surface protection, outlet works, spillway, and a cementitious foundation cutoff wall extending to bedrock. Please refer to Section IV.E., Dam Methodology, for dam design details. The dam is estimated to cost $159,000,000.

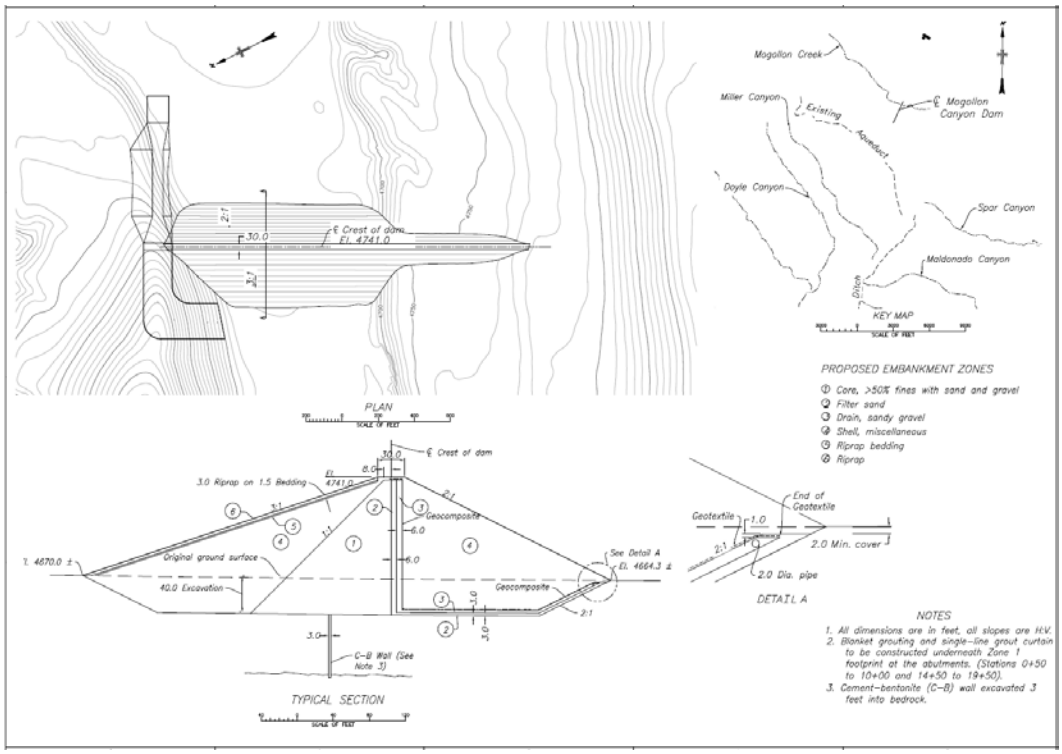

Figure III-7. - Mogollon conceptual dam and cross section

The geologic suitability of the dam site, water tightness of the foundation and abutments, depth to bedrock, geotechnical stability of the dam abutments, and soils characteristics are some of the most significant unknowns associated with a dam at this location. Although Reclamation performed seismic refraction geophysics surveys at the proposed Mogollon dam site to estimate depth to bedrock, all geophysics conclusions need to be confirmed with drill holes, test pits, and geologic field investigations. The results of the geophysics investigations are described in detail in Appendix E. Briefly, the geophysics indicated the depth of alluvium above bedrock at the Mangas dam location to range from 30 to 40 feet.

Mogollon Creek abutments consists of Gila Conglomerate, a sedimentary unit consisting of interbedded sandstone and conglomerate. The conglomerate is typically moderately hard with varying amounts of fines, sand, gravel and cobbles well cemented by calcium carbonate. The conglomerate is irregularly bedded, displaying a mixture of coarse and fine layers and is usually very slightly fractured to unfractured in outcrop. The channel is filled with sand, gravel, cobbles and boulders with minor fines up to 50 to 120 feet thick. The bedrock beneath the alluvium probably consists of Gila Conglomerate. Hydraulic conductivity (K) values in the alluvium likely range from 100 to 1,000 ft/day. K values in the underlying conglomerate range from 0.01 to 1 ft/day.

Disregarding the critical lack of geologic data, the dam site does not present unreasonable construction challenges; the site can be accessed with minimum road improvements, the work is not problematically confined, stream diversion and foundation dewatering are relatively uncomplicated.

The Gila River would provide a more reliable source of water for a Mogollon reservoir than the Mogollon watershed, but would require a diversion structure and conveyance. Reclamation looked at four diversion locations on the Gila River. Diversion Point 2 allows for water to gravity flow from the Gila River to a storage site capable of storing 4,000 AF in Mogollon Creek. This diversion location would necessitate a 5 mile long conveyance channel. The cost for diversion from the Gila River at Diversion Point 2, gravity conveyance, and a 4,000 AF Mogollon dam based on Diversion Point 2 is estimated to be $149,000,000.

Diverting from Diversion Point 4 would allow 11,500 AF to be gravity conveyed and stored in a Mogollon reservoir. The dam associated with an 11,500 AF reservoir would have a structural height of 115 feet, with a top of storage elevation of 4766 which is the canal invert elevation at the discharge point into the reservoir. The 8-mile canal from Diversion 4 would have an elevation loss of approximately 13 feet.

A reservoir at Mogollon, or any upper valley storage site, provides several operational opportunities. Besides storage and releases that could keep portions of the river flowing during low flow periods, the reservoir provides another potentially critical function related to the required pumping into the Mangas Reservoir. The Deming Tier 2 proposal proposes an underground infiltration gallery diversion capable of producing 115 cfs where the diverted flows would then be lifted by pumping to a reservoir on Mangas Creek. Reclamation's concern with this concept is the cost and physical complexities associated with the ability to pump 115 cfs. This magnitude of pumping requires high capacity pumps that are not 'off the shelf" items and significant new power infrastructure since the local power facilities are not capable of incorporating these types of electrical loads. However, since this operation would likely be considered a "diversion", the pumping rates would need to comply with AWSA diversion restrictions. Therefore, infiltration gallery diversions would be restricted the same as surface flow diversions. Reclamation's interpretation of the AWSA and CUFA requirements would limit pumping to the periods when surface diversions could occur, so there is justification for pumping at high flow rates.

However, a reservoir at Mogollon would enable lower pumping rates to a Mangas reservoir by allowing captured flows at Mogollon to be released after the runoff pulse is past. So, the infiltration gallery and associated pumping plant for the Mangas reservoir would simply match releases from the Mogollon reservoir. Reclamation believes this would meet the intent of the AWSA, but needs

confirmation with legal review. The Mogollon releases would be held to levels which could be recovered and pumped from reasonably sized pumping facilities not requiring as large and costly equipment. This slow release of captured flows to correspond with downstream pumping could also be accomplished using other side drainage storage sites.

3. Infiltration gallery diversion

The subsurface diversion identified in the proposal consists of five horizontal collector wells capable of diverting 115 cfs. The diversion's location was identified as being in the Gila River floodplain near Mangas Creek. Conveying water from an infiltration gallery or well field to a reservoir capable of storing 30,000 AF of water will require pumping to lift the water roughly 340 feet to the required reservoir elevation. The Deming proposal locates the dam about 2.4 stream miles from the Gila River, requiring a structural dam height of approximately 220 feet. The top of storage would be at elevation 4720. The reservoir surface would extend upstream to US Highway 180. Reclamation identified another potential dam site 1.5 stream miles from the Gila River that would enable a larger storage capacity of up to 36,000 AF.

An infiltration gallery capable of producing 115 cfs in the Deming proposal would require an estimated 4,200 feet of 3-foot diameter slotted collection piping. 5-foot diameter piping would reduce the required length to 3,500 feet. This assumes the infiltration gallery would be placed beneath the active river channel, buried 30 feet deep to prevent scour damage. The "on-shore" type of infiltration gallery (not under the active channel) would require a significant amount of additional collection piping. An infiltration gallery at this site appears to be a viable alternative to surface diversions, considering soil types and the available area. The biggest unknown is whether the aquifer can sustain a discharge of 115 cfs for a functional amount of time. The infiltration gallery, pumping plant and associated power infrastructure to pump at a rate of 115 cfs would cost an estimated $34,100,000. Pumping 10,000 acre-ft per year at 115 cfs results in energy costs of $570,000 per year.

A more cost effective concept might be to install a wellfield made up of common sized, industry standard wells, each capable of pumping roughly 300 gallons per minute (0.7 cfs). Reclamation's alluvial groundwater pumping modeling and analysis suggests the pumping rate from individual wells should be limited to 300 gpm to prevent quick dewatering of the wells. Although this system would be operated intermittently, Reclamation considered 30 days to be the required pumping time and the aquifer needs to be able to produce for at least that duration. Preliminary evaluations indicate a maximum of about 30 wells could be fit into the Gila River floodplain near the mouth of Mangas Creek, and produce 20 cfs without dewatering the aquifer too quickly. A wellfield of this size is estimated at $2,520,000.

Both the 115 cfs and 20 cfs pumping rates fall well below the AWSA maximum diversion rate of 350 cfs. As described in Section B.2, both concepts would need to utilize post-runoff releases from the proposed Mogollon Dam to achieve maximum diversion potential.

Infiltration gallery or wellfield alternatives would both produce nearly sediment-free discharges. Most sediment and other impurities would be introduced during storage in the Mangas Creek reservoir. Sediment and loose vegetative matter would be carried into the reservoir from the Mangas Creek watershed runoff and wind. Algae growth could significantly impact water quality; studies should be done to evaluate algae potential given reservoir cycle times. Reclamation does not believe these issues pose significant challenges or increased expense to the actual conveyance of water, but are more of a water quality concern for the end use, particularly if the water is to be treated for municipal use. Any water treatment facility would need to be designed with these water quality issues in mind.

4. Mangas Creek Dam

The City of Deming proposes pumping water produced from an infiltration gallery approximately 340 feet vertically over 2.5 miles to be stored in a 30,000 AF reservoir on Mangas Creek. The dam associated with a reservoir of this size would have a structural height of 220 feet. Another potential reservoir site about 1 mile downstream of the proposed Deming site is capable of containing the 36,000 ac-ft with a structural height of 230 feet. Conceptual plan view and cross-sections for a dam at the site 1 mile downstream of the proposed site is shown in Figure III-8.

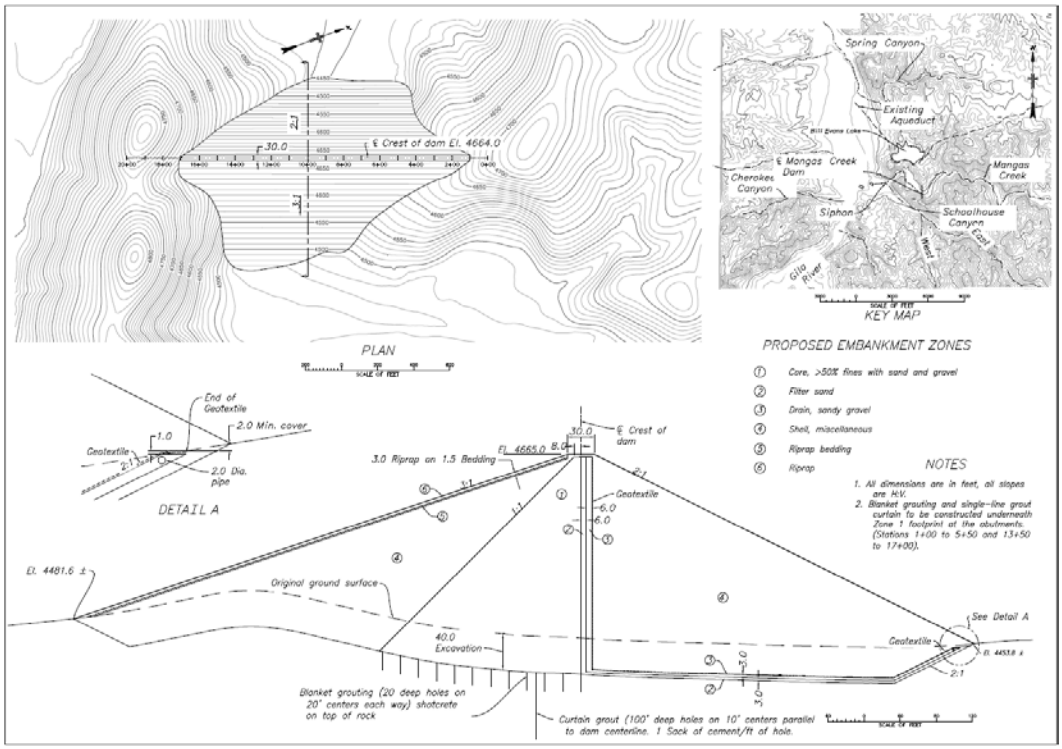

Figure III-8. - Mangas downstream site conceptual dam and cross section

Both sites would likely utilize earthfill embankment dams. Conceptual plan view and cross-sections for a dam at the Deming proposed site is shown in Figure III-9. The conceptual dam would be a zoned structure, with an impermeable clay core, filters, drains, outer general earth-fill zones, riprap surface protection, outlet works, and spillway. Please refer to Section IV.E., Dam Methodology, for dam design details.

Runoff events generated within the Mangas Creek watershed will periodically exceed 350 cfs. According to AWSA restrictions, diversions are limited to 350 cfs, which implies that natural runoff entering a reservoir exceeding 350 cfs would be released from the reservoir at the same rate. This could be achieved if reservoir levels were high enough to utilize the spillway. However, the majority of time the outlet works would be the only way to release stored water. Outlet works are sized for downstream use and to meet reservoir evacuation criteria. For economic reasons, outlet works would not normally be sized to spill high flow flood events. Reservoir levels below spillway initiation require temporary storage of flood flows. Stored flood volumes are then released per legal requirements or for downstream use. The AWSA does not specifically address this flood storage issue. Legal review is recommended to define flood storage policy.

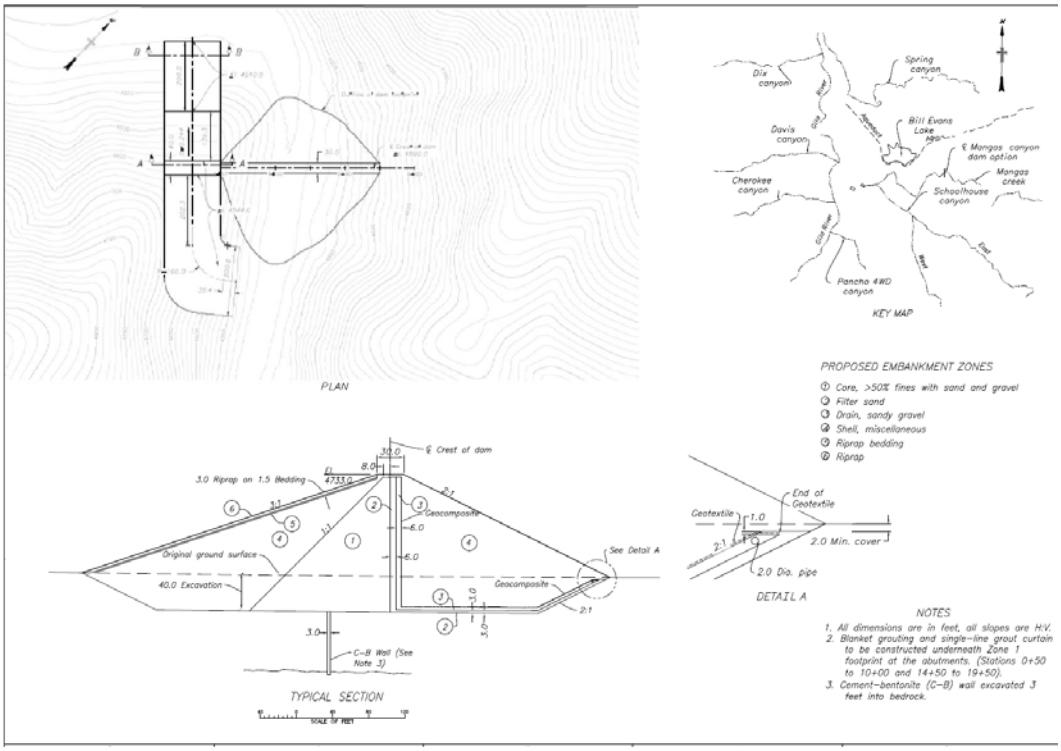

Figure III-9. - Mangas conceptual dam and cross section

Reclamation performed seismic refraction geophysics surveys at the downstream dam site to estimate depth to bedrock. The results of the geophysics survey were incorporated into the conceptual design. In this case, 40 feet of alluvium would be removed to allow the dam embankment to tie directly to the bedrock. Blanket and curtain grouting of the bedrock would be necessary to reduce seepage through the foundation. The geologic suitability of the dam site, water tightness of the foundation and abutments, depth to bedrock, geotechnical stability of the dam abutments, and soils characteristics are some of the most significant unknowns associated with a dam at this location. All geophysics conclusions need to be confirmed with drill holes, test pits, and geologic field investigations.

Mangas Creek abutments consist of rhyolite that is moderately hard, moderately to slightly weathered, intensely to moderately fractured. Color is light gray where fresh, light tan where weathered. The foundation probably consists of rhyolite having hydraulic conductivity K values that range from 10^{-5} - 10^{-6} ft/day.

No sampling of potential construction materials has been conducted for the Mangas Creek dam. A cursory field examination in 1987 by Reclamation indicated that suitable materials for a zoned earthfill embankment structure could likely be obtained from the Mangas Valley area approximately 2.5 to 4 miles upstream from the proposed damsite. [Environmental Impact Statement Upper Gila Water Supply Study 1987 Reclamation] All or a large part of this borrow area would be within the reservoir area.

Water stored in the Mangas Creek reservoir is expected to experience some level of eutrophication, which means significant populations of phytoplankton, or algae growth.[ ] [Environmental Impact Statement Upper Gila Water Supply Study 1987 Reclamation]. Gila River water has limited nitrogen concentrations to help limit eutrophication, but lengthy hydraulic residence times could result in eutrophication issues affecting water quality.

Reclamation estimated the evaporation and seepage losses that could realistically be expected at the proposed dam site. With the reservoir at 100 % full and a surface area of 438 acres, the evaporative losses are estimated to be 2200 ac-ft/yr. Seepage losses are difficult to accurately quantify without geologic data, but based on the surface geology and historic seepage from similar reservoirs, seepage losses were estimated at 800 ac-ft/yr. Taken together, when the reservoir is 100% full, these estimated losses would require 4.1 cfs (minus natural inflow) to be continuously pumped into the reservoir to maintain a constant water surface elevation. However, reservoir operations are not expected to maintain a full reservoir and losses would decline as the reservoir level declines.

As an alternative, water from the infiltration gallery could be pumped directly into the conveyance pipeline to Deming, thereby eliminating the need for a reservoir on Mangas Creek. In order for this approach to be viable, the concept of delayed releases from Mogollon Creek matched by infiltration gallery production would be required. Infiltration gallery diversions would be limited to the pipeline capacity of 14 cfs, hence the need for surface water diversion and storage at Mogollon Creek (or other upper valley storage facility), with delayed releases after the runoff event and matching pumping at the infiltration gallery.

Cost of dam on Mangas Creek:

- Deming proposed site, 30,000 ac-ft - $155,000,000
- Downstream site(Reclamation) 35,800 ac-ft, pumping or gravity flow from diversion 3 or higher - $ 163,000,000
- Downstream site(Reclamation) 10,000 ac-ft, pumping or gravity flow from diversion 1 - $ 95,000,000

5. Conveyance pipeline to Deming

From the Mangas Creek reservoir, water would be conveyed through a 73-mile pipeline roughly paralleling US Highway 180 to Silver City and mining communities of Bayard, Santa Clara, Hurley, then to the Deming area (see Figure III-10). The elevation gain from the reservoir (El. 4550) to the high point (El. 6230) at the Continental Divide near Silver City is 1680 feet, requiring 5 pumping plants. Water would gravity flow from the Continental Divide to Deming (El. 4325) without further pumping.

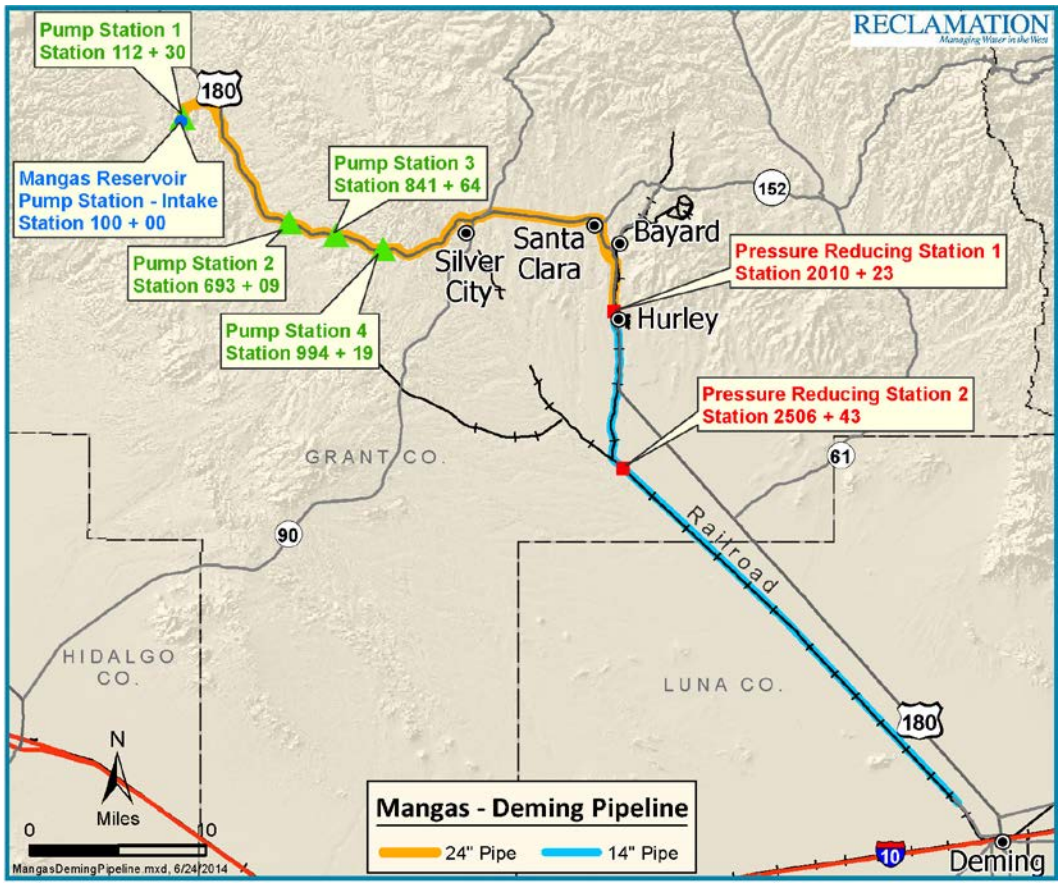

Figure III-10. - Deming pipeline plan view

A concrete intake structure would be built low enough in the reservoir to utilize most of the stored water. Pumps would be sized for about 14 cfs, the pipeline capacity at the beginning. The initial diameter of the pipe would be 24 inches, and after turnouts to Silver City and the mining communities, dropping to a 14-inch diameter pipe for the final 40 miles to the Peru Hill Mill near Deming.

Pipeline criteria:

- Maximum velocity – 5 feet/second
- Capacity – 14 cfs to Silver City, 3.5 cfs to Deming
- Maximum lift per pumping plant – 400 feet
- Size – Primarily 24-inch and 14-inch diameter
- Pipe type – Steel mortar lined (pressure dependent, other types can be evaluated during design process)
- Maximum pressure – 580 feet or 250 psi
- Peaking factor – Not used, assume storage at demand points.
- Friction losses – Hazen-Williams equation, C = 140

- Friction losses - Limited to 25% of the total dynamic head between pump stations

New electrical power infrastructure would be required to power the pumping plants. A power study is needed to evaluate capacities of existing power lines in the area and determine necessary upgrades. For the purpose of this study, we know new lines, substations, and switchyards will be necessary, but the magnitude of these facilities is not known. Reclamation assumes 10 miles of additional power lines will be needed.

Between Silver City and Deming two pressure reducing stations or in-line hydropower generators would be required keep the pipeline pressure below 250 psi (See Figure III-11). Prior to determining whether to use standard pressure reducing mechanisms or generators, a cost analysis should be undertaken to determine if power generation is economically viable. Generally, Reclamation assumes the power plant has to pay for itself in less than 20 years, which is about the age when major components need to be replaced requiring another large infusion of capital.

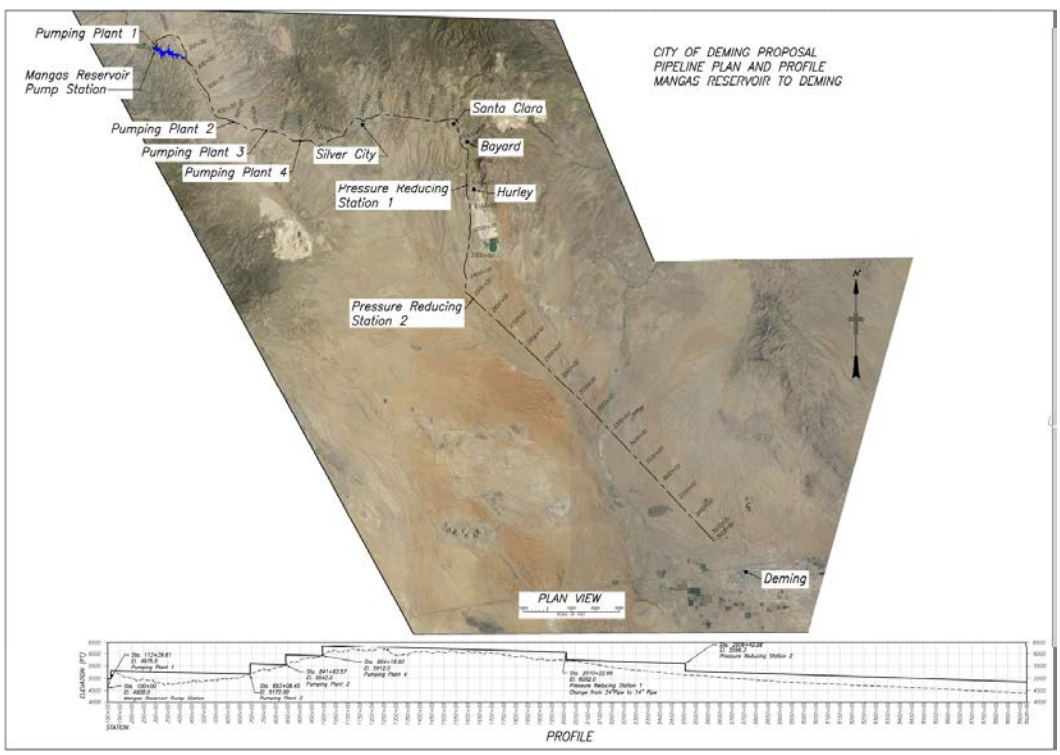

Figure III-11. - Pipeline from Mangas Reservoir to Deming

Technically, there are no particularly difficult engineering challenges or obstacles to building a conveyance pipeline to Deming. The water pumped into the reservoir will be good quality with low sediment. Natural runoff into the reservoir should not contribute enough sediment to negatively impact pumping

and conveyance. Geology is the most significant unknown. About a quarter of the total pipeline length, from Mangas to Silver City, will pass through rocky areas, which will effect trench excavation costs. Reclamation assumed percentages for three different types of excavation methods for cost estimating purposes, based on preliminary site assessments: soils and rock that can be excavated with an excavator, harder materials requiring ripping, and hard rock that requires blasting.

6. Operation and maintenance

Operation, Maintenance, and Replacement (OM&R)costs were broken down into two main categories: Storage dams (Mogollon and Mangas); and wellfield and pipeline. OM&R for both catagories was based on historical data for similar Reclamation facilities. Electrical costs for pumping at the wellfield and along the pipeline were assumed to be 10¢ per kilowatt hour. Replacement costs are included in these estimates as average costs per year, but in reality replacement needs would increase as the system ages.

OM&R is estimated to average $8,850,000 per year.

Storage dams (Mogollon and Mangas)	$2,600,000
Infiltration gallery and Pumping Plant	$ 512,000
Energy cost to pump to reservoir	$ 570,000
Pipeline to Deming	$2,330,000
Energy cost to pump to Deming at 10¢/KWhr	$2,840,000
	$8,850,000

7. City of Deming proposal evaluation summary

1. Mogollon Creek Diversion – Flows would be diverted before reaching the Gila River by capturing naturally occurring runoff from the Mogollon Creek watershed in a 5,000 AF reservoir and dam. The site characteristics lend themselves to a zoned earthen dam, roughly 1600 feet across the stream with a structural height of 80 feet. The dam site is about 1.2 miles upstream from the confluence with the Gila River. The dam is estimated to cost $159,000,000.

2. Infiltration Gallery Diversion – This diversion method consists of five subsurface horizontal collector wells capable of diverting 115 cfs, located in the Gila River floodplain near Mangas Creek.

3. 200 feet of 3-foot diameter slotted pipe would be required. The infiltration gallery, pumping plant and associated power infrastructure to pump at a rate of 115 cfs would cost an estimated $34,100,000.

4. Mangas Creek Dam – Utilize an earth-fill, zoned structure with an impermeable clay core capable of holding 30,000 AF. The dam would have a structural height of 220 feet, with a 1,010-foot crest. The dam is estimated to cost $110,000,000.

5. Pipeline – A 73-mile pipeline would convey water to the Deming area. The 24-inch diameter pipeline would have a capacity of 14 cfs. The last 40 miles would be 14 inches in diameter. Five pumping plants would lift the water 1,300 feet over the Continental Divide with gravity flow the last 50 miles.

8. Engineering Conclusions City of Deming proposal

1. Reclamation did not identify specific problems that would prevent dams from being constructed at Mogollon Creek and Mangas Creek. However, significant unknowns associated with geology, geotechnical information, foundation and abutment water holding capability would need to be addressed prior to considering either site a viable location for a dam.

2. An infiltration gallery appears to be a viable alternative to surface diversions if the aquifer can produce 115 cfs. Preliminary calculations indicate 115 cfs is achievable.

   Since 115 cfs falls below the AWSA maximum diversion rate of 350 cfs, post-runoff releases from the proposed Mogollon Dam could potentially be used to achieve maximum diversion potential.

   A wellfield made up of common sized, industry standard pumps may be a cost effective alternative to the infiltration gallery. Preliminary evaluations indicate a maximum of about 30 wells could be fit into the Gila River floodplain near the mouth of Mangas Creek, and produce 20 cfs without dewatering the alluvial aquifer too quickly. A wellfield of this size is estimated at $2,520,000.

   Infiltration gallery or wellfield alternatives would both produce nearly sediment-free discharges.

3. There are no technical constraints prohibiting the construction of a pipeline to the Deming area.

9. Project cost

The total cost for the Southwest New Mexico Regional Water Supply Project is estimated at $503,100,000.

Mogollon dam	$158,000,000
Infiltration Gallery and Pumping Plant	$ 34,100,000
Mangas dam	$155,000,000
Pipeline to Deming	$156,000,000
	$503,100,000
OM&R	$8,850,000/yr

10. Environmental

Biology - Southwest New Mexico Regional Water Supply (Deming Surface Water Diversion).

The project is within the habitat of the southwestern willow flycatcher, and proposed yellow-billed cuckoo.

Mangas Creek has the endangered loach minnow and spikedace. Historically spikedace were detected in Mangas Creek, but no surveys have been conducted in several years.

The Mainstem Gila has the potential to have the threatened narrow-headed gartersnake and the northern Mexican gartersnake that could be impacted during construction or by reduced flows to the Gila River.

Cultural - Southwest New Mexico Regional Water Supply (Deming Surface Water Diversion).

There is very little information available regarding cultural resources associated with this alternative. However, as cultural resources are likely to exist in the proposed project areas, a complete survey and analysis as identified under the Grant County Recharge project will be necessary. Avoidance of all cultural resources is recommended if possible as testing and excavation can be a very costly undertaking. As planning proceeds, it is recommended that the costs for the surveys and any possible mitigation be included into the overall project costs.

C. Hidalgo County

Overview – Summary of the Hidalgo County project proposal

Hidalgo County proposes diverting 10,000 ac-ft of water per year from the Gila River for storage in a 5,500 ac-ft reservoir in Schoolhouse Canyon. The stored water would be used to enhance agricultural opportunities in the Redrock and Virden areas. Another small storage reservoir would be constructed in the Virden area, fed by the existing Sunset Canal.

The proposal locates the surface water diversion structure just downstream of Mogollon Creek. The conveyance would be primarily open channel, gravity flow paralleling the Gila River to the mouth of Schoolhouse Canyon where the dam would be constructed.

Water would be diverted and stored according to the parameters of the Arizona Water Settlement Act and the Consumptive Use and Forbearance Agreement.[8]

The Hidalgo County Off-Stream Project proposal involves three components: diversion, conveyance, and storage. Each component of the proposal is evaluated below using information contained within the proposal.

The principle components of the Hidalgo County proposal are:

1. Divert surface flows from the Gila River.
2. Convey diverted Gila River water to Schoolhouse Canyon.
3. Construct dam to store Gila River water in reservoir at Schoolhouse Canyon.
4. Construct dam near Virden to store water conveyed by existing Sunset Canal.

1. Diversion from the Gila River

Hidalgo County proposes a new diversion structure just downstream of the mouth of Mogollon Creek. The width of the active river channel at this point is roughly 600 feet wide but the entire floodplain is almost 1,200 feet across. To ensure the river does not erode around the end of the diversion, the structure would need to extend into the low terraces, requiring a total structural length of about 1,200 feet.

It may be less costly to build the diversion where the canyon is narrow, despite the additional conveyance distances, an estimated $1,000,000 less. However, the Hidalgo County proposed diversion location ensures the use of flows generated within the Mogollon Creek watershed. The conveyance canal from this diversion structure would run on the east side of the river.

A 300-foot section of the diversion structure would be structural concrete with a 7-foot tall crest to check up the water depth for the intake to the conveyance ditch (see Figure IV-1. - Typical Diversion Structure Design). The intake inlet would be controlled with gates. Large debris would be kept from entering the conveyance system with a trash rack. The remaining 900 feet of the structure would be constructed of sheet piling and earthfill across the alluvial river terraces.

[8] Hidalgo County Offstream Proposal

The cost to construct a diversion immediately downstream of Mogollon Creek is estimated at $9,300,000.

Scour – Scour analyses need to be performed during the design phase for both the structural concrete section and the sheet piling wing wall to ensure the various types of scour do not undercut the structure.

Wing walls – Non-erodible wing walls, such as the proposed sheet piling, is essential to prevent the river from rerouting during runoff events and bypassing the structure. The initial capital investment in a stable structure with solid abutment tie-ins will significantly reduce long-term maintenance costs. Materials used to construct wing walls should be evaluated for cost effectiveness and ease of construction.

Sheet Pile Wall - Sheet piles can be used to create cost effective cutoff walls. Boulders in the alluvium can increase driving difficulties. Test pit investigations should be performed to determine how the boulder content of the underlying alluvium would affect construction bid prices. Steel sheet piling may have corrosion issues over time. Plastic sheet piling will resist corrosion, but the ability to be driven into rocky alluvium is limited.

Earth Materials – Concrete and riprap armored earth embankment could be constructed above existing ground to ensure all flows are directed over the structural concrete section of the diversion. Assuming a 300-foot structural concrete section, the embankment may need to be roughly 15 feet in height in order to contain the historical high flood flows.

Secant piles or slurry wall – These methods create a cementitious cutoff wall below ground. Low-strength concrete slurry mix of 1000 to 1500 pound/square inch compressive strength could be used. A reinforced wall would need to be extended above ground to roughly the height of the diversion structure's outer walls.

Sediment and debris – Since a significant amount of diversions will take place during higher flows, the intake to the conveyance system will need to be designed to handle sediment and debris. Trash racks will prevent larger debris, such as trees and branches, and floating vegetation like grasses from entering the conveyance intake.

Sands and gravels can be settled quickly with a wider, slower velocity section at the upper end of the conveyance system. These settled materials would be sluiced back to the river downstream of the diversion structure. A second sluice gate further downstream would provide a mechanism to flush the conveyance system of any materials making it past the first sluice gate. There may be a need for additional sluice gates further down the canal.

There are no specific engineering or construction issues that would prohibit a diversion at the proposed location. Since the floodplain is 1,200 feet across at this site, there is a significant cost to construct sheet pile wing walls to prevent lateral movement of the river around the structure during runoff events. But, the concern can be addressed with the proper design. Also, because of the anticipated depth of alluvium in the river, it is probably not cost effective to tie the structural concrete section of the diversion to bedrock. Therefore, the structure will need to be engineered to withstand scour considering the alluvial foundation. This is usually done with underground walls that extend below scour action. Construction access is excellent for all types of equipment including concrete transit mixers. The diversion site is located on National Forest land.

The estimated cost of a diversion near Mogollon Creek is $9,300,000.

2. Water conveyance

A 35-mile conveyance system would be required to transport diverted flows to Schoolhouse Canyon. Once above the Gila River floodplain, the canal would follow the contours of the upland land forms, with siphons or overchutes when crossing major drainages. The concrete lined canal would have a capacity of 350 cfs, the maximum diversion flow allowed under AWSA. The canal cross-section is shown in Figure IV-2. The water surface at full capacity would be 24 feet across with maintenance roads on each side of the canal.

33 miles of the system would be open channel canal, with roughly 2 miles of 8-foot diameter siphon pipe. The canal slope of 0.0003 combined with siphon pipe friction losses would result in a 72-foot elevation drop from the diversion to Schoolhouse Canyon.

Decisions on where to utilize open channel flow versus siphons or overchutes would be done during the design phase, but generally speaking, the cost of a siphon pipeline is about four times as much per linear foot as open channel. So, whether to follow the contour or transition to a siphon is a cost optimization exercise. Pipelines have more pressure head loss than open channels, which ultimately costs elevation potential at the reservoir. Advantages of buried pipelines over open canals are reduced costs associated with windblown debris or sedimentation from cross-drainages. Conversely, open channels are easier and less costly to repair.

Maintenance concerns associated with most open canals include removal of windblown bebris and vegetation control. These activities are relatively uncomplicated, but require dedicated O&M effort. Trash racks located above siphons to catch debris and for public safety would require periodic cleaning.

Because of the AWSA and New Mexico restrictions on when river flows can be diverted, one can assume that when diversions can occur the water will typically be sediment laden. Dealing with sediment will be a constant maintenance concern and will increase O&M costs, but Reclamation believes this is a manageable issue.

Sands and gravels that enter the conveyance intake can be settled quickly with a wider, slower velocity settling basin section at the upper end of the conveyance system. These settled materials would be sluiced back to the river downstream of the diversion structure, or excavated periodically. A second sluice gate further downstream would provide a mechanism to flush the conveyance system of any materials making it past the first settling basin gate. There may be a need for additional sluice gates further down the canal.

Finer sediment carried beyond the settling basins will remain suspended while the system is being operated. When diversions cease, the canal would drain, leaving water only in the siphons at the major cross-drainages. If the suspended sediment load is such that settlement could potentially reduce capacity of the siphons, the siphons can be drained immediately following system operation. Siphons could be drained to the elevation of the cross-drainage stream channel with above-ground blow-off valves. Draining below-channel sections of the siphons would require pumping or gravity flow piping to daylight (heavily dependent on topography). Overchutes culd be utilized instead of inverted siphons at drainage crossings, eliminating the potential for trapped sediments.

The conveyance system from a diversion near Mogollon Creek to Schoolhouse Canyon is estimated to cost $111,000,000.

3. Storage dam and reservoir at Schoolhouse Canyon

A suitable dam site in Schoolhouse Canyon is located 2,100 feet upstream of the Schoolhouse confluence with Mangas Creek (see Figure III-12). The dam would likely be a central core, zoned earthfill structure. Reclamation's assumptions and considerations for embankment dams are discussed in Section IV.E., Dam Methodology, of this report. Cost estimates include river outlet works and a concrete spillway sized to pass the probable maximum Flood (PMF) calculated for the Schoolhouse watershed.

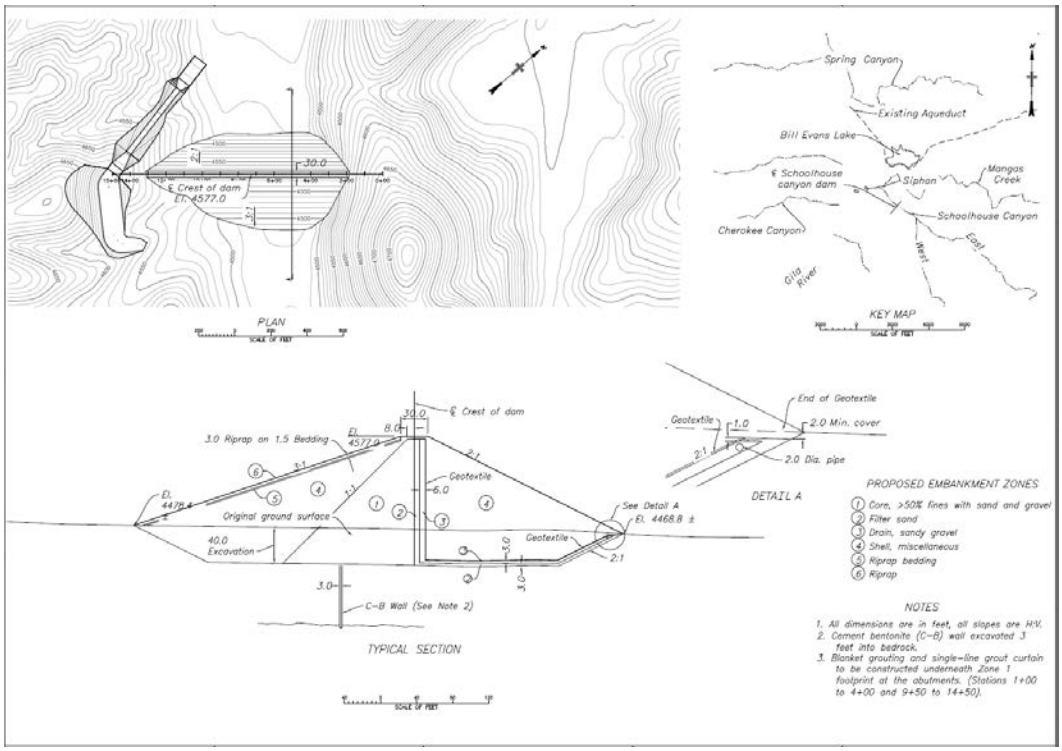

Figure III-12. - Schoolhouse conceptual dam and cross section

From the proposed diversion site and gravity flow with 72 feet of elevation loss, the maximum reservoir water surface attainable in Schoolhouse is elevation 4560. The associated reservoir capacity at elevation 4564 is 2,070 AF, which is short of the 5,500 ac-ft in the proposal. If the diversion structure was located 2 miles upstream at Reclamation's diversion point #1, the reservoir could be filled roughly 30 feet higher to elevation 4594 and a capacity of 4,150 ac-ft. Two additional miles of canal would need to be constructed, costing about $5,000,000. Locating the diversion at Reclamation's diversion point #2 would enable storage of the proposed 5,500 ac-ft (actually 8,800 ac-ft), but would require 6 more miles of conveyance channel than the proposed diversion location.

The dam would have a structural height of about 100 feet. The embankment crest would be approximately 1,300 feet long across the canyon.

Runoff events generated within the Schoolhouse Canyon watershed will periodically exceed 350 cfs. According to AWSA restrictions, diversions are limited to 350 cfs, which implies that natural runoff entering a reservoir exceeding 350 cfs would be released from the reservoir at the same rate. This could be achieved if reservoir levels were high enough to utilize the spillway. However, the majority of time the outlet works would be the only way to release stored water. Outlet works are sized for downstream use and to meet reservoir evacuation criteria. For economic reasons, outlet works would not normally be sized to spill high flow flood events. Reservoir levels below spillway initiation

require temporary storage of flood flows. Stored flood volumes are then released per legal requirements or for downstream use. The AWSA does not specifically address this flood storage issue. Legal review is recommended to define flood storage policy.

The cost of the embankment dam in Schoolhouse Canyon associated with the proposed diversion location is estimated to be $105,000,000. A dam capable of storing 4,150 ac-ft from diversion poijnt #1 is estimated to cost $115,000,000.

The geologic suitability of the dam site, water tightness of the foundation and abutments, depth to bedrock, geotechnical stability of the dam abutments, and soils characteristics are some of the most significant unknowns associated with a dam at this location. Although Reclamation performed seismic refraction geophysics surveys at the proposed Schoolhouse dam site to estimate depth to bedrock, all geophysics conclusions need to be confirmed with drill holes, test pits, and geologic field investigations.

Schoolhouse Canyon abutments consists of hard, slightly weathered to fresh, light gray rhyolite. Flow joints are spaced 1/2-2 inches apart, intensely to moderately fractured, with localized very intense fracturing. Alluvium consisting of sand, gravel, cobbles and boulders with minor fines ranges from 70 to 115 feet thick overlies bedrock that probably consists of rhyolite having hydraulic conductivity K values ranging from 10^{-5} - 10^{-6} ft/day.

Disregarding the critical lack of geologic data, the dam site does not present unreasonable construction challenges; the site can be accessed with minimum road improvements, the work is not problematically confined, stream diversion and foundation dewatering would be straightforward at this site.

4. Storage dam and reservoir near Virden

An embankment dam is proposed 0.6 miles east of the town of Virden where the Sunset Ditch loops around a small drainage, shown in Figure III-13. The reservoir would be fed by the existing Sunset Ditch. Topography and ditch elevation limit the dam height to approximately 40 feet with a maximum reservoir elevation of 3784. The zoned, clay core earthfill dam structure would be 690 feet long. Storage capacity at this site is 57 ac-ft, which is substantially lower than the 1000 ac-ft in the proposal. Storage is limited by the existing canal at elevation 3787.

Figure III-13. - Storage facility in Virden

The limited storage capacity does not necessarily mean the yearly diversion is limited to 57 ac-ft. The reservoir could theoretically be filled and emptied several times a year depending on river flows and CUFA restrictions. A likely scenario incorporates two fillings: spring runoff fills the reservoir, stored water is released during a warm dry month like June, monsoon runoff refills the reservoir, stored water is released during drier September. Provided there is some extra capacity in the existing Sunset Ditch (unknown at this time), the reservoir could be filled without impacting normal ditch operations. For example, diverting just 5 cfs from the Sunset Ditch would fill the reservoir in about 6 days.

The geologic suitability of the dam site, water tightness of the foundation and abutments, depth to bedrock, geotechnical stability of the dam abutments, and soils characteristics are some of the most significant unknowns associated with a dam at this location.

Disregarding the lack of geologic data, the dam site does not present unreasonable construction challenges; the site is easily accessible, the work is not problematically confined, stream diversion and foundation dewatering would be straightforward at this site.

The cost of an earthfill dam and associated outlet works, spillway, and intake gating is estimated at $14,700,000.

5. Operation and maintenance

Operation, Maintenance, and Replacement (OM&R) costs were broken down into two main categories: Diversion dam and conveyance canal; and Storage dam (Schoolhouse). OM&R for both catagories was based on historical data for similar Reclamation facilities. Replacement costs are included in these estimates as average costs per year, but in reality replacement needs would increase as the system ages.

OM&R is estimated to average $1,530,000 per year.

Diversion dam and canal	$480,000
Storage dam (Schoolhouse)	$1,050,000
	$1,530,000

6. Hidalgo County proposal evaluation summary

1. A new structural concrete diversion structure downstream of Mogollon Creek does not present difficult engineering and construction issues. But the width of the floodplain at this location requires significant wing wall protection to prevent runoff damage and keep O&M costs low, resulting in an estimated cost of $9,300,000 for a reliable, stable structure.

2. The canal required to convey water to Schoolhouse Canyon is 35 miles in length. Once above the Gila River floodplain, the canal would follow the contours of the upland land forms, with siphons or overchutes when crossing major drainages. The concrete lined canal would have a capacity of 350 cfs, the maximum diversion flow allowed under AWSA. The cost of the canal is estimated to be $111,000,000.

3. The dam at Schoolhouse Canyon would be a zoned, earthfill, clay core dam with a structural height of about 100 feet. The embankment crest would be approximately 1,300 feet long across the canyon. If Gila River water is diverted at the proposed location downstream of Mogollon Creek, gravity flow would allow a maximum reservoir size of 2,070 AF. Diverting from Reclamation's identified diversion point #1 would enable 4,150 AF to be stored. The cost of a dam at Schoolhouse is estimated to be $105,000,000.

4. The proposed 40-foot tall dam and reservoir at Virden could store 57 ace-ft. The earthfill dam would be zoned with a clay core. A dam at Virden is estimated to cost $14,700,000.

7. Engineering Conclusions Hidalgo County proposal

1. Reclamation did not identify critical concerns associated with diversion structure, although the wide floodplain location requires significant wing wall components which result in additional costs.

2. The 35-mile canal to convey water to Schoolhouse Canyon is costly but straightforward engineering and design-wise. There may be ways to optimize costs with siphons or overchutes to reduce some of the length. Dealing with sediment from the river will and require ongoing O&M efforts and result in a minor increase to constructions costs.

3. Reclamation did not identify specific problems that would prevent dams from being constructed at Schoolhouse Canyon and Virden. However, the damsites have significant unknowns associated with foundation information, abutment stability, water holding capability. Thorough geologic evaluations are needed to determine if the sites have potential for a dam and reservoir. At this time, acknowledging the lack of geologic information known about the sites, Reclamation has not identified problems or concerns enough to eliminate the sites from consideration.

8. Project cost

The total project cost is estimated at $235,000,000.

Diversion dam and canal	$115,000,000
Schoolhouse dam	$105,000,000
Virden dam	$14,700,000
	$234,700,000
OM&R	$1,530,000/yr

9. Environmental

Biology – Hidalgo County Offstream Project

There is very little information available regarding cultural resources associated with this alternative. However, as cultural resources are likely to exist in the proposed project areas, a complete survey and analysis will be necessary. Avoidance of all cultural resources is recommended if possible as testing and excavation can be a very costly undertaking. As planning proceeds, it is recommended that the costs for the surveys and any possible mitigation be included into the overall project costs.

Cultural – Hidalgo County Offstream Project

There is very little information available regarding cultural resources associated with this alternative. However, as cultural resources are likely to exist in the proposed project areas, a complete survey and analysis will be necessary. Avoidance of all cultural resources is recommended if possible as testing and excavation can be a very costly undertaking. As planning proceeds, it is recommended that the costs for the surveys and any possible mitigation be included into the overall project costs.

D. Miscellaneous considerations

These topics were not specifically identified as Reclamation tasks, but the subjects have been raised over the last few months during public meetings, input group meetings, and other discussions. Reclamation is providing this information because of the apparent interest in these topics.

1. Replace diversion structures with infiltration gallery

This concept is promoted by fishery biologists to avoid dividing threatened or endangered fish populations with an impassable structure, and by preservationists desiring to maintain the free flow and natural character of the river. In order to functionally replace the surface diversion structure the infiltration gallery must be capable of producing 350 cfs to allow the maximum diversion of AWSA related flows.

Reclamation's assumptions associated with underground infiltration galleries are described in detail in Appendix A. Initial calculations estimate 40,000 feet of 36-inch diameter slotted pipe would be needed below the river channel to develop 350 cfs. At least one mile of river channel and floodplain would be significantly disturbed to install the system. The gallery piping would need to be buried below river scour action, roughly 30 feet deep.

Assuming gravity flow, the infiltration gallery discharge pipe needs to daylight using a flatter slope than the river channel. Because the infiltration gallery begins below scour depth, the daylight point would be more than 30 feet below a canal. Additionally, friction energy losses in the discharge pipe would be higher than losses associated with open channel flow, resulting in additional losses. These elevation differences and losses impact storage options. Since the gallery would be some 30 feet lower than surface water diversions, the potential for storage in a given side channel reservoir would be about 30 feet lower than surface diversions. A reduction in storage capacity is a notable concern, particularly in the upper valley storage sites.

Besides native fish and visual benefits, another advantage of infiltration galleries is sediment-free discharges.

Reclamation estimates a 350 cfs infiltration gallery to cost $16,200,000, compared with $5,000,000 for a surface diversion structure.

2. Cost of water treatment at the Deming pipeline termination

Several times over the last few months Reclamation has fielded questions about the cost of water treatment if water is brought to the Deming area from the Gila River. Although this topic was not included in Reclamation's scope of work, because of the interest in this item, an appraisal level estimated cost is provided for information. The cost estimate considered overall Gila River water quality, but actual costs would be affected by specific water chemistry at the delivery point, total dissolved solids (TDS), finished water quality requirements, etc.

A typical conceptual unit cost for estimating the capital cost of a conventional water treatment plant is $3 per gallon per day of raw water treated. This cost includes:

- Pretreatment
- Flocculation
- Coagulation
- Sedimentation
- Filtering
- Disinfection

The capacity of the plant is based on the City of Deming's proposal of 3,900 acre-ft per year, yielding 3,482,000 gallons per day.

Assuming a new treatment plant is required to treat surface water, the total estimated cost of the treatment plant is $21,100,000. This figure includes design, construction, and contingencies.

3. Tunnel versus open channel water conveyance

There is an opportunity to shorten the water conveyance system at the Gila River loop near Mogollon Creek. A 2,700-foot tunnel could be constructed, thereby eliminating 14,000 feet of canal. With no geologic information available, Reclamation assumed the tunnel would need to be concrete lined for stability. Lining would probably be utilized regardless of geology to reduce water losses. A typical price per linear foot of tunnel was assumed, which includes rock excavation, lining, rock bolting, and other tunneling activities such as portals, water control, ventilation, muck removal, etc. Because the tunnel length is

relatively short, a tunnel boring machine or blasting would probably result in similar costs.

A canal on river left would need to be built on some steep slopes, requiring rock excavation and attaching a concrete section to the hillside. Reclamation estimated the cost of a concrete walled canal on a slope of 1:1 or steeper to cost about $3,000 per foot. A more standard canal could be built for about 55% of the length for $400 per foot. The weighted unit price would be $1,750 per foot.

Reclamation estimated a cost of $3,800 per foot for tunnels. The estimated cost for the tunnel was $10,300,000 compared to $24,500,000 for the canal. These figures indicate a tunnel may be a cost effective option at the Gila River loop.

4. Lining reservoirs

Water losses resulting from seepage may have a significant impact on yield and overall cost. Some percentage of seepage from off-channel storage reservoirs will make its way back to Gila River surface or subsurface flows and may not count against New Mexico as consumptive use (this to be determined). But controlled releases of this stored water is no longer possible once the water percolates into the ground. Although fines carried into the side channel reservoirs may tend to slow some seepage, this action would not even register in magnitude if geologic features are present that allow large movement of water through reservoir foundations.

One way to limit seepage is to line reservoirs with high Density polyethylene geomembrane. As part of the Gila Basin Irrigation Commission proposal analysis, Reclamation estimated the cost to furnish and install a liner for a 2–acre pond to be $163,000, assuming $1.74/square foot. Liners are typically covered with soils to protect against weathering and livestock, and so the black plastic is not visible.

The cost to line one of the side channel reservoirs was calculated to help with future analyses of this concept. Diverting from Diversion Point 1 allows 2,750 AF of water to be stored in Winn Canyon with a reservoir surface of 109 acres. Allowing for another 10% for ground surface slope, the acreage to line is about 120 acres. At $1.74/square foot, the cost to line Winn Canyon reservoir is about $9,100,000. If end uses are defined, an analysis could be done to determine if lining is cost effective.

5. Environmental miscellaneous considerations

Biology - Grant County Recharge and Storage.
This Gila River diversion stores water near Fort Bayard at Twin Sisters and Cameron Creeks.

There is possible suitable habitat in the area for the gray vireo which is a New Mexico species of concern. The Gray Vireo was listed as endangered, group 2, by the New Mexico Department of Game and Fish in 1983, and as a species of greatest conservation need under the Comprehensive Wildlife Conservation Strategy-New Mexico in 1990 and 2005. While not listed under the federal Endangered Species Act, the bird has been listed by Partners in Flight as a priority species in North America and by the U.S. Fish and Wildlife Service as a priority species of conservation concern. Its preferred habitat is juniper, piñon-juniper, and oak habitat along foothills and bajadas in New Mexico.

Cultural - Grant County Recharge and Storage.
This Gila River diversion stores water near Fort Bayard at Twin Sisters and Cameron Creeks. Limited desktop review to determine cultural resources was conducted by the Interstate Stream Commission's contractor. The review indicates that cultural resources are present throughout the footprint of this diversion proposal. It also indicates that some areas are very dense with cultural sites, especially along waterways. The project would require a one-hundred percent cultural resources survey in all areas of ground disturbance as well as less intensive surveys as developed in consultation under the NHPA, Section 106 process with the New Mexico SHPO, interested Native American groups and other interested parties. Avoidance of all cultural resources is recommended if possible as testing and excavation can be a costly undertaking. As planning proceeds, it is recommended that the costs for the surveys and any possible mitigation be included into the overall project costs.

IV. Other diversion and storage options (alternatives)

Overview - Reclamation's alternatives consist of diverting, conveying and storing Gila River water in the side canyons and tributaries within the Gila River floodplain. The goal of this report is to provide the New Mexico Interstate Stream Commission the data needed to make an informed decision. Reclamation has identified four potential locations for constructing diversions. The diversion structure allow water to be conveyed to different elevations for storage within the side canyons.

The diversion structures use regulating gates to control flows entering the canal. Each diversion structure can be designed to divert water to either side of the river. The conveyance canals use a slope of 0.03%. Siphons were used when crossing large drainages to reduce canal length and costs. Overchutes could be used at these locations instead of siphons.

A. Diversion locations

Reinforced concrete diversion dam structures were used, with ogee crest overflow section, sluice gates, and twin canal gates. The structure would be sized to pass the design flood over the crest. During low river flows, the canal gates would be closed and most or all flow would pass over the dam crest along with suspended sediment and bed load. When AWSA flows can be diverted, the canal gates would be opened to direct flows into the canal(s). Concrete cutoffs along the upstream and downstream portions of the dam would protect the structure from scour damage. Figure IV-1 shows the typical diversion structure design. During design, final dimensions and grades would be determined to suit local geology, hydraulics, and specific site conditions.

Reclamation recommends requiring on-site personel for opening and closing of gates to ensure visual confirmation that gates actually open when needed. This would require all weather vehicular access to the vicinity of the diversion and foot access to the control panels.

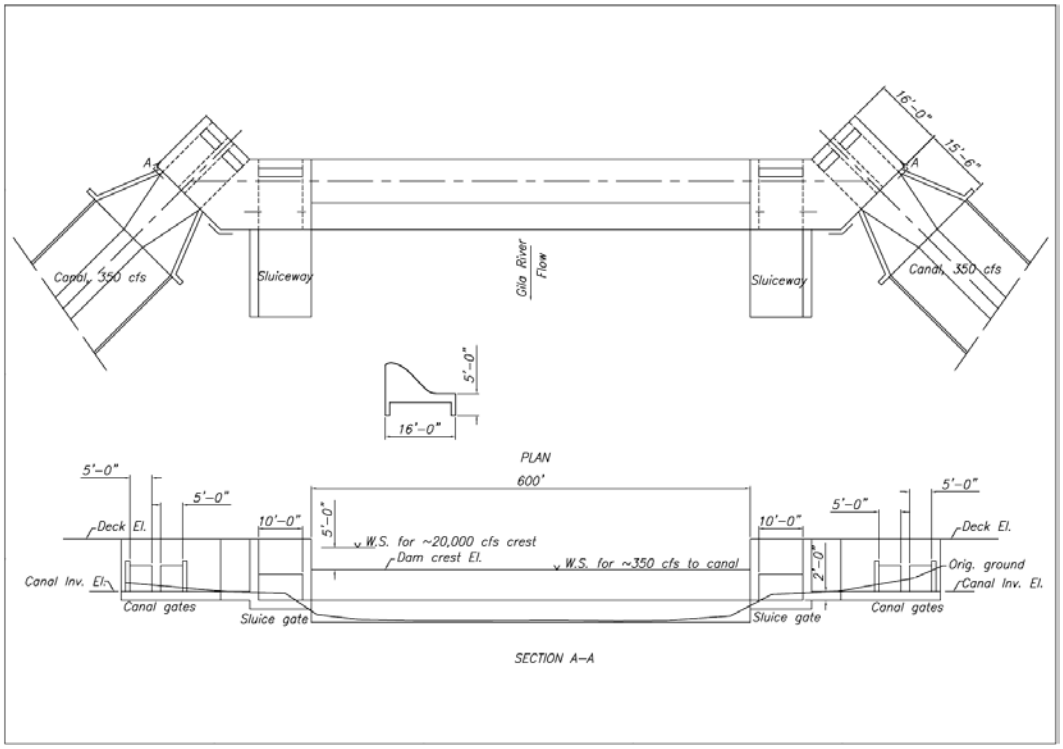

Figure IV-1. - Typical diversion structure design

Diversion point 1 (latitude 33° 3'41.50"N, longitude 108°32'14.76"W, 1984 WGS Web Mercator) - The diversion site is located approximately 1.85 miles upstream from the confluence of Mogollon Creek and the Gila River at elevation 4660 above mean sea level (MSL). The narrow canyon at this site provides a cost effective locatin for a diversion structure. The site has good construction access via a 2-mile road to the stream gage from NM State HWY 293. The canyon walls are approximately 290 feet across. This diversion site has the additional advantage of being at the very downstream end of the box canyon, making conveyance simpler than within the box canyon. USGS Stream gage no. 09430500 is located on the left abutment. Reclamation performed geophysics work at this site and the seismic refraction survey indicated a depth to bedrock of approximately 110 feet. The structure would require approximately 910 CY of concrete.

Diversion point 2 (latitude 33° 3'39.32"N, longitude 108°30'7.88"W) - The diversion site is located approximately 5.67 miles upstream of Mogollon Creek at elevation 4742. The site was chosen because of good access via Turkey Creek Road and narrowing of the canyon. The canyon walls are approximately 600 feet across. Reclamation did not perform geophysics work at this location but assumed the depth to bedrock to be similar to the depth to bedrock at diversion point 1. The structure would require approximately 2,100 CY of concrete.

Diversion point 3 (latitude 33° 4'32.00"N, longitude 108°29'48.45"W) - The diversion site is located approximately 7.28 miles upstream from Mogollon Creek at elevation 4770. The site was chosen due to the canyon narrowing and access from Turkey Creek Road. Portions of the remaining ½–mile closed section of Turkey Creek Road would require upgrades to reach the site. The canyon walls are approximately 600 feet across. Reclamation did not perform geophysics work at this location but assumed the depth to bedrock to be similar to the depth to bedrock at diversion point 1. The structure would require approximately 2,100 CY of concrete.

Diversion point 4 (latitude 33° 4'39.47"N, longitude 108°29'34.78"W) - The diversion site is located approximately 7.8 miles upstream from Mogollon Creek and 0.2 miles downstream of Turkey Creek at elevation 4777. The site was chosen due to the canyon narrowing and access from Turkey Creek Road. Portions of the remaining 1–mile closed section of Turkey Creek Road would require upgrades to reach the site. The canyon walls are approximately 600 feet across. Reclamation did not perform geophysics work at this location but assumed the depth to bedrock to be similar to the depth to bedrock at diversion point 1. The structure would require approximately 2,100 CY of concrete.

B. Conveyances

Conveyance canals were sized to convey 350 ft^3/s to enable maximum diversions allowed by AWSA and the New Mexico Consumptive Use and Forbearance agreement. At 350 ft^3/s, canal depth is 5.25 ft and average velocity is 4 to 5 ft/s to limit sediment deposition in the canal. The canal would be concrete-lined to provide a hard surface for operation of maintenance equipment. Contraction joints with waterstop will limit seepage water losses. Figure IV-2 shows the typical canal section.

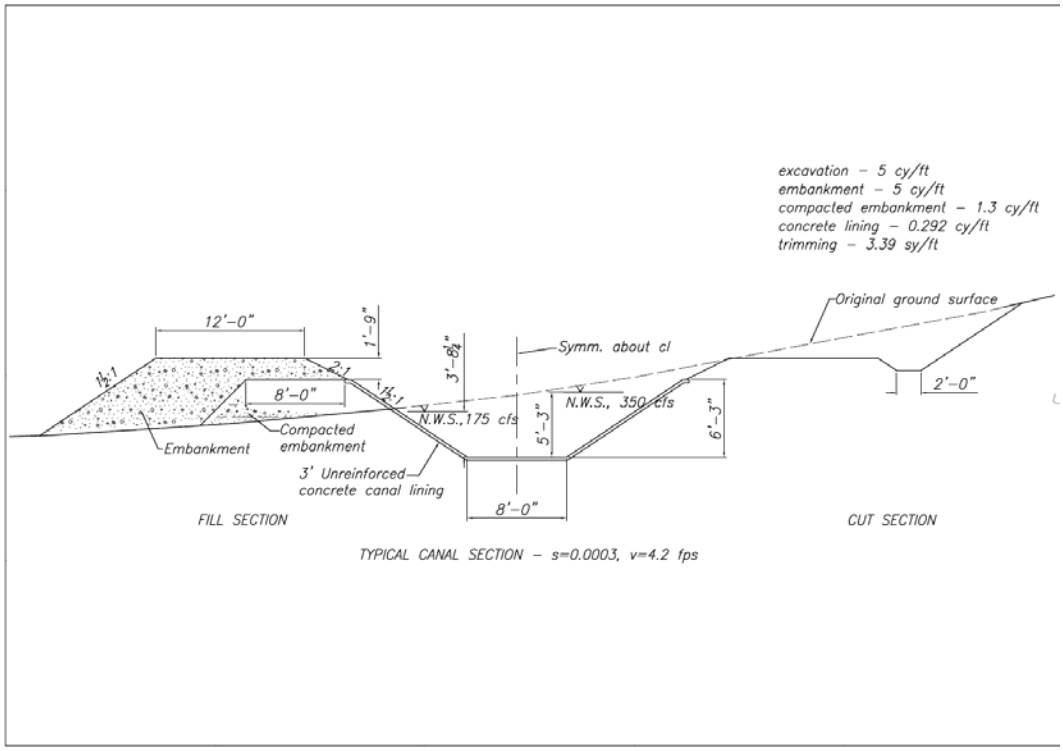

Figure IV-2. - Typical canal design

Canals would use a 0.03 percent slope. The canal alignment would generally follow the natural ground contours of the west or east side of the valley. Cut and fill would balanced as much as possible to limit imported materials and reduce haul costs. Refer to figures Figures A-1 through A-4 in Appendix A for conveyance alignments from diversions to storage reservoirs. Each side of the canal would have operation and maintenance roads. A ditch in cut sections would collect and carry storm runoff to cross-drainage culverts below the canal. The culverts would be reinforced concrete pipe with headwalls and wingwalls and entrances and exits. Culverts would be located at cross drainages. For cost estimating purposes, this study assumed culverts every 2,000 feet. Figure IV-3 shows a typical culvert design.

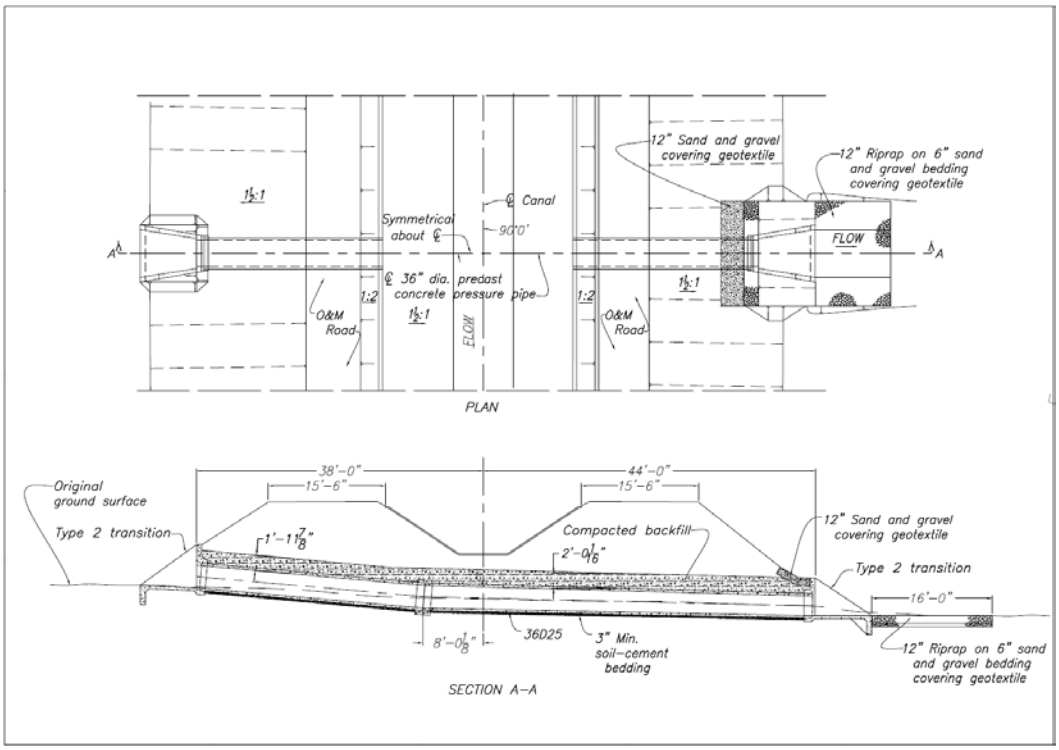

Figure IV-3. - Typical culvert design

Canals would encounter a number of side canyons. Where practical, the canal would follow the contours up into the drainage. However, this is not always cost effective, particularly for the large drainages. At large drainages, inverted pipe siphons would be buried below the drainage channel. Overchutes can be used instead of siphons to convey water across and above cross-drainages.

Siphon barrels would be constructed of concrete lined steel pipe with reinforced concrete transition structures. The 90-inch pipe was sized for a flow velocity of 8 ft/s when carrying 350 cfs, which is considered sufficient to limit sediment deposition. When diversions cease, the canal would drain, leaving water only in the siphons at the major cross-drainages. If the suspended sediment load is such that settlement could potentially reduce capacity of the siphons, the siphons can be drained immediately following system operation. Siphons could be drained to the elevation of the cross-drainage stream channel with above-ground blow-off valves. Draining below-channel sections of the siphons would require pumping or gravity flow piping to daylight (heavily dependent on topography).

A typical siphon design is shown in Figure IV-4.

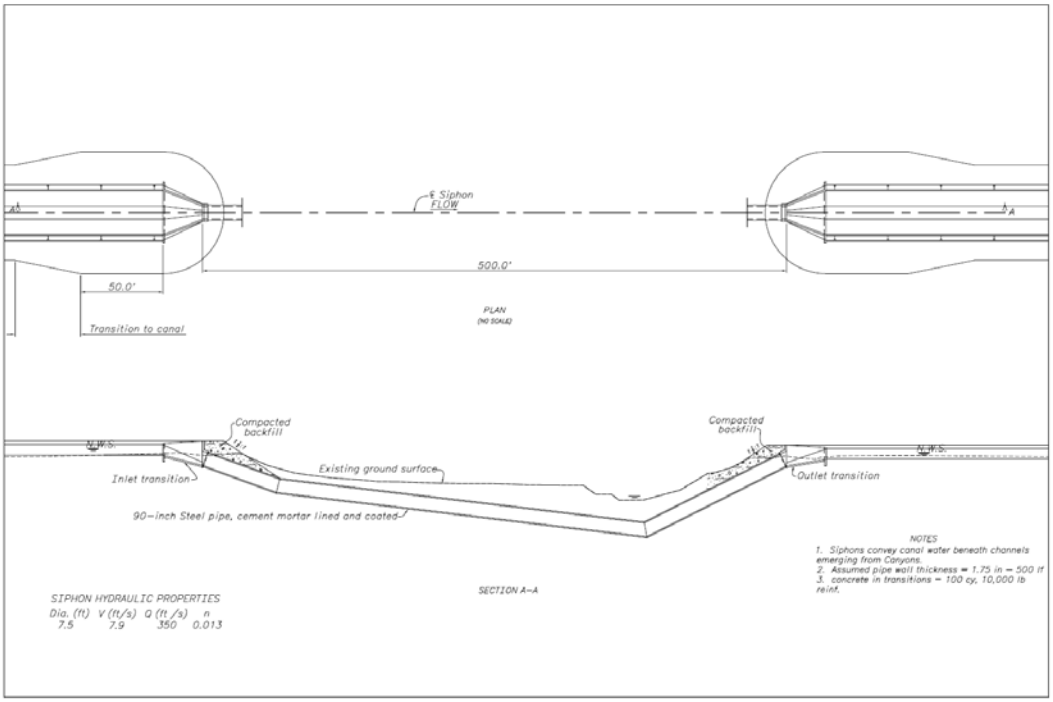

Figure IV-4. - Typical siphon design

At certain locations the canals intersect existing roadways, which would need a road crossing at these locations. Road crossings would be reinforced concrete trapezoidal structures, an economical type of small bridge, as shown in Figure IV-5.

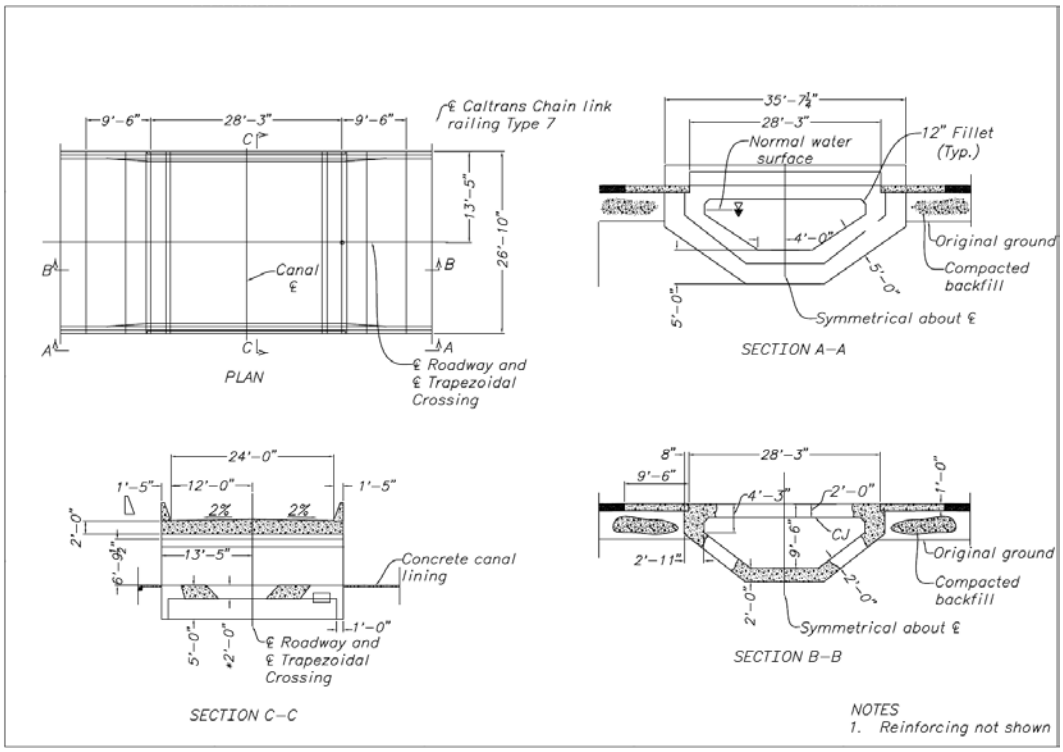

Figure IV-5. - Typical road crossing design

C. Single canyon options

Storage capacities were developed for 24 potential storage reservoirs. Please refer to Section IV.E., Dam Methodology, for dam design details. Each storage site was evaluated to determine the storage potential from the four diversion locations. Storage capacities were calculated by creating a surface of the existing terrain using AutoCAD Civil 3-D. Reclamation assumed the bottom 10 feet of the reservoirs would be filled with sediment over the life of the reservoir, so a digital surface was created from existing terrain with sediment fill. The high water elevation defined the maximum storage capacity in the reservoirs. Capacities were determined for all 24 sites, from all four diversion locations. The results are shown in Table A-1 in Appendix A.

1. Greenwood Canyon

A storage reservoir in Greenwood Canyon could potentially store up to 26,000 ac-ft of Gila River water, if diverted at Diversion 1. The dam site was selected primarily because of its storage capacity and being the furthest upstream of the viable large capacity reservoirs. The site's primary disadvantage is 3 miles of US HWY 180 would be within the reservoirs area. The embankment dam would have a structural height of 176 ft and a crest length of 1412 ft. The proposed dam and reservoir would have the following characteristics:

- Storage capacity- 26,000 ac-ft
- Reservoir area- 481 acres
- Dam structural height- 176 ft
- Embankment dam crest length- 1412 ft
- Dam crest elevation- 4632 ft
- Embankment dam volume- 3,035,000 cubic yards
- Canal conveyance length from Diversion 1 to reservoir of 136,600 ft

The proposed reservoir would inundate 481 acres of land, including 3 miles of US HWY 180 and the interchange between US 180 and NM 211. About 1 mile of NM 211 would be abandoned from the existing intersection north. US HWY 180 could be relocated to the north and a new interchange at US HWY 180 and NM 211 would be constructed. Approximately one mile of existing power lines, would also need to be rerouted from Greenwood to Pope Canyon. The cost of road and power relocations are included in the cost estimate.

Within the proposed reservoir footprint, there is a structure located on parcel # 3098093410250. The parcel has an assessed value of $26,821 for 3.876 acres. There are approximately 7 parcels within Greenwood Canyon with values per acre ranging from $5 to $6,920.

Total costs associated with diverting, conveying and storing flows at Greenwood Canyon are $280,000,000. Diversion dam costs include construction of a diversion structure with gates capable of diverting up to 350 cfs. Conveyance costs include 136,600 ft. of concrete lined canals, 3,800 ft. of 7.5 ft. diameter siphons, 24 culverts and 5 road crossings. Storage dam costs include constructing an embankment dam, including the cost of a spillway and outlet works, highway and powerline relocations. Conceptual plan view and cross-sections for a dam at this site are shown in Figure IV-6. Table IV-1 shows a summary of the estimated costs for this site. Refer to Appendix B for detailed cost estimates.

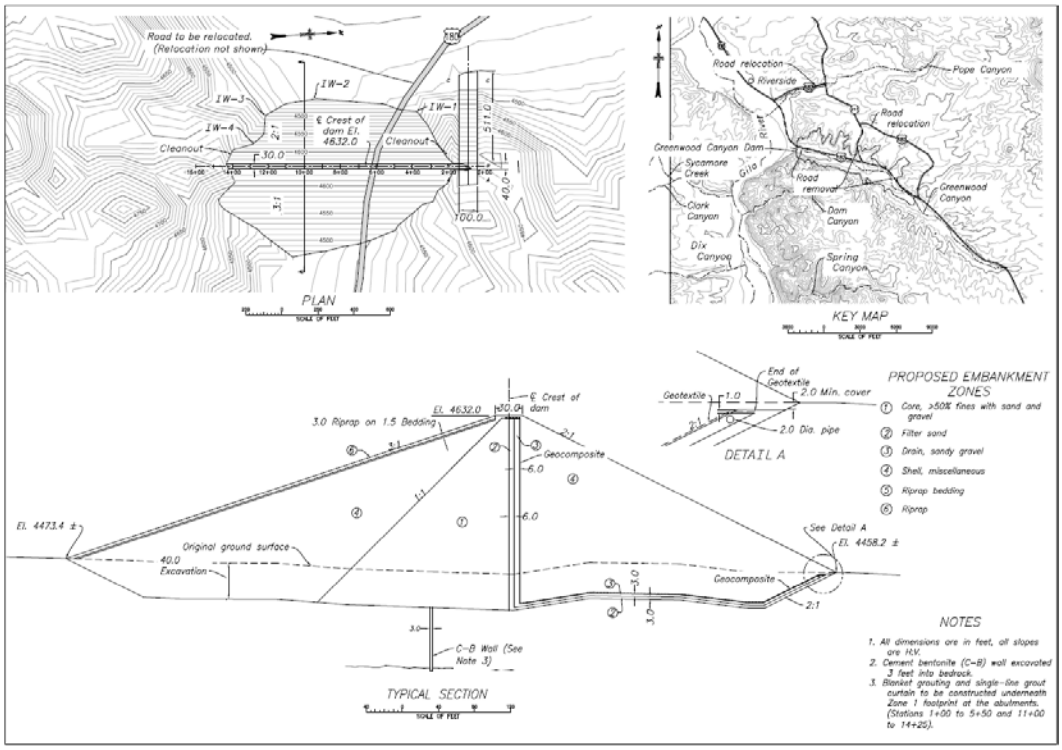

Figure IV-6. - Greenwood conceptual dam and cross section

Table IV-1. - Greenwood Canyon cost estimates

Description	Cost ($)
Relocate HWYs US 180 and NM 211	56,600,000
Diversion Dam	3,200,000
Conveyance	103,000,000
Storage Dam	118,000,000
Total	**280,000,000**

2. Spar Canyon

A storage reservoir in Spar Canyon could potentially store up to 3,100 ac-ft of Gila River water, if diverted at Diversion 4. Being the furthest upstream storage site besides Mogollon Creek, Spar Canyon has the advantage of providing releases to the entire Cliff-Gila valley. Water stored at Spar Canyon can be released into the river and diverted at Fort West Diversion and Gila Farm Diversion. Water could also be piped across the Gila River to the Upper Gila Diversion. The embankment dam would have a structural height of 122 ft and a crest length of 1100 ft. The proposed dam and reservoir would have the following characteristics:

- Storage capacity- 3,100 ac-ft
- Reservoir area- 36 acres
- Dam structural height- 122 ft
- Embankment dam crest length- 1100 ft
- Dam crest elevation- 4777 ft
- Embankment dam volume- 1,050,000 yd^3
- Canal conveyance length from Diversion 4 to reservoir of 51,500 ft

There are no structures or power lines within the proposed reservoir's 36-acre footprint. Several residences lie within 0.1 miles downstream of the dam site and the imacts on these residences would need to be evaluated. The reservoir area inundates two US Forest service and two privately owned parcels. Parcels within Spar have assessed values per acre ranging from $4 to $13,296.

Total costs associated with diverting, conveying and storing flows at Spar Canyon are $162,000,000. Diversion dam costs include construction of a diversion structure with gates capable of diverting up to 350 cfs. Conveyance costs include 51,500 ft. of concrete lined canals and 18 culverts. Storage cost is the cost to construct an embankment dam with a structural height of 122 ft., spillway and outlet works. Conceptual plan view and cross-sections for a dam at this site are shown in Figure IV-7 Table IV-2 shows the cost estimated for this site. Refer to Appendix B for detailed cost estimates.

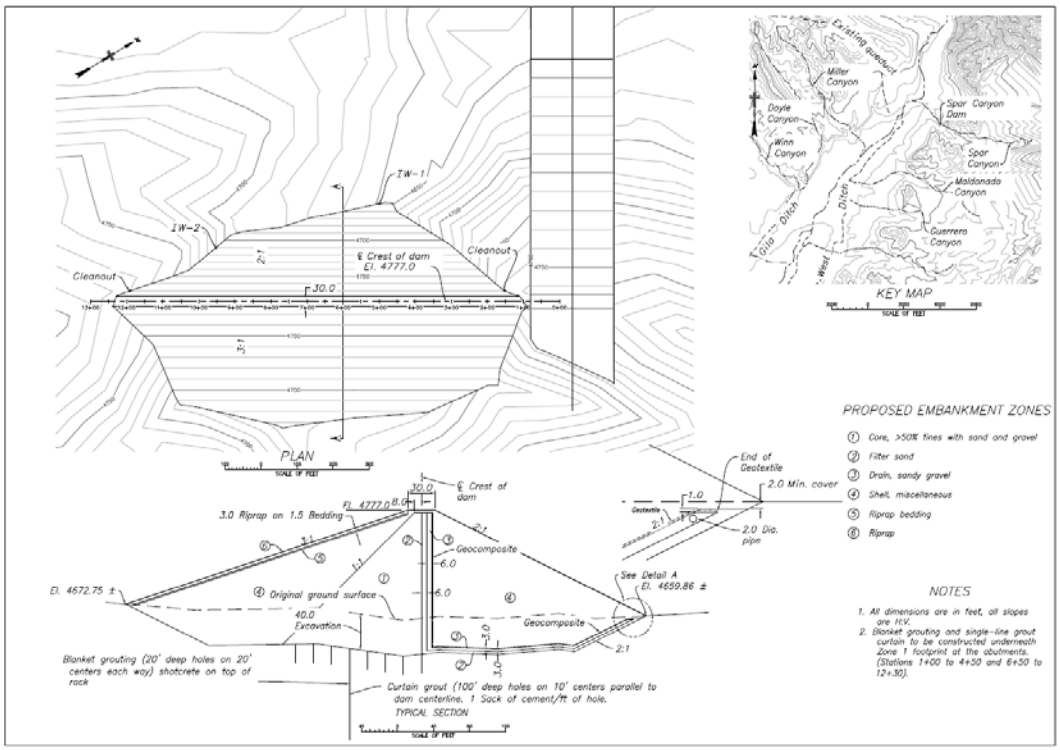

Figure IV-7. - Spar conceptual dam and cross section

Table IV-2. - Spar Canyon cost estimates

Description	Cost ($)
Diversion Dam	4,720,000
Conveyance	76,000,000
Storage Dam	80,600,000
Total	**162,000,000**

3. Sycamore Canyon

A storage reservoir in Sycamore Canyon could potentially store up to 36,900 ac-ft of Gila River water, if diverted at Diversion 1. A Sycamore Canyon reservoir has the largest storage capacity of all storage reservoirs associated with Diversion 1. A Sycamore Canyon reservoir would not be able to provide water to the upper Cliff-Gila Valley via Upper Gila, Fort West and Gila Farm Diversions. The embankment dam would have a structural height of 186 feet and a length of 4400 feet. The proposed dam and reservoir would have the following characteristics:

- Storage capacity- 36,900 ac-ft
- Reservoir area- 583 acres

- Dam structural height- 186 ft
- Embankment dam crest length- 4400 ft
- Dam crest elevation- 4623 ft
- Embankment dam volume- 6,800,000 yd^3
- Canal conveyance length from Diversion 1 to reservoir of 118,950 ft

The proposed reservoir would inundate approximately 583 acres of land including a portion of McCauley Road, 1 residence, and power lines. There are approximately 11 parcels within Sycamore Canyon with county assessed values per acre ranging from $5 to $225,301. A large portion of the land ownership belongs to BLM and the State of New Mexico. Approximately 4,200 ft. of McCauley Road would need to be relocated, presumably using the crest of the dam.

Total costs associated with diverting, conveying and storing flows at Sycamore Canyon are $364,000,000. Diversion dam costs include construction of a diversion structure with gates capable of diverting up to 350 cfs. Conveyance costs include 118,950 feet of concrete lined canals, 10,950 feet of 7.5-foot diameter siphons, five road crossings and 24 culverts. Storage cost is the cost to construct an embankment dam with a structural height of 186 feet, a spillway, and outlet works. Table IV-3 shows the cost estimated for this site. Refer to Appendix B for detailed cost estimates.

Table IV-3. - Sycamore Canyon cost estimates

Description	Cost ($)
Diversion Dam	3,200,000
Conveyance	,80,000,000
Storage Dam	281,000,000
Total	**364,000,000**

4. Winn Canyon

A storage reservoir in Winn Canyon could potentially store up to 2,750 ac-ft of Gila River water, if diverted at Diversion 1. One of the furthest upstream reservoir sites, a Wynn Canyon storage facility could provide releases to the Upper Gila and Gila Farm Ditches. A siphon pipe across the Gila would be necessary to get water to the Fort West Ditch. The embankment dam would have

a structural height of 81 feet and a length of 1500 feet. The proposed reservoir would have the following characteristics:

- Storage capacity- 2,750 ac-ft
- Reservoir area- 109 acres
- Dam structural height- 81 ft
- Embankment dam crest length- 1500 ft
- Dam crest elevation- 4670 ft
- Embankment dam volume- 829,000 yd^3
- Canal conveyance length from Diversion 1 to reservoir of 42,230 ft

The proposed reservoir would inundate approximately 109 acres of land to including a flood control dam located 1,100 feet upstream of the proposed embankment dam. There are no permanent structures or power lines located within the footprint of the dam. There are 3 parcels within Winn Canyon with values per acre ranging from $5 to $614. Most of the reservoir is located within parcel numbers 3099086066066 and 3098086264264. The reservoir inundates less than an acre of parcel number 3099087396264.

Total costs associated with diverting, conveying and storing flows at Winn Canyon are $83,300,000. Diversion dam costs include construction of a diversion structure with gates capable of diverting up to 350 cfs. Conveyance costs include 42,230 feet of concrete lined canals, ten culverts, and three road crossings. Storage cost is the cost to construct an embankment dam with a structural height of 81 feet, a spillway, and outlet works. Conceptual plan view and cross-sections for a dam at this site are shown in Figure IV-8. Table IV-4 shows the cost estimated for this site. Refer to Appendix B for detailed cost estimates.

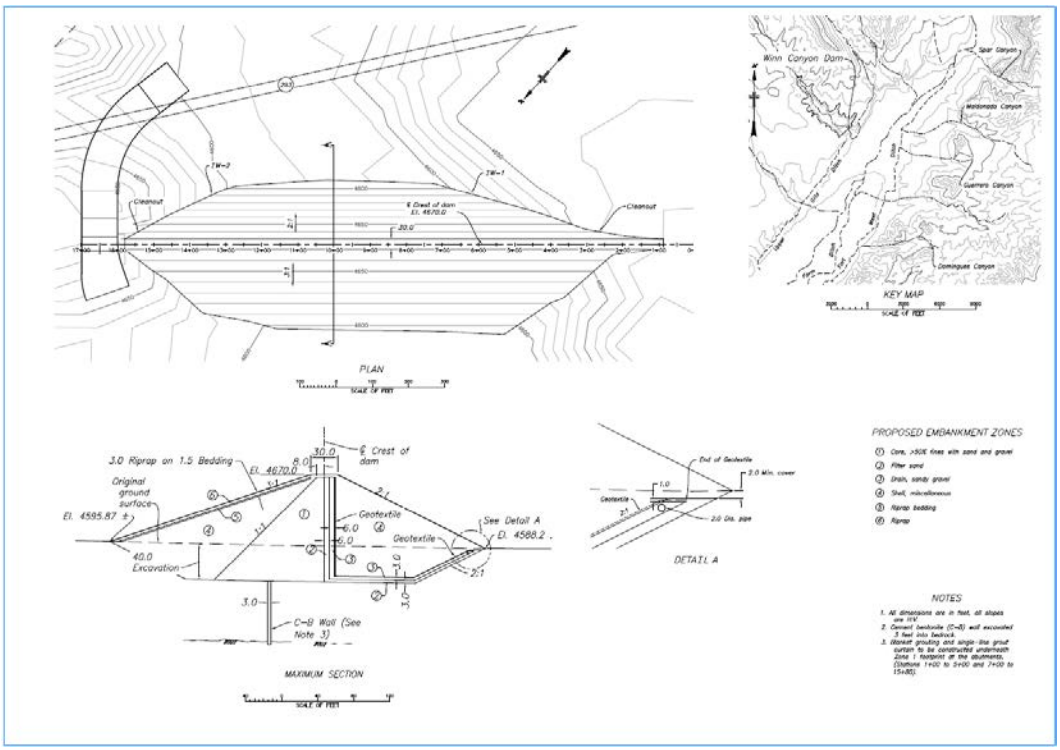

Figure IV-8. - Winn conceptual dam and cross section

Table IV-4. - Winn Canyon cost estimates

Description	Cost ($)
Diversion Dam	3,200,000
Conveyance	16,400,000
Storage Dam	63,700,000
Total	**83,300,000**

5. Pope Canyon

A storage reservoir in Pope Canyon could potentially store up to 7,900 ac-ft of Gila River water, if diverted at Diversion 1. Water stored at Pope Canyon could be released into the Gila River and diverted at Riverside and Clark Diversions. The embankment dam would have a structural height of 126 feet and a length of 1500 feet. The proposed reservoir would have the following characteristics:

- Storage capacity- 7,900 ac-ft
- Reservoir area- 219 acres
- Dam structural height- 126 ft

- Embankment dam crest length- 1500 ft
- Dam crest elevation- 4633 ft
- Embankment dam volume- 2,440,000 yd3
- Canal conveyance length from Diversion 1 to reservoir of 113,750 ft

The proposed reservoir would inundate approximately 219 acres. A 4,500-foot section of NM State Route 211 would be inundated by the reservoir and would require relocation. There are no permanent structures or power lines located within the footprint of the reservoir. The three land parcels within Pope Canyon were each assessed by the County at about $5 per acre.

Total costs associated with diverting, conveying and storing flows at Pope Canyon are $234,000,000. Diversion dam costs include construction of a diversion structure with gates capable of diverting up to 350 cfs. Conveyance costs include 113,750 ft. of concrete lined canals, 3,800 feet of 7.5-foot diameter siphons, 24 culverts and five road crossings. Storage cost is the cost to construct an embankment dam with a structural height of 126 feet, a spillway, and outlet works. Table IV-5 shows the cost estimated for this site. Refer to Appendix B for detailed cost estimates.

Table IV-5. - Pope Canyon cost estimates

Description	Cost ($)
Diversion Dam	3,200,000
Conveyance	94,300,000
Storage Dam	137,000,000
Total	**234,000,000**

6. Dam Canyon

A storage reservoir in Dam Canyon could potentially store up to 9,400 ac-ft of Gila River water, if diverted at Diversion 2. Water stored at Dam Canyon could be siphoned under the Gila River to provide water to the Clark Ditch. The embankment dam would have a structural height of 247 feet and a length of 1,715 feet. The proposed reservoir would have the following characteristics:

- Storage capacity- 9,400 ac-ft
- Reservoir area- 135 acres

- Dam structural height- 247 ft
- Embankment dam crest length- 1715 ft
- Dam crest elevation- 4685 ft
- Embankment dam volume- 4,290,000 yd3
- Canal conveyance length from Diversion 2 to reservoir of 172,900 ft

There are no permanent structures or power lines located within the proposed reservoir's 135-acre footprint. The proposed reservoir would inundate two parcels, US Bureau of Land Management and one privately owned parcel. Land within Dam Canyon is relatively inexpensive with the privately owned parcel having a county assessed value of $5 per acre.

Total costs associated with diverting, conveying, and storing flows at Dam Canyon are $307,000,000. Diversion dam costs include construction of a diversion structure with gates capable of diverting up to 350 cfs. Conveyance costs include 172,900 feet of concrete lined canals, 5,060 feet of 7.5-foot diameter siphons, 24 culverts, and five road crossings. Storage cost is the cost to construct an embankment dam with a structural height of 126 ft, a spillway, and outlet works. Conceptual plan view and cross-sections for a dam at this site are shown in Figure IV-9. Table IV-6 shows the cost estimated for this site. Refer to Appendix B for detailed cost estimates.

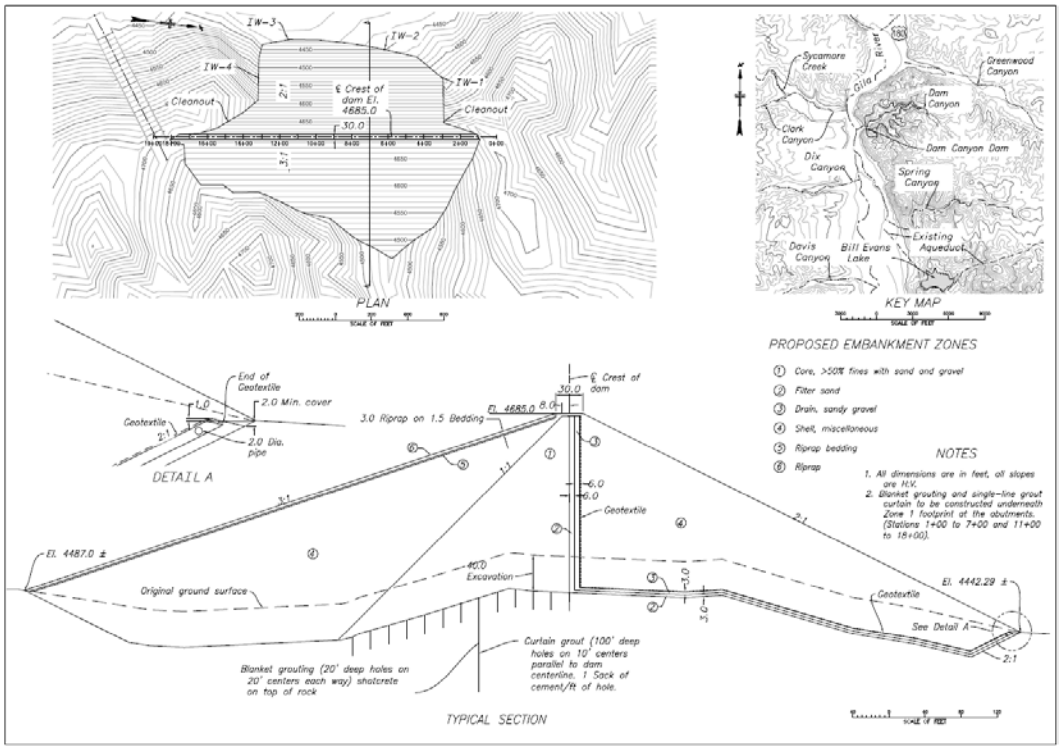

Figure IV-9. - Dam conceptual dam and cross section

Table IV-6. - Dam Canyon cost estimates

Description	Cost ($)
Diversion Dam	4,700,000
Conveyance	161,000,000
Storage Dam	141,000,000
Total	**307,000,000**

7. Garcia Canyon

A storage reservoir in Garcia Canyon could potentially store up to 7,500 ac-ft of Gila River water, if diverted at Diversion 3. Water stored at Garcia Canyon could be released to provide water to the Gila Farm Ditch and a portion of the Fort West Ditch. Water from Garcia could also be siphoned under the river to provide water for the Upper Gila Ditch. The embankment dam would have a structural height of 115 feet and a crest length of 2,650 feet. The proposed reservoir would have the following characteristics:

- Storage capacity- 7,500 ac-ft

- Reservoir area- 203 acres
- Dam structural height- 115 ft
- Embankment dam crest length- 2650 ft
- Dam crest elevation- 4762 ft
- Embankment dam volume- 2,120,000 yd^3
- Canal conveyance length from Diversion 3 to reservoir of 87,800 ft

There are no permanent structures or power lines located within the proposed reservoir's 115-acre footprint. Approximately 2,000 feet downstream of the embankment dam is a flood control structure which currently would impound water downstream of the embankment dam. There are five parcels within Garcia Canyon with county assessed values ranging from $7 to $232 per acre.

Total costs associated with diverting, conveying and storing flows at Garcia Canyon are $208,000,000. Diversion dam costs include construction of a diversion structure with gates capable of diverting up to 350 cfs. Conveyance costs include 87,800 feet of concrete lined canals and 20 culverts. Storage cost is the cost to construct an embankment dam with a structural height of 115 feet, a spillway, and outlet works. Conceptual plan view and cross-sections for a dam at this site are shown in Figure IV-10. Table IV-7 shows the cost estimated for this site. Refer to Appendix B for detailed cost estimates.

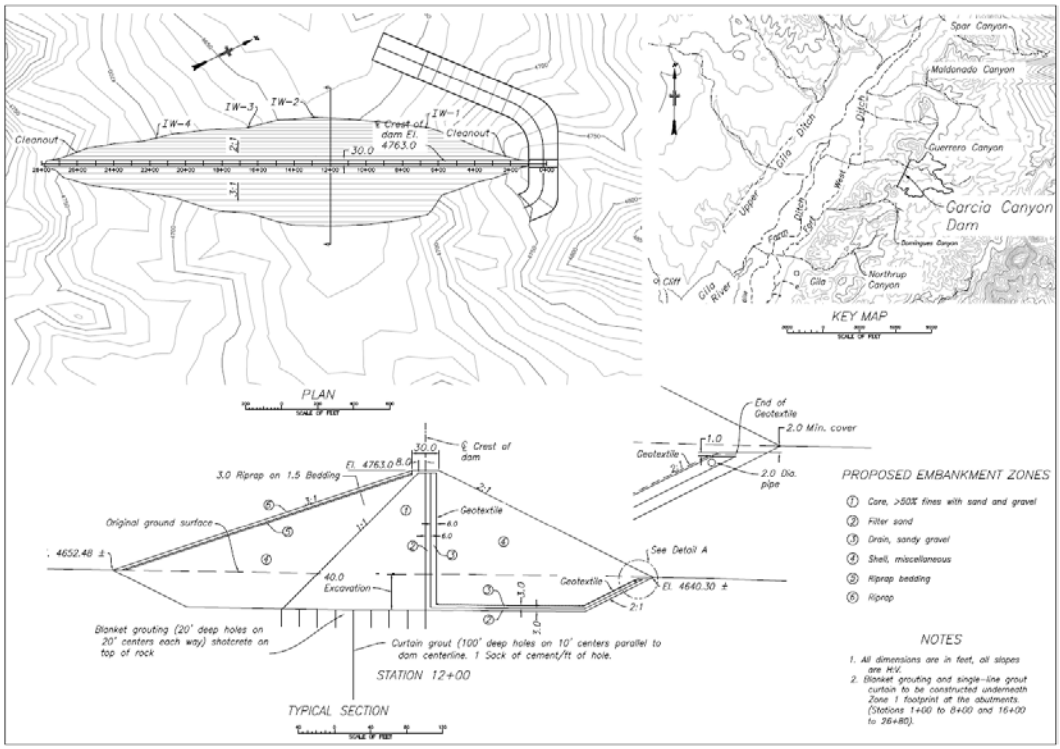

Figure IV-10. - Garcia conceptual dam and cross section

Table IV-7. - Garcia Canyon cost estimates

Description	Cost ($)
Diversion Dam	4,700,000
Conveyance	81,000,000
Storage Dam	122,000,000
Total	**208,000,000**

Reclamation evaluated where stored water could be be diverted, using existing diversion dams and non pressure flow. The results are summarized in Table IV-8.

Table IV-8. - Existing diversions reachable from storage dam (non pressure flow)

Storage Dam	Diversion Dams				
	Upper Gila	Fort West	Gila Farm	Riverside	Clark
Spar	No	Yes	Yes	Yes	Yes
Winn	No	No	Yes	Yes	Yes
Garcia	No	No	Yes	Yes	Yes
Pope	No	No	No	Yes	Yes
Greenwood	No	No	No	No	Yes

Storage Dam	Diversion Dams				
	Upper Gila	Fort West	Gila Farm	Riverside	Clark
Sycamore	No	No	No	No	No
Dam	No	No	No	No	No
Mangas*	No	No	No	No	No
Schoolhouse*	No	No	No	No	No

* For information only, not Reclamation alternative

Reclamation also analyzed the percentage of irrigation distribution systems to which water could be conveyed, evaluating both pressure flow and non-pressure flow from specific storage reservoirs. The results are summarized in Table IV-9.

Table IV-9. - Percentage of acreage supplied from storage dam

Storage Dam	Irrigation Distribution System				
	Upper Gila	Fort West	Gila Farm	Riverside	Clark
Spar	100[A]	100	100	100	100
Winn	91[B]/83[C]	100[A]	100	100	100
Garcia	83[A]	100[B] / 77[C]	100	100	100
Pope	0	0	0	100	100
Greenwood	0	0	0	100[A]	100
Sycamore	0	0	0	0	100[C]
Dam	0	0	0	0	100[A]
Mangas*	0	0	0	0	0
Schoolhouse*	0	0	0	0	0

* For information only, not Reclamation alternative
[A] Pressure siphon/pipeline required under river from storage reservoir to existing irrigation distribution system.
[B] Pressure pipeline required from storage reservoir to existing irrigation distribution system.
[C] Open channel flow (non-pressurized).
Reservoir elevations at storage dams assumed to be 5 feet above low level outlet works for pressure pipe flow

D. Multi-canyon alternatives

Alternative 1 (65000 AF) - Alternative 1 consists of a diversion structure at Diversion point 1 and storage at the two largest potential reservoirs; Greenwood and Sycamore. Gila River water would be conveyed to Greenwood Canyon by means of a 136,600-foot concrete lined canal. Water could be released into the reservoir or continued to be conveyed 7,350 feet further downstream, using the embankment dam to cross Greenwood Canyon. Water would then be siphoned

below the river using 2,660 ft of 90-inch pressure pipe. The siphoned flow will be released directly into Sycamore Canyon for storage.

Sycamore Canyon would be able to store approximately 36,900 ac-ft of water and Greenwood Canyon would be able to store 26,000 ac-ft for a total storage of 62,900 ac-ft of water. The top of storage at Greenwood Canyon is elevation 4619 and the conveyance head loss between Greenwood and Sycamore is approximately 7.7 feet. The top of storage at Sycamore Canyon is elevation 4610. The Alternative 1 plan view can be seen in Figure IV-11. - Alternative 1 Storage at Greenwood and Sycamore Canyon and the potential cost for this alternative can be seen below in Table IV-10.

Table IV-10. - Construction cost for alternative 1

Reservoir	Conveyance	Diversion Dam	Storage Dam	Total Construction Cost
Greenwood & Sycamore	$196,380,000	$3,200,000	$398,870,000	$598,450,000

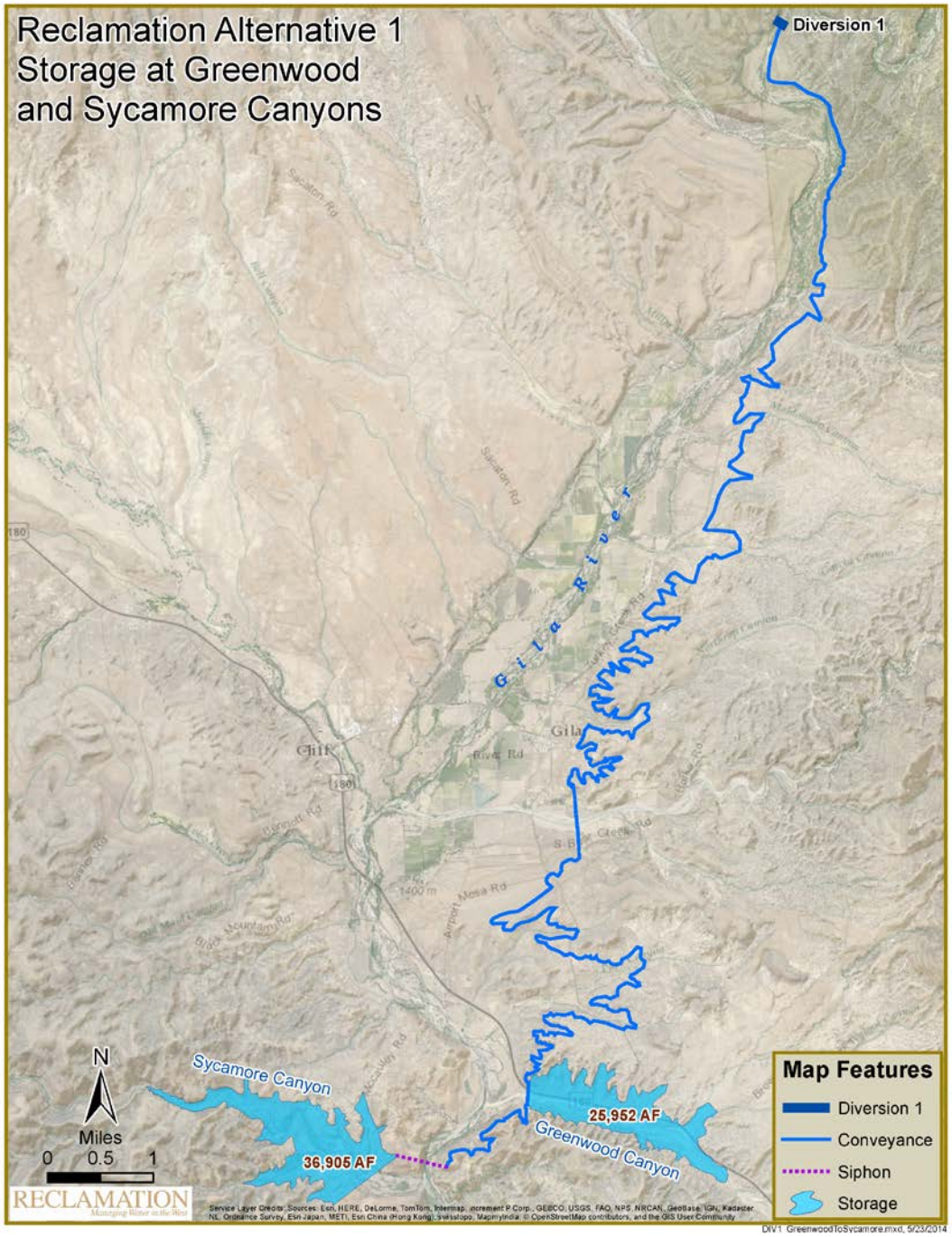

Figure IV-11. - Alternative 1 storage at Greenwood and Sycamore Canyon

Alternative 2 (10,000 AF) - Alternative 2 consists of a diversion structure at diversion point 4 and storage within two of the uppermost storage reservoirs on the east side of the river; Spar and Garcia. Gila River water would be conveyed to Spar Canyon via 51,500 feet of concrete lined canal. Water could be released

into the reservoir or conveyed across the Spar embankment dam another 28,000 feet to Garcia Canyon for storage.

Spar Canyon would be able to store approximately 3,100 ac-ft of water and Garcia Canyon would be able to store 7,500 ac-ft for a total storage of 10,600 ac-ft of water. The top of storage at Spar Canyon is elevation 4764 and the conveyance head loss between Spar and Garcia is 8.4 feet. The top of storage at Garcia Canyon is elevation 4749. The Alternative 2 plan view can be seen in Figure IV-12. - Alternative 2 Storage at Spar and Garcia Canyons and the potential cost for this alternative can be seen below in Table IV-11.

Table IV-11. - Construction cost for alternative 2

Reservoir	Conveyance	Diversion Dam	Storage Dam	Total Construction Cost
Spar & Garcia	$87,780,000	$4,700,000	$202,870,000	$294,373,000

Alternative 3 (14,000 AF) - Alternative 3 consists of a diversion structure at diversion point 4 and storage within two of the uppermost storage reservoirs on the west bank of the river; Mogollon and Winn. Gila River water would be conveyed to Mogollon Canyon via 41,800 feet of concrete lined canal. Water could be released into the reservoir or conveyed across the Mogollon embankment dam another 46,000 feet to Winn Canyon for storage.

Mogollon Canyon would be able to store approximately 11,500 ac-ft of water and Winn Canyon would be able to store 2,750 ac-ft for a total quantity of 14,250 ac-ft. The top of storage at Mogollon Canyon is elevation 4766 and the conveyance head loss between Mogollon and Winn is 13.8 ft. The top of storage at Winn Canyon is elevation 4657. The Alternative 3 plan view can be seen in Figure IV-13. - Alternative 3 Storage at Mogollon and Winn Canyons and the potential cost for this alternative can be seen below in Table IV-12.

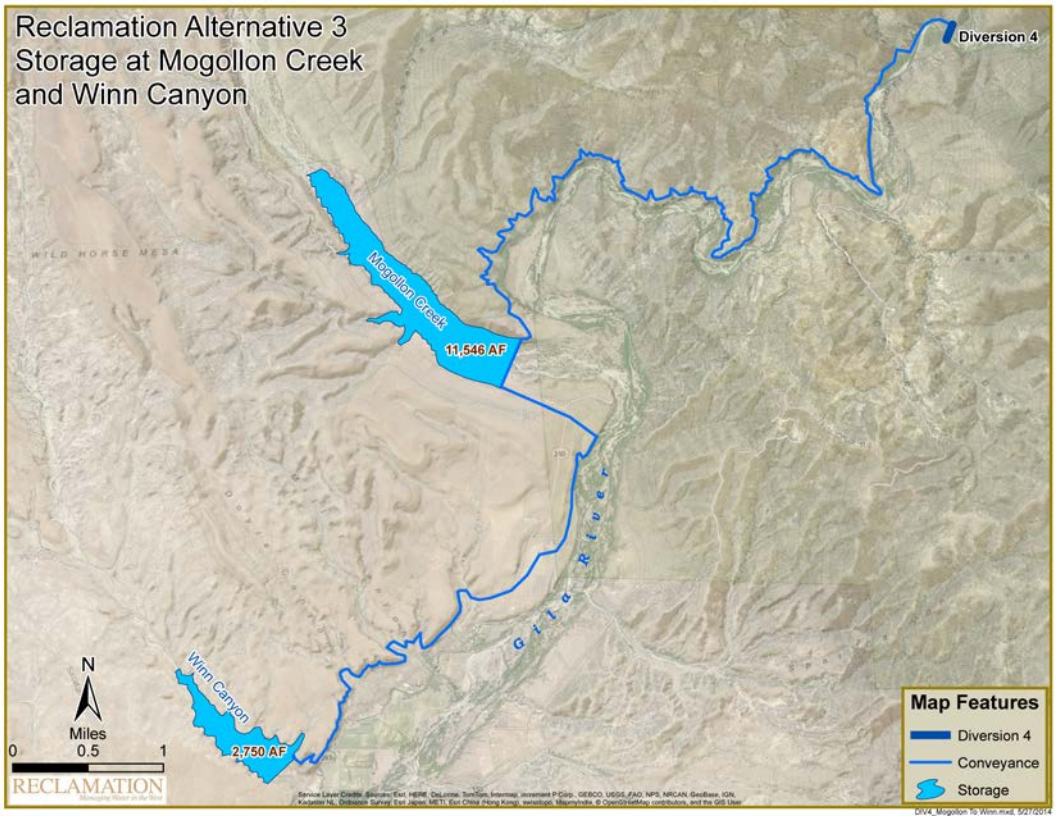

Figure IV-13. - Alternative 3 storage at Mogollon and Winn Canyons

Table IV-12. - Construction cost for alternative 3

Reservoir	Conveyance	Diversion Dam	Storage Dam	Total Construction Cost
Mogollon & Winn	$83,900,000	$4,700,000	$218,680,000	$307,303,000

Reclamation selected the preceding alternatives based on the storage needs identified. Alternative 1 satisfies storing up to 64,000 AF of water in one year, the maximum allowable under AWSA. Alternative 3 allows storage up to 14,000 AF of water in a year, the average yearly allowable storage over 10 years under AWSA. Lastly, Alternative 2 stores up to 10,000 AF of water, the yearly average minus the San Francisco's 4,000 ac-ft.

Alternatives Cost per AP in Table IV-13 shows the average cost per AF of water for each alternative.

Table IV-13. - Alternatives cost per AF

Storage Sites	Storage Volume (AF)	Construction Cost ($)	Cost per AF
Sycamore & Greenwood	62,900	$598,450,000	$9,514.31
Mogollon & Winn	14,250	$307,303,000	$21,565.10
Spar & Garcia	10,600	$294,373,000	$27,771.00

E. Dam methodology

1. Dam Selection

Reclamation originally considered the evaluation of constructing Roller Compacted Concrete (RCC) dams at the same site locations that had been selected for embankment dams. However, based on the provided design data and canyon geomorphology it was estimated anywhere from 50 to 100 feet of alluvial material would have to be excavated to reach a rock foundation. Considering the dam heights ranged from 70 to 270 feet before excavation of materials was considered, the potential addition to the height of the RCC dams due to excavation would greatly increase the physical size and ultimately cost of the dam. Further, based on the provided design data the bearing capacity of the underlying rock foundation was estimated between 25 to 35 kip/ft^2, which would be insufficient unless the dam base width was increased substantially. Based on these primary

factors the RCC dam concepts were not pursued and the embankment dam was the only viable alternative considered.

2. Embankment dam design

Embankment dams are all similarly-designed central core, zoned earth fill-type dams. The primary differences between the dams are the crest elevation, structural and hydraulic dam heights, dam lengths, and the foundation treatments to be performed at each site. The zoning, materials, cutoff, embankment cross-sectional shapes, foundation excavation and treatment were all similar from dam to dam. Figure IV-14. shows the typical embankment dam design.

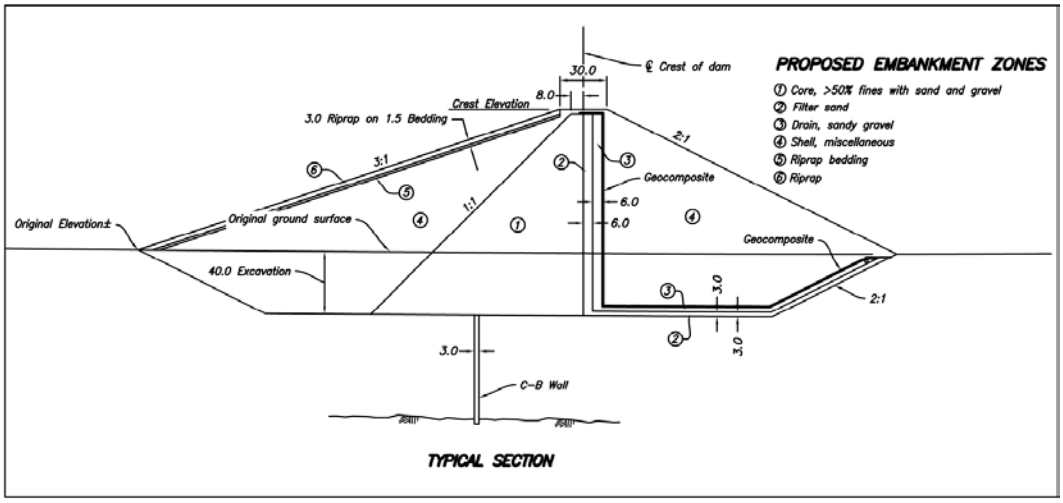

Figure IV-14. - Typical embankment dam design

The amount of foundation excavation and/or need for a cutoff wall beneath each dam was based on geophysics data at selected sites. It is assumed that 90% of the foundation excavation would be in common materials, and 10% would be in rock for all dams. For all dams, the foundation excavation slopes are assumed to be stable on 2(H):1(V) slopes. For Mangas Creek Dam about 40 feet of foundation excavation is required in the main channel of the dam site and about 20 feet of foundation excavation is assumed on the abutments. This will allow Mangas Creek Dam to be founded entirely on bedrock. For Mongollon Dam and Schoolhouse Dam, geophysics showed that bedrock in the main channel could be up to 110 feet deep. Therefore for the main channel foundation at Mongollon Dam and Schoolhouse Dam, it was assumed that 40 feet of foundation excavation would be completed. After completion of the foundation excavation, it was assumed that a cement-bentonite cutoff wall would be excavated 3 feet into bedrock and serve to cutoff seepage for the remaining 70 feet to bedrock. At the abutments of Mongollon Dam and Schoolhouse Dam, blanket and curtain grouting will be used as a seepage barrier through fractured rock. Since Mangas

Creek Dam is founded entirely on bedrock, the blanket grouting and single-line grout curtain will extend across the entire dam length. For all three dams, it was assumed that blanket grouting would be completed in 20-foot-deep holes at 20-foot spacing and that a 70-foot deep single-line grout curtain would be completed at the mid-point of the impervious zone or core. Some secondary and tertiary grout holes split spaced between the 10-foot primary holes will undoubtedly be necessary for a complete closure, but are not included in this appraisal level design. Based on available information from Bill Evans Dam which is close to all of the proposed dam sites and information from past Reclamation grouting jobs, all grouting was assumed to take an average of 1 sack of cement per foot of hole. The soil material left after the excavation beneath the footprint should suffice to support the embankment shells. Other treatments, such as blasting to shape the foundation, slush grouting or dental concrete, are expected to be minor and not included in the appraisal level design. No grout cap is planned to be used.

Dewatering is assumed to be required for the foundation excavation at the dams. A line of wellpoints above both the upstream and downstream slopes of the foundation excavation and partially up the abutments was assumed for the appraisal level cost estimates.

The embankments are zoned somewhat typically for an embankment dam. The impervious zone or core will be placed with 1(H):1(V) upstream slope and a vertical downstream slope. The core is expected to contain more than 50% fines with sand and gravel, derived from local borrow areas or required excavations. The core will extend to the bottom of the foundation excavation. Immediately downstream of the core there will be a Zone 2 chimney of filter sand to provide filter protection against seepage. The filter sand will also be placed as a Zone 2 blanket on the downstream slope of the cutoff trench and beneath the core and shell downstream of the cutoff trench. Downstream of the Zone 2 filter will be a Zone 3 gravel drain that lowers the phreatic surface within the dam and conveys seepage to a downstream toe drain. The Zone 2 and Zone 3 are expected to be produced from commercial sources. The toe drain pipe will be a 2-foot-diameter, Standard Dimension Ratio (SDR) 17 perforated toe drain pipe located at the downstream toe of the dam and it will extend across the valley. The toe drain will discharge to a suitable outfall location and each end of the toe drain will be exposed at the ground surface at cleanouts. Inspection wells will be located along the toe drain about every 500 feet for monitoring and maintenance purposes. The core, Zone 2, and Zone 3 will be buttressed by a Zone 4 shell that consists of miscellaneous materials. The miscellaneous materials are expected to be pit run material from local borrow or required excavations. A geotextile will be used to cover and separate the gravel drain from the Zone 4 and it will serve to prevent the finer fraction of the Zone 4 from being transported into the gravel drain. The downstream face of the dam is designed with a 2(H):1(V) slope assuming adequate shear strength of the compacted shell materials; however, if the shear strength of the shell materials proves to be inadequate, the slope may need to be

flattened up to 2.5(H):1(V). The upstream face of the embankment will be sloped at 3(H):1(V) to provide for slope stability, especially during rapid drawdown. Overlying the upstream shell will be a layer of armor or slope protection consisting of riprap and bedding.

The dam crest for each dam will be 30-feet wide to facilitate construction, operation and maintenance. The elevation of each dam crest is based on the required reservoir storage and is assumed to incorporate flood, seismic and security freeboard requirements. Crest details such as camber, crest drainage, or traffic features are not included in the appraisal level designs.

3. Embankment dam location selection

Embankment dam locations were selected to maximize the storage volume based on topography and conveyance elevations. The top of storage elevation was assumed to be the invert of the inlet from the conveyance feature. Reclamation assumed the dam's crest elevation was 13 feet above the top of storage elevation, including freeboard. Using 5 to 10 meter digital elevation models (DEMs) to create surfaces, Reclamation created dam crest alignments enclosing the reservoirs while maximizing storage upstream of the embankment dams.

The dams are located in their respective drainages to optimize the use of the existing natural topography. They are located to minimize the amount of fill required for the dam embankment while maximizing the amount of storage available upstream. Some consideration was given with respect to the inflow and outflow structures to reduce the lengths of the inflow water conveyance canal, spillway and outlet works. Saddle dams or dikes were assumed not to be required and not included in the appraisal level design.

4. Outlet Works

The water demand or minimum discharge capacity for the outlet works structures at each potential dam site location was set at 100 ft^3/s. In order to comply with Reclamation's criteria and guidelines for evacuating storage reservoirs, each dam site was evaluated to determine what the maximum discharge capacity of the outlet works would have to be to evacuate the reservoir in accordance with the evacuation guidelines displayed in table IV-14. The guidelines for high hazard / high risk dams was assumed as it was the most conservative evacuation time range given and this is an appraisal level study.

Table IV-14 – General Guide for Determining Emergency Evacuation Time

Evacuation Stage	High Hazard / High Risk Dam Evacuation Time (days)
75% Hydraulic height	10-20
50% Hydraulic height	30-40
10% Reservoir storage	40-50
25% Hydraulic height	60-80

For each of the dam sites (Mangas, Schoolhouse, and Mogollan) a reservoir storage capacity table was developed based on design data information. Table IV-15 displays the reservoir storage capacity for each potential dam site.

Table IV-15. - Reservoir Storage Capacity Tables for Proposed Dam Sites

Mangas		Schoolhouse		Mogollan	
RWS El. (ft)	Storage (ac-ft)	RWS El. (ft)	Storage (ac-ft)	RWS El. (ft)	Storage (ac-ft)
4510	0	4480	0	4700	0
4580	972	4520	380	4701	0
4660	10,510	4560	1,634	4720	729
4730	29,450	4600	4,263	4747	3,845

Based on the storage volume for the Mangas Dam site location it was concluded that a discharge capacity of approximately 480 ft^3/s (947 ac-ft/day) would be required to evacuate the reservoir from reservoir water surface (RWS) elevation 4730 to 4660 (33% hydraulic height) within the 20 day time limit. Due to the potential variability of storage versus elevation it was concluded that the outlet works at the Mangas Dam site location could be sized to accommodate a 480 ft^3/s discharge capacity since additional storage capacity data was not available to refine the design. Similarly at the Schoolhouse and Mogollan Dam site locations it was concluded that a discharge capacity of 100 ft^3/s (198 ac-ft/day) would be adequate to evacuate the reservoir storage volumes within the 20 day time limit.

The outlet works was modeled to conform to a typical Reclamation outlet works configuration consisting of a reinforced concrete intake structure, outlet works conduit, gate access shaft (within the embankment and located upstream of the crest of the dam), and an impact-type stilling basin. Because of the uncertainties such as foundation conditions, seismic loading, soil properties, etc. at each potential dam site location, no design calculations were performed; rather conservative general cross-sections and dimensions were assumed for determining quantity estimates. The outlet works structures at Fontenelle, Belle Fourche, and A.R. Bowman Dam (although all are capable of passing much larger releases) were all considered as a guide in determining the general dimensions used for this study. Figure IV-15 displays a sketch of the general layout and cross sections

used for quantity estimates. It was assumed that at all dam sites the outlet works would be within the embankment and not tunneled through the abutment rock.

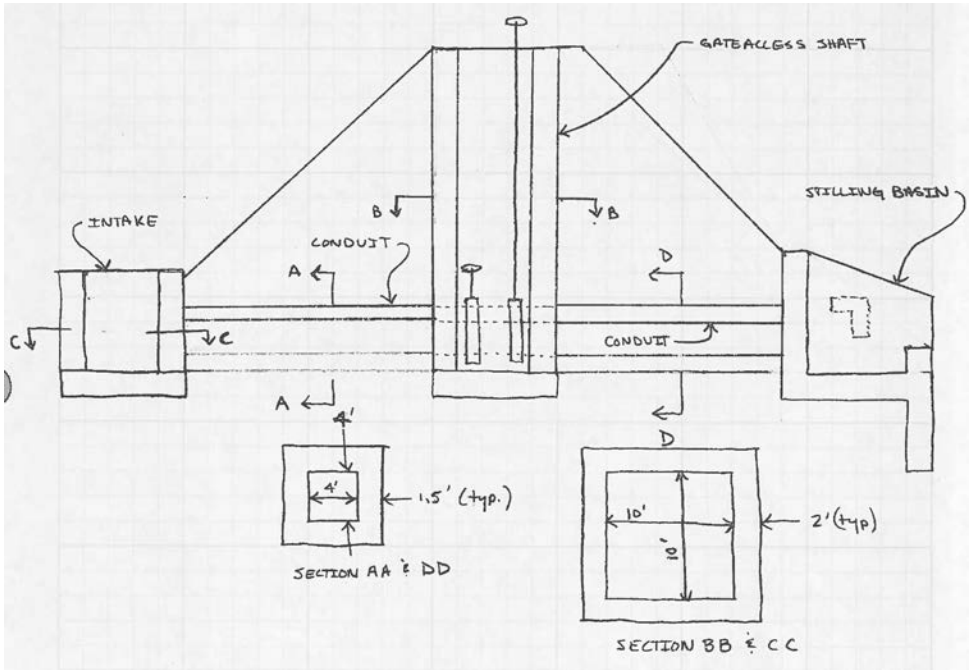

Figure IV-15 – Sketch of General Configuration of Outlet Works

Simple geometric shapes were assumed for simplifying quantities. However, as designs progress the shape of the outlet works conduit would be modified to a more efficient shape for carrying the embankment loads. Also, given the upstream conduit would be pressurized, steel liners would likely be considered. For the 4-foot by 4-foot conduits, the emergency and regulating gates were assumed to be 5-foot by 5-foot slide gates.

5. Spillways

Hydrology for the dam sites is limited for this level of study; therefore, it was determined to size the spillways based on being capable of passing peak inflow estimates. No routings were performed at this time. The peak inflow estimates for each dam site were determined based on the following equation provided by the Technical Service Center's (TSC) Flood Hydrology and Consequences Group (86-68250).

$$Q = (16{,}871) * X^{0.407}$$

Where:
Q = peak discharge (ft^3/s)
X = area of drainage basin (mi^2)

Table IV-16 displays the area of drainage and the computed peak discharge for each dam site.

Table IV-16. - Drainage Area and Peak Discharge for Proposed Dam Sites

Dam Site	Area (mi^2)	Peak Discharge (ft^3/s)
Mangas	194	143,971
Schoolhouse	9.19	41,611
Mogollan	120	118,404

Once the peak discharge estimates were computed the first spillway alternative evaluated was the use of a overflow spillway. Based on design data, a freeboard of 13 feet from the crest of the dam was desired at all locations. Assuming the overflow spillways would be allowed to operate with depths ranging from 10 to 13 feet (to allow for 3 to 0 feet of freeboard to the dam crest) and a coefficient of discharge of C = 4.0 (high value to determine shortest length of crest) was assumed, the following required crest lengths were computed shown in Table IV-17.

Table IV-17. - Overflow Spillway Crest Lengths

Dam Site	Max. 10 foot depth overflow	Max. 13 foot depth overflow
Mangas	1138	768
Schoolhouse	330	222
Mogollan	936	632

Because of the substantial size of the overflow spillway crests and no obvious location to place this type of structure at the selected dam locations, the use of overflow spillways was not considered feasible. Labyrinth crests were not considered to be very practical for this study either, since they begin to lose efficiency once overtopping depths start to exceed 5 feet. It was determined that the most reasonable option would be to use large gated spillways capable of passing and regulating large releases while maintaining a smaller crest length requirement.

Reclamation has several dams with high capacity gated spillways such as Bartlett, Guernsey, and Brantley Dam which use 50-ft by 50-ft fixed wheel gates. In

interest of optimizing time and budget for this project it was decided to model the gated spillways at the selected dam sites after the gated spillway at Guernsey Dam which is capable of passing approximately 52,000 ft^3/s with the single gate. Figure IV-16 displays sections of the gate house from Guernsey Dam which was used to develop quantities for this project.

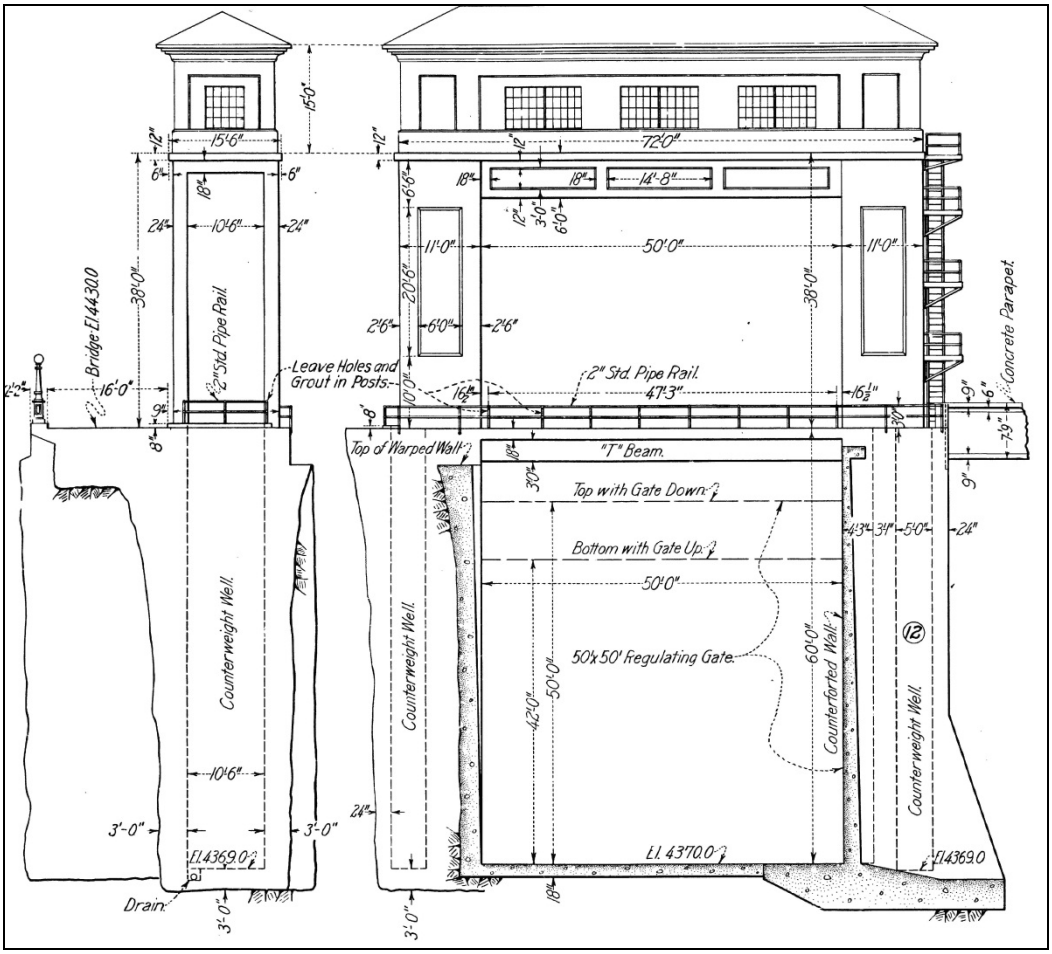

Figure IV-16 – Sections of the Gate House at Guernsey Dam

Based on the discharge capacity (52,000 ft^3/s) of Guernsey Dam's spillway it was assumed that one gate would be adequate for the Schoolhouse dam site and two gates would be adequate for the Mogollan and Mangas dam sites. Although two gates would not meet the peak discharge estimate for Mangas and Mogollan it was assumed flood attenuation would occur reducing the demand at the two dam locations. Further analysis with frequency flood hydrographs and flood routings will be required to accurately size the spillways as studies progress. The spillways consisted of an approach channel, gate house, discharge chute, and stilling basin. The size, location, and general layout differed at each dam site and quantities were adjusted accordingly based on the layout of the spillway.

Drawings were prepared for each dam site showing the excavation that would be required for each spillway in proximity to the embankment dams.

Flood Control Benefits – Storage dams described in this report will provide flood control benefits, ranging from entenuating runoff surges to reducing sediment deposition from side drainages in farming areas. Reservoirs would also allow suspended materials to settle prior to use, benefitting downstream uses.

Evaporation - Evaporation from canals and reservoir will be an reduce yield. Evaporation within the Cliff- Gila Area is approximately 60 inches per year[9] . Table IV-18 shows the theoretical yearly evaporation rates from the reservoirs if kept full for an entire year, and more realistic anticipated evaporation assuming reservoirs contain water 70% of the time and have exposed surface areas 50% of full reservoirs. These considerations reduce evaporation losses by 65% [1.0 - (0.7 x 0.5)]. The 70% figure is an overall average; larger reservoirs will likely contain water longer than smaller reservoirs. The yearly evaporation rates do not include the evaporation losses in the canals.

Table IV-18. - Yearly evaporation at alternate storage locations

Storage Reservoir	Surface Area with Full Reservoir (acres)	Evaporation with Full Reservoir (ac-ft/yr)	Anticipated Evaporation (ac-ft/yr)
Spar	36	180	63
Winn	109	545	191
Garcia	203	1015	355
Pope	219	1095	383
Greenwood	481	2405	842
Sycamore	583	2915	1,020
Dam	135	675	236

Seepage Lossses - Seepage losses are difficult to quantify without geologic data. In addition to geologic hydraulic conductivity rates, seepage variables include wetted reservoir area, periods of time when the reservoirs are low or dry, reservoir operations, water table, reservoir depth, geologic fracturing and faults, seepage cutoff methods, and grouting effort. Seepage rates will slow as foundation materials become saturated. Some percentage of reservoir seepage will return to the Gila River and may not count against diversion volumes, although this may be

[9] Soils Conservation Service, "Gross Annual Lake Evaporation" (New Mexico, 1972)

difficult to quantify. Fine sediments carried into reservoirs will settle on the bottom, slowing infiltration rates, but geologic characteristics could cancel out that benefit.

No drilling or permeability testing has been conducted at any of the proposed dam sites. The following foundation seepage discussion is based on limited geologic descriptions of outcrops at or near the abutments. The outcrops were inspected during seismic refraction surveys that were conducted to determine the depth to bedrock at selected sites. Based on the outcrop geology, a range of hydraulic conductivity values was chosen for the proposed foundation utilizing Table 1 which has been modified from Jacob Bear's "Dynamics of Fluids in Porous Media".

Generally, reservoirs overlying sandstone and conglomerate, like Mogollon and Winn, will have higher seepage rates than Mangas and Schoolhouse with volcanic rhyolite foundations. The dams would be designed with cementitious cut-offs to limit flows through alluvial materials.

Seepage related information associated with the four reservoir sites on which Reclamation performed seismic refraction geophysics work is included below. Quantitative estimates of yearly seepage are not provided for the conglomerate foundation dams because the hydraulic conductivity can vary by two magnitudes, yielding ranges that are not particularly useful for this study. Permeability testing of the conglomerate materials is advised prior to quantifying seepage. Rhyolitic foundation dams have lower seepage rates with ranges that likely vary within a single magnitude, making estimates more practical. Any further attempt to quantify seepage is inappropriate at this time without geologic coring, permeability testing, and analysis.

The abutments at the proposed Mogollon Creek site consist of Gila Conglomerate, a sedimentary unit consisting of interbedded sandstone and conglomerate. The conglomerate is typically moderately hard and is composed of varying amounts of fines, sand, gravel and cobbles that are well cemented by calcium carbonate. The conglomerate is irregularly bedded, displaying a mixture of coarse and fine layers and is usually very slightly fractured to unfractured in outcrop. It is assumed that the foundation also consists of Gila Conglomerate having similar engineering characteristics. No permeability testing has been conducted in the proposed foundation, but based on values given in Table 1; the saturated hydraulic conductivity (K) of the underlying conglomerate probably ranges from 0.01 to 1 ft/day.

The abutments at the proposed Winn Canyon site consist of river terrace deposits composed of uncemented sand, gravel and cobbles with interbedded sand lenses and minor amounts of boulders. Seismic refraction surveys conducted along the proposed alignment indicate the terrace deposits are 40 to 100 feet thick. The

bedrock beneath probably consists of Gila Conglomerate. No permeability testing has been conducted in the proposed foundation or abutments, but based on values given in Table IV-19, the saturated hydraulic conductivity of the unconsolidated terrace deposits may range from 100 to 1,000 ft/day. The K values of the underlying conglomerate probably range from 0.01 to 1 ft/day.

The abutments at the proposed Schoolhouse Canyon site consist of hard, slightly weathered to fresh, light gray rhyolite. Flow joints are spaced 1/2-2 inches apart and the rock is intensely to moderately fractured with localized very intense fracturing. Rhyolite having a saturated hydraulic conductivity value that ranges from 10^{-5} to 10^{-6} ft/day is assumed to form the foundation. Based on these K values and wetted ground surface area, calculations indicate that Schoolhouse Canyon reservoir would lose less than 10 ac-ft/year to seepage.

At the proposed Mangas Creek site, the abutments consist of rhyolite. The rhyolite is moderately hard, moderately to slightly weathered and intensely to moderately fractured. The proposed foundation is assumed to also consist of rhyolite having a saturated hydraulic conductivity value that ranges from 10^{-5} to 10^{-6} ft/day. Based on these K values and wetted ground surface area, calculations indicate that Mangas Creek reservoir would lose less than 10 ac-ft/year to seepage.

Table IV-19 - Saturated Hydraulic Conductivity (K) values found in nature.

K (cm/s)	10^2	10^1	10^0=1	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}	10^{-10}
K (ft/day)	10^5	10,000	1,000	100	10	1	0.1	0.01	0.001	0.0001	10^{-5}	10^{-6}	10^{-7}
Relative Permeability	Pervious				Semi-Pervious				Impervious				
Aquifer	Good					Poor				None			
Unconsolidated Sand & Gravel	Well Sorted Gravel		Well Sorted Sand or Sand & Gravel			Very Fine Sand, Silt, Loess, Loam							
Unconsolidated Clay & Organic					Peat		Layered Clay			Fat / Unweathered Clay			
Consolidated Rocks	Highly Fractured Rocks				Oil Reservoir Rocks			Fresh Sandstone		Fresh Limestone, Dolomite		Fresh Granite	

Source: modified from Bear, 1972

6. Project construction cost

Appraisal level cost estimates were prepared for the seven alternatives presented in this section. Construction costs consist of diversion, conveyance and storage. Conveyance alignments, dam locations, and storage quantities were done at the Phoenix Area Office. Diversion and conveyance quantities were developed by Reclamation's Water Conveyance group, located at the Technical Service Center (TSC) in Denver, CO. Storage dam design and quantities were developed by the Geotechnical Division, also located at the TSC. Unit pricings for the estimates were provided by the Estimating, Specifications, & Construction Management Division located at the TSC.

Table IV-20 shows a summary of the diversion, conveyance and storage dam cost including construction cost.

Table IV-20. - Estimated construction cost

Reservoir	Conveyance	Diversion Dam	Storage Dam	Construction Cost
Spar	76,250,000	4,723,000	80,610,000	161,583,000
Winn	16,410,000	3,201,200	63,680,000	83,291,200
Garcia	80,950,000	4,723,000	122,260,000	207,933,000
Pope	94,310,000	3,201,200	136,500,000	234,011,200
Greenwood	159,680,000	3,201,200	117,630,000	280,511,200
Sycamore	79,160,000	3,201,200	281,240,000	363,601,200
Dam	161,200,000	4,723,000	141,300,000	307,223,000

7. Land cost

Land purchases and easements will be required to construct proposed conveyances, diversions, and storage reservoirs. Reclamation's Diversion point one is located on Parcel Number 3096083396330, which is owned by The Nature Conservancy (TNC). As of 2013, the TNC land has an assessed value of $136,090. Reclamation's diversion points 2, 3 and 4 are located on US Forest Service land, which will require lease agreements for construction.

Conveyances from diversion dam to storage reservoir will require numerous Right-of-Way Easements. The average County assessed value of the land along canal alignments within the Cliff-Gila Valley is roughly $250 per acre. The majority of canal alignments are located on land along the hillsides, outside of the floodplain farm land. Reclamation also assumes a 150 ft easement zone, which is

75 ft to the left and right of the conveyance center line. Table IV-21 shows the assessed value of land for the conveyances to their respective storage facility.

Table IV-21. - Assessed value of conveyance easement lands

Storage Dam	Conveyance Length (ft)	Easement Area (acres)	Estimated Cost* ($)
Spar	51,500	177	44,400
Winn	42,230	145	36,400
Garcia	87,800	302	75,600
Pope	113,750	392	98,000
Greenwood	136,600	470	117,600
Sycamore	118,950	410	102,500
Dam	172,900	595	148,900

*Conveyance assessed land values at $250/acre

Land cost at the proposed reservoir sites differ from site to site depending on ownership and development. Reclamation summed the assessed values of the parcels within the canyon and used the total value as the land cost for storage at the site. Table IV-22 shows the county assessed land cost for the respective canyon. The land cost does not include cost for leasing government land.

Table IV-22. - Parcel assessed values at reservoir sites

Storage site	Land Value($)
Spar	176,800
Winn	349,700
Garcia	40,200
Pope	5,200
Greenwood	44,300
Sycamore	358,700
Dam	2,600

8. Operation, maintenance and replacement

Operation, maintenance and replacement (OM&R) will need to be performed on the diversion dam, conveyances and storage reservoirs in order to retain functionality of the system. Reclamation made the following assumptions with regard to OM&R cost.

Diversion OM&R cost consist of removal of sediment, servicing of gates, concrete repair and general replacement of components over time. Reclamation assumed the diversions Annual OM&R cost will be 1% of the construction cost.

Conveyance OM&R cost consist of removal of sediment, erosion protection, side slope repairs and roadway maintenance. Reclamation used current OM&R cost from the Towaoc canal, which is $13,735 per mile to estimate the cost of OM&R for proposed canals.

OM&R for the storage reservoirs consist of weed control, erosion repairs, servicing spillway gates, cleaning intakes and removing sediment. Reclamation assumed the storage reservoirs annual OM&R cost will be 1% of the construction cost. OM&R cost for diversion, conveyance and storage are summarized in Table IV-23.

Table IV-23. - Estimated annual OM&R cost

Storage site	Conveyance ($)	Diversion Dam ($)	Storage Dam ($)	Construction Cost ($)	OM&R ($)
Spar	76,250,000	4,723,000	80,610,000	161,583,000	990,000
Winn	16,410,000	3,201,200	63,680,000	83,291,200	780,000
Garcia	80,950,000	4,723,000	122,260,000	207,933,000	1,500,000
Pope	94,310,000	3,201,200	136,500,000	234,011,200	1,700,000
Greenwood	159,680,000	3,201,200	117,630,000	280,511,200	1,560,000
Sycamore	79,160,000	3,201,200	281,240,000	363,601,200	3,150,000
Dam	161,200,000	4,723,000	141,300,000	307,223,000	1,910,000

Reclamation estimated the cost per AF of each alternative to allow comparison of alternatives. Project cost estimates were used, excluding land costs which present too many variables to be useful. Table IV-24 shows each of the alternatives cost divided by AF of storage.

Table IV-24. - Cost per AF at storage sites

Storage site	Construction Cost ($)	Storage Volume (AF)	Cost per AF
Spar	161,583,000	3,100	52100
Winn	83,291,200	2,750	30300
Garcia	207,933,000	7,500	27700
Pope	234,011,200	7,900	29600
Greenwood	280,511,200	26,000	10800
Sycamore	363,601,200	36,900	9900
Dam	307,223,000	9,400	32700
Mangas	183,180,000	9,500	19,300
Schoolhouse	180,175,000	4,200	42,900
GBIC Alluvium and Pond Storage	41,800,000	1,640	25,500

F. Environmental review of other diversion and storage options

Biology – other diversion and storage options

This review pertains to federally listed species and state of New Mexico listed species.

Any possible species impacts would be those that are riparian obligates. Habitats are water and vegetation dependent.

Mogollon Creek contains speckled dace (Rhinichthys osculus), and longfined dace (Agosia chrysogoster) but no listed fish. The upper portion of Mogollon Creek supports the Endangered Gila Trout (*Oncorhynchus gilae*). This area is within the Gila Wilderness boundary where the fish have been reintroduced into the West Fork of Mogollon Creek, along a 6 mile stretch of creek. Reservoir storage downstream will not impact the Gila Trout. There is little riparian vegetation along Mogollon Creek which is mostly a sycamore complex up to the forest boundary. Surveys for southwestern willow flycatchers have not been done and they are not likely to be in the area. Yellow-billed cuckoo may be in the area. The western yellow-billed cuckoo (*Coccyzus americanus occidentalis*) has been proposed for listing as a threatened distinct population segment. Systematic surveys have not been carried out on the Gila, San Francisco, and San Juan Rivers. The extent of habitat in these areas is limited, and much is discontinuous and fragmented. Based on available habitat, a maximum of 35 yellow-billed cuckoo pairs could breed on the Gila River, while no more than 15 and 5 pairs could breed on the San Juan and San Francisco Rivers, respectively. An estimated 100 to 155 yellow-billed cuckoo pairs currently breed in western New Mexico.

Mangas Creek contains the *Endangered loach minnow (Tiaroga cobitis*), and possibly the Endangered spikedace (*Meda fulgida*). This creek is isolated from other creeks that contain non-native fish and bull frogs, and is unique in that respect. This isolation has been instrumental in the persistence of both listed species. The drop off of spring flow from snowpack is critical to spawning as this provides water in the side channels and backwater habitat. This habitat maintains larval fish mid to late April. In addition, temperature and photoperiod contributes to maintaining larval fish. A gradual drop off is very important.

Cultural Resources – other diversion and storage options

There is very little information available regarding cultural resources associated with this alternative. However, as cultural resources are likely to exist in the proposed project areas, a complete survey and analysis will be necessary. Avoidance of all cultural resources is recommended if possible as testing and excavation can be a very costly undertaking. As planning proceeds, it is

recommended that the costs for the surveys and any possible mitigation be included into the overall project costs.

Technical Information –

Found in appendix F.

V. Appraisal level economic analysis of the benefits, costs, and regional impacts from the Arizona Water Settlements Act Tier-2 Proposals

A. Background

A 2013 Memorandum of Understanding (MOU) between the New Mexico Interstate Stream Commission (ISC) and the United States Bureau of Reclamation (Reclamation) outlined the responsibilities of Reclamation in assisting the ISC's decision-making process for the Arizona Water Settlement Act (AWSA). One of the responsibilities indicated for Reclamation was to conduct an appraisal level economic analysis for each of the proposals being evaluated. The types of analyses discussed in the MOU included an appraisal level cost-benefit analysis as well as a regional impact analysis. The resource categories identified for the economic analysis included water supplies for agricultural and/or municipal and industrial (M&I) use, recreation, water quality, and fish and wildlife. As stated in the MOU, an appraisal level analysis typically relies on currently available data and information. As a result, the estimates of benefits include a range of benefits to reflect the uncertainty associated with the use of existing information rather than conducting lengthy site specific studies and analysis. In some cases benefits are only described qualitatively due to the lack of existing information.

The MOU also discussed the need to evaluate likely future conditions without any of the proposed projects being implemented. This can be difficult due to the uncertainty associated with predicting how water users would likely react to future water supply conditions. For example, it may be expected that conservation and reuse may become more widespread as population and economic activity grows in the future. It is also possible that some economic activity could be lost if water supplies become insufficient in the future. For the purposes of this analysis, it was assumed that any benefits provided by the proposed projects represent incremental benefits in addition to any actions that would be taken without a project in place.

This report includes an appraisal level evaluation of the benefits, costs, and regional economic impacts of 15 AWSA Tier-2 proposals that are currently under consideration by the ISC as well as three possible combined diversion and storage alternatives and five individual storage alternatives evaluated by the BOR, Phoenix Area Office. The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G's) are used as the basis for evaluating benefits and costs in this analysis (U.S. Water Resources Council, 1983). It should be noted that the P&G's were updated by the new Principles and Requirements in March of 2013. However, the new Principles and Requirements will not take effect until 180 days after the

publication of the final Interagency Guidelines. The final Interagency Guidelines have not yet been published as of the writing of this appraisal level report. In addition, a cost-effectiveness type of analysis is presented showing the estimated cost per acre-foot of water provided or saved by each proposal. It should be noted that some benefits, such as environmental and ecosystem service benefits could not be estimated at the appraisal level. Therefore, this analysis should be interpreted as providing information that can be used to aid in the decision making process rather than precise estimates of benefits, costs, and regional impacts. This report includes three sections: estimation of project benefits, estimation of project costs, and estimation of regional impacts associated with each proposal. The project benefit section is further divided into sub-sections discussing the source of water resource based values and the estimation of the proposed project benefits.

B. Estimating the benefits from the AWSA Tier-2 proposals

The benefits associated with water related activities such as irrigated agriculture, municipal and industrial (M&I) water supplies, recreation, and ecosystem services would ideally be estimated from original research using methods such as farm budget analysis, estimation of municipal water demand curves using historical or cross sectional use and price data, travel cost models for recreation, or contingent valuation studies. However, when budget or time constraints exist such that an original research study cannot be completed, other approaches can be used to estimate benefits. The approach used in this appraisal level analysis of benefits is benefit transfer, which is the use of previously completed studies and available data to estimate resource values. There are four basic steps in the application of benefits transfer.

1. Identify existing studies and value estimates that are available for transfer.
2. Evaluate the extent to which existing studies are representative of resources and conditions where the values will be transferred.
3. Evaluate the quality of the studies from which values will be transferred.
4. Apply either a point value estimate or range of estimates from the appropriate studies.

The assumption in the use of benefit transfer is that the resource characteristics at the site from which benefit estimates are estimated (the study site) are similar enough to the area for which benefit estimates are needed (the analysis site) that the estimated benefits are representative of values that would be expected at the analysis site. It should be noted that the benefits transfer approach is considered acceptable at an appraisal level, where the purpose of the analysis is to present information on the expected magnitude of benefits and to assist in narrowing the number of alternatives to a manageable level for further analysis. However, it is generally recognized that benefit transfer is not as accurate of a method for estimating benefits as completing an original research analysis. Future analyses

which require more detailed and accurate cost and benefit estimates for project justification may be best served by paying the higher cost of original research studies (Allen and Loomis, 2008). The sources of information used to estimate a range of water resource related values for the proposed projects are discussed below.

Sources of Information for Estimating Water Resource Based Values
A variety of different sources were used to obtain representative resource values. To the extent possible southwestern New Mexico based estimates were used for benefits. In the event that regional estimates were not available, New Mexico or southwestern U.S. estimates were used. Estimates from other states and regions in the southwest provide additional information and context to better understand the range of potential values.

Agricultural Water Supply Values
According to the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G's), the benefits from irrigation water supplies can be measured as the value of increases in the agricultural output of the nation and the cost savings in maintaining a given level of output (U.S. Water Resources Council, 1983). Benefits include reduced production costs, reduced damages from floods and erosion, the value of increased production of crops, the economic efficiency of increasing the production of crops in the project area. The P&G's indicate that a farm budget approach can be used to estimate these benefits, where a budget is generated that represents typical costs and returns with irrigation and a second budget with is created representing dryland conditions. The difference in net income with and without irrigation represents the value of water as an input and is therefore a measure of agricultural water supply benefits. The P&G's indicate that a land value approach can also be used to estimate the value of irrigation water supplies because the value of water would be incorporated within the value of land. Along these same lines, the annual rental value of cropland with and without irrigation could be used as a proxy for irrigation water value and published studies estimating the value of agricultural water supplies can be used to estimate values for irrigation water. Studies and statistics estimating the value of agricultural water supplies using the approaches mentioned above are also used to estimate a range of values used to estimate agricultural water supply benefits.

A study by Ward and Michelson (2002) estimated a range of water supply values based on linear programming models for various policy scenarios and conditions. The conditions assumed in their analysis included: an operation of 500 acres of cotton, a price of $1 per pound, a yield of 750 pounds per acre, water use of 2.5 AF per acre, non-water production costs of $500 per acre, and groundwater pumping costs of $36 per acre-foot. Under these conditions the average value of water based on the change in farm income was $58 to $74 per acre-foot depending on alternative future supplies assumed and the marginal values ranged

from $0 to $74 per acre-foot. This value would be applicable for relatively high valued crops, such as cotton or vegetables. Water values were also estimated for the water supplied to Middle Rio Grande Conservancy District (MRGCD) farmers for water lost as part of an endangered species policy and drought conditions reducing surface water to El Paso agriculture. The drought condition values would be expected to be considerably higher than other policy scenarios. The MRGCD average value was $36 per acre-foot and marginal value was $27 per acre foot. The El Paso average value was $111 per acre-foot and marginal value was $80 per acre-foot. Assuming that these values represent conditions in 2002, when the study was submitted for publication, the values were indexed from 2002 to 2013 using the Consumer Price Index (CPI). The range of average values indexed to 2013 is about $47 to $144 per acre-foot. The range of values in perpetuity, which would be comparable to the value of a permanent water right, at the current planning rate of 3.5% would be $1,330 to $4,100 per acre-foot in 2013 dollars.

A study of water values in southeastern Colorado and southwestern Kansas (Naeser and Bennet, 1998) estimated the value of water for irrigated corn, sorghum, and wheat using two approaches, farm crop budgeting and comparison of yields. The farm crop budget approach estimates the total non-water input costs subtracted from total crop revenues. The difference represents the amount an irrigator would be willing to pay for water and still cover production costs. The yield comparison approach estimates the maximum willingness to pay as the difference between average per acre returns from irrigated and non-irrigated acreage. The increase in net farm income from adding water represents willingness to pay. The estimated value of water in 1995 dollars ranged from $28 to $81 per acre-foot using farm crop budgets and $28 to $124 per acre-foot using the yield comparison approach depending on the crop. The regional average values for all crops were $45 to $76 per acre-foot for Southeastern Colorado and $62 to $74 for Southwestern Kansas. The range of values from this study using the CPI to index to 2013 dollars is $42.80 to $189.50 per acre-foot for individual crops and $68.80 to $116.20 per acre-foot for all crops combined.

Cost and Return Estimates for Farms and Ranches are generated by the New Mexico State University College of Agricultural, Consumer and Environmental Sciences for 2002 to 2014 (New Mexico State University, 2014). These cost and return budgets are generated for several areas throughout New Mexico. A whole farm budget including alfalfa and alfalfa establishment, permanent pasture and pasture establishment, and livestock was available for Grant and Catron counties combined. The most recent information available for these counties was 2012. The total farm size budgeted was 60 acres and the amount of irrigation water used was 5 AF per acre for alfalfa and 2.67 AF per acre for pasture.

Net farm income for the budgeted operation was estimated to be $24,577. The net farm income figure accounted for gross return, cash expenses, fixed expenses,

labor and management costs, and capital costs. The net farm income figure is equal to $409.62 per acre, which includes fallow land and homestead and waste. The budgeted operation includes irrigation on 29 acres of alfalfa (including establishment acres) and 12 acres of pasture (including establishment). The estimated total amount of irrigation water applied would be 145 AF for alfalfa and 32 AF for pasture, or 2.95 AF per farm acre. The net farm income associated with irrigation water is estimated to be the net farm income per acre divided by the AF of water per acre, or about $139 per acre-foot. Indexing this value to 2013 dollars using the CPI would result in a value of $141 per acre-foot.

Cash rent data were obtained for southwest New Mexico counties and the region as a whole for irrigated and non-irrigated cropland and pastureland from the United State Department of Agriculture, National Agricultural Statistics Service (NASS). Cash Rent is defined as land rented on a per acre basis for cash only. This excludes land rented for a share of the crop or livestock, land rented as a fee per head or animal unit month (AUM), land rented on a unit of production basis, and land including buildings such as greenhouses or dairy barns. A summary of southwest New Mexico regional data is shown in Table V-1.

Table V-1. - Annual average cash rent per acre, southwest New Mexico

Land use	2013	2012	2011	2010	2009	5 year average
Cropland	$105.00	$74.00	$67.00	$50.00	$40.50	$67.30
Irrigated	$145.00	$130.00	$117.00	$116.00	$118.00	$125.20
Non-irrigated	$19.00	$18.00	$16.50	$16.00	$16.00	$17.10
Pastureland	$2.80	$2.80	$2.40	$2.20	$2.40	$2.52

The cropland value is the value of land used to grow field crops, vegetables or land harvested for hay, except for wild hay. Land that is part of government conservation programs would also be included as cropland. Irrigated cropland value is the value of land that normally receives or has the potential to receive water by artificial means to supplement natural rainfall. Non-irrigated cropland value is the value of land that only receives water by natural rainfall. The pastureland value is the value of land that is normally grazed by livestock.

The average 5 year annual difference in cash rent between irrigated and non-irrigated land is $108.10 per acre. New Mexico State University Cost and Return Estimates for Farms and Ranches in the southwest region indicate that an alfalfa – pasture operation with livestock would require about 4.33 AF of water per irrigated acre. Therefore, the difference in irrigated and non-irrigated cash rent over the five year period is about $25 per acre-foot or a value of $714 per acre-foot in perpetuity. The difference in irrigated and non-irrigated cash rent ranged from $100 to $126 per acre over the five year period, or about $23.10 to $29.10 per acre-foot. The $26 value occurred in 2013 while the $100 value occurred in

2010. The 2010 value indexed to 2013 using the CPI would be $107.20 per acre and $24.75 per acre-foot.

A study of the market value of ranches and grazing permits in New Mexico (2012) indicated the value of a Bureau of Land Management (BLM) permit from 1996 to 2010 has stayed at a relatively constant $40 per acre in 2010 dollars for Hidalgo County. Hidalgo County is the closest county to the study area included in their analysis. The study uses a hedonic model to value permits. The hedonic approach is based on an evaluation of the factors that contribute to differences in land values. The hedonic model indicated a declining importance of livestock income in determining pasture and rangeland values. However, unlike reduced earned income for New Mexico ranches, cropland values have seen recent increases. Therefore, using cropland based water values would not appear to undervalue water used for livestock.

The estimated agricultural water supply values range from $23 to $144 per acre-foot and the average value of all estimates is about $88 per acre-foot. Agricultural benefits are estimated using all three estimates of value. The range of agricultural water supply values would be $657 to $4,114 per acre-foot in perpetuity at a 3.5% discount rate, which would be equivalent to a permanent water right value.

Municipal and Industrial Water Supply Values

The P&G's indicate that the basis for evaluating the benefits from municipal and industrial (M&I) water supply is society's willingness to pay for the increase in the value of goods and services supported by the water supply. If market conditions exist such that the price of water reflects marginal cost of providing water supplies (in other words, an equilibrium market condition exists), then price can be used as a measure of willingness to pay. However, if direct measures of willingness to pay are not available, then the P&G's allow the M&I water supply benefits to be measured by the resource cost of the alternative most likely to be implemented in the absence of the project under consideration. Studies estimating the value of M&I water supplies using the above approaches are used to estimate the value of water for M&I use.

The willingness to pay for improved water supplies was estimated to range from $11.63 to $17.29 per household per month for the Gallup-Navajo area of New Mexico (Piper and Martin, 1997). The willingness to pay estimate was based on a household survey. Assuming average monthly use of slightly less than 12,000 gallons per connection, the value of water for household use was estimated to be $315 to $465 per acre-foot. Using the CPI to index the values from 1997 to 2013, the value would be range from $455 to $677 per acre-foot.

A Reclamation survey of municipal and industrial water rates in the 17 western states provided estimates of wholesale prices for a variety of municipalities and

other water supply entities (Reclamation, 2006). The 2006 Reclamation study indicated that wholesale water values were approximately 40% of retail M&I values. A study of rural water systems in southwest Texas indicated that source water represented 15% to 40% of total water costs for rural water systems and 4.5% to 81% of total costs for rural communities (Freese and Nichols, 2009). Assuming a wholesale value equal to 40% of retail cost, the wholesale equivalent value of water for M&I use based on the Gallup-Navajo study would range from $182 to $271 per acre-foot annually.

A potentially more accurate application of the benefits transfer approach would be to input site specific data for all model variables to estimate water supply values. This was done in a simple analysis for the Silver City area presented at the Gila Planning Economic Forum in 2009 (Piper, 2009). Water rate and use data were obtained from the New Mexico Environment Department for 2006 for the study area. Additional data were obtained for average temperature, precipitation, income, and household size. Applying this data to a domestic water demand model for the Western United States, the average benefit of water was estimated to be about $650 per acre-foot in 2009 dollars. Indexing the value to 2013 dollars using the CPI, the average annual value of water would be about $710 per acre-foot or a wholesale equivalent of $284 per acre-foot based on 40% of retail value described above.

The 2006 Reclamation study provided wholesale water values for New Mexico suppliers. The values ranged from $206 to $422 per acre-foot, with the highest value in Taos, New Mexico. Indexing these values to 2013 dollars ranged in value from $240 to $490 per acre-foot. This translates into a retail equivalent value of $600 to $1,225 per acre-foot. The Taos value could overstate the value of water in southwest New Mexico because of the unusual supply and demand conditions in the Taos area.

A study of intrastate and interstate water values for M&I use associated with the Colorado River (Booker and Young, 1994) provided a range of marginal water values. Under normal, non-drought conditions marginal values are typically greater than average values when evaluating additional water supplies. The high end of the range was $96 per acre-foot in 1992 dollars. The value of water is a little over $159 per acre-foot in 2013 dollars.

Another possible measure of the value of M&I water is the amount paid for water service, or the cost of service. If water users are actually paying a given amount for water, then the benefits provided by the water supply must be at least equal to that cost.

A statistical abstract published by the Southwest New Mexico Council of Governments (2012) provides residential and commercial water service cost information for several communities in the Gila study region. The cost of

residential water presented in the abstract for 2011 ranged from $13.84 for 6,000 gallons in Deming to $28.50 in Bayard. The cost of water for 6,000 gallons for commercial use ranged from $19.97 for Silver City to $36.44 for Bayard. The equivalent cost in dollars per acre-foot range from $752 to $1,548 for residential water and $1,085 to $1,979 for commercial water. The value of water in 2013 dollars ranges from $778 to $1,602 per acre-foot for residential water and $1,122 to $2,048 for commercial water. Wholesale equivalent values range from $311 to $641 per acre-foot for residential use and $450 to $819 for commercial use using the 2006 Reclamation study to convert retail values to wholesale values. Averaging the residential and commercial values provides a range of $380 to $730 per acre-foot.

A water service agreement between the Town of Silver City and the Arenas Valley Water Association (Association) provides additional information regarding recent municipal water sales in the region (Silver City, 2008). The agreement is a commitment to provide up to 200 AF of potable water at a Peterson Road and Highway 180 connection point to the Association. As of June 2014 the rate charged by Silver City included an $8.43 access fee for each account and a charge of $5.90 per 1,000 gallons up to 10,000 gallons (Silver City, 2014). Assuming 6,000 gallons of use, this translates to an equivalent of $2,380 per acre-foot in 2014 dollars or $2,346 indexing to 2013 dollars. The amount charged by the Association is $6.49 per acre-foot plus the $8.43 access fee. However, the difference in cost is attributable to distribution costs rather than a reflection of the value of water as a wholesale source. Using the retail value of M&I water to value M&I water supply benefits would likely overstate benefits because a retail value represents water at the tap. Therefore, a retail value is a treated and delivered value. However, each proposed project would provide a water source that would then need to be treated and distributed to the end users. Therefore, a wholesale supply value would be a more appropriate measure of M&I water values. The 2006 Reclamation study indicated 17.91% of average water system costs are attributable to water treatment and 34.81% are attributable to distribution and transmission. Treatment costs are subtracted from the potable water value to represent an untreated source supply and transmission costs are subtracted to reflect bringing water to the connection point. The wholesale equivalent value is estimated to be $1,125 per acre-foot.

A study reviewing an appraisal of Phelps Dodge Tyrone water rights (Brown, 2004) provides information on assessed water rights values in the area and the potential for increased values in the future. The initial water right valuation was stated to be $6,210 per acre-foot in 2003 dollars. This represents a permenant water right value, which translates into an annual equivalent value of $217 per acre-foot in 2003 dollars using a 3 ½% discount rate or $279 per acre-foot in 2013 dollars. It is stated in the 2004 Brown report that the only buyers for water at this price would be municipal users and the Nature Conservancy because farmers

could not afford the water at this price to irrigate crops and transfers out of the region would be problematic.

Lastly, information provided in a 2007 analysis of water prices as a measure of scarcity (Brown, 2007) indicated a range of permanent water right values in the Lower Rio Grande region of New Mexico and Texas of $2,000 to $5,000, or an equivalent annual value of $70 to $175 using a discount rate of 3.5%. The equivalent annual value indexed to 2013 is $77 to $197 per acre-foot.

Retail M&I water supply values are estimated to range from $455 to $2,346 per acre-foot and the average retail value for all retail estimates is about $1,200 per acre-foot. As discussed above, the relevant water value for estimating municipal water supply benefits is a wholesale value. Wholesale equivalent M&I values range from $159 to $1,125 per acre-foot. The average wholesale value for all estimates is about $471 per acre-foot. The range of annual wholesale M&I water values would be $4,540 to $32,140 per acre-foot in perpetuity at a 3.5% discount rate.

M&I water supply benefits are estimated using annual values of $159 and $1,125 per acre-foot in part to reflect uncertainty in the ultimate value of water used for M&I purposes. A value of $730 is used as a representative "best estimate" of M&I benefits because it represents an average of residential and commercial values for several communities in the region.

Recreation Values

The P&G's indicate that the benefits associated with increased recreation opportunities created by a project, or conversely the costs associated with reduced opportunities, are measured terms of willingness to pay. The benefits of project features that increase the supply of recreation resources are measured as the willingness to pay for each increment of additional supply. In addition, recreation benefits can also be generated by a project that improves the quality of the recreation experience (or costs can be imposed if a project reduces the quality of the recreation experience). Willingness to pay includes entry and use fees actually paid to access a site use plus any unpaid value enjoyed by consumers. Willingness to pay can be difficult to measure because recreation it is typically publicly provided so price and consumption data are usually not available.

Three acceptable methods of measuring willingness to pay are listed in the P&G's. These methods include the travel cost method, the contingent valuation method, and unit day values. The travel cost method is based on derivation of a demand curve using the variable costs of travel and the value of time as an approximation for price. As variable and travel time costs increase, the number of recreation visits would be expected to decrease. The derived demand curve can then be used to estimate recreation benefits. The contingent valuation approach estimates willingness to pay by directly asking individual households their

willingness to pay for changes in recreation opportunities at a given site. Individual values are aggregated by summing willingness to pay for all users in the study area. Unit day values rely on expert opinion and judgment to estimate the average willingness to pay of recreation users. Benefit transfer is equivalent to the unit day value approach. Also, the transferred values are generally based on studies using either contingent valuation or the travel cost approaches.

The primary source of values for this analysis is a database of recreation values maintained by Randall S. Rosenberger at Oregon State University (Rosenberger, 2013). Recreation benefit estimates per recreation day as well as estimates of the number of days per trip are obtained from the Rosenberger database for New Mexico and Arizona studies. A second source of information used to evaluate potential recreation benefits is a 2005 study of outdoor recreation use values per recreation day on national forests and other public lands (Loomis, 2005). Even though the Loomis study is older than the Rosenberger database, Loomis provides average values for various types of recreation by region. Representative values are shown in Table V-2.

The information provided in Table V- 2 indicates that there is a very wide range of potential recreation values, depending on the type of recreation as well as the source of benefit estimates. The benefit values in 2013 dollars ranges from $15.12 to $269.18 per visit. To narrow the range down to a manageable number, the values for fishing, wildlife viewing, and picnicking were found to range from $45.68 to $89.73 per visit. The range of values is intended to represent a picnicking value at the low end and a fishing value at the high end. This range as well as a point estimate of $75 per visit is used to evaluate recreation benefits.

Table V-2. - Representative values for potential water based recreation activities

Recreation activity	Study source of values	Location of values	Value per day Provided in study	Value per day indexed to 2013 dollars	Value per trip in 2013 dollars
Boating					
Motorized	Rosenberger	NM	$20.75 - $54.48	$22.24 - $58.39	$102.52 - $269.18
Non-motorized	Loomis	Intermountain	$67.70	$84.15	$84.15
Camping	Rosenberger	NM, AZ	$8.48 - $39.07	$9.09 - $41.87	$26.18 - $120.60
Fishing	Rosenberger	NM, AZ	$22.24 - $83.72	$23.84 - $89.73	$23.84 - $89.73
Hiking	Rosenberger	NM, AZ	$14.11 - $160.35	$15.12 - $171.86	$15.12 - $171.86
Hunting	Rosenberger	NM, AZ	$21.80 - $105.88	$23.36 - $113.48	$23.36 - $113.48
Mountain biking	Rosenberger	NM	$147.91 - $203.36	$158.53 - $217.96	$158.53 - $217.96
Nature visiting	Rosenberger	NM	$8.56 - $71.27	$9.17 - $76.39	$26.70 - $222.28
Picnicking	Rosenberger	AZ	$23.42	$25.10	$45.68
Picnicking	Loomis	Intermountain	$28.27	$35.14	$63.95
Wildlife viewing	Rosenberger	NM, AZ	$19.91 - $80.05	$21.34 - $85.80	$62.74 - $85.80
Wildlife viewing	Loomis	Intermountain	$37.24	$46.29	$46.29
General recreation	Rosenberger	Arizona	$19.26 - $41.53	$20.64 - $44.51	$20.64 - $44.51
General recreation	Loomis	Intermountain	$48.46	$60.23	$60.23

Environmental Values

The P&G's indicate that an environmental quality (EQ) account can be used to identify beneficial and adverse effects on environmental resources and attributes. Recent revisions of the P&G's also indicate the need to identify and quantify to the extent possible impacts on environmental resources and ecosystem services. The P&G's indicate EQ attributes are the ecological, cultural, and aesthetic properties of natural and cultural resources that sustain and enrich human life. Ecological attributes are defined components of the environment and the interactions among all its living and nonliving components that directly or indirectly sustain dynamic, diverse, viable ecosystems. This section identifies previous work that has been completed in the general region that indicates the value and importance of these resources.

A report by Patton, et al. (2012) provided approaches and estimates for ecosystem service benefits for four wildlife refuges, including Sevilleta and Bosque del Apache National Wildlife Refuge (NWR) in New Mexico. Although the conditions in Sevilleta and Bosque del Apache NWR's are not exactly the same as in the Tier 2 evaluation area, the results will provide an understanding of the likely magnitude of potential benefits associated with ecosystem services provided in the study area.

The analysis provided estimates of gross economic values for four different types of services: storm protection, water quality, commercial fishing habitat, and carbon storage. The estimated values for Sevilleta and Bosque del Apache NWR's are shown below in Table V-3.

Table V-3. - NWR ecosystem service values

Type of service	Value per acre
Storm protection	$47
Water quality	$80
Commercial fishing habitat	$0
Carbon storage	$14
Total all services	$141

The overall goal of the research was to develop an ecologic-economic simulation model that can be used to evaluate economic value of ecosystem services supported by National Wildlife Refuges. The model would provide a way to evaluating ecosystem services when primary data studies are not possible due to funding and/or time constraints. This describes the situation for this evaluation of Tier 2 projects very well. It should also be noted that although the models are applied to NWR's, the values are for ecosystem services provided by NWR's but are not exclusive only to NWR's. The values are, however, directed towards wetland acreages. The values for storm protection, water quality, and habitat and nursery support for commercial fishing species were estimated using meta-analysis based benefit transfer while carbon storage benefits are based on point

estimate benefit transfer from studies on the willingness to pay to avoid climate change damages.

Another study by Izon, et al. (2010) estimated the value of protecting inventoried roadless areas (IRA's) in New Mexico. Although this study is aimed at the value of inventoried roadless areas, the paper indicates that the policy debate involves questions about the relative values of protection versus development. New Mexico IRA's provide nonmarket environmental benefits, which are related to natural landscapes and amenities, including protected forests and grasslands. A hedonic approach, based on differences in land values, is used in the IRA analysis to estimate the benefit of IRA's. The analysis indicated IRA's located within a Census tract have a statistically significant positive impact on housing values and therefore generate economic benefits.

A large portion of both IRA's in southwest New Mexico are part of the Gila National Forest, so it is applicable to the study area. TableV-4 summarizes the values presented in the Izon, et al. study. Use of the terms direct effect and indirect effect should not be confused with similar terms used in the context of regional impact analysis. The direct effect is a measure of the impact a small change in IRA density has on social benefits within aCensus tract while the indirect effect shows the impact of changes in IRA density on neighboring areas. Therefore, the total aggregate effect is the entire impact and is a measure of total benefits.

Table V-4. - IRA benefit estimates

County/State	IRA Acreage	Aggregate benefits	Aggregate benefit per acre	Direct benefits	Direct benefit per acre
Catron	422,957	$17,714,000	$41.88	$15,785,000	$37.32
Grant	218,545	$111,650,000	$510.88	$50,990,000	$233.32
Rio Arriba	136,241	$138,551,000	$1,016.96	$79,903,000	$586.48
Sierra	129,108	$39,260,000	$304.09	$16,590,000	$128.50
Socorro	170,326	$12,699,000	$74.56	$6,202,000	$36.41
New Mexico	1,549,573	$1,889,425,000	$1,219.32	$1,241,063,000	$800.91

A study of non-industrial private forestland (NIPF) in the Western United States by Venn and Calkin (2007) evaluated the potential for accommodating the full range of non-market values enhanced or diminished by wildfire in and adjacent to NIPF within the benefit-cost analysis framework. TableV-5 shows the effects of wildfire that would need to be considered as part of a benefit-cost analysis.

Table V-5. - Positive and negative effects of wildfire

Non-market resource	Examples of positive fire effects	Examples of negative fire effects
Recreation	Improved scenic viewing Potential improved habitat Potential improved long run hunting & fishing success	Campsites destroyed Debris – hiking & biking Aesthetic loss from burned forest Short term fishing loss
Flora, fauna, invasive species	Short run increase in wildlife food and habitat diversity Low intensity fire can favor native plants & facilitate ecosystem restoration Potential reduction in epidemic insect and disease infestation Long term aquatic habitat improvement	Fuel accumulation increase probability of a severe fire event Short term negative impact on fish and amphibians Some non-native plant species may flourish
Air quality		Respiratory health Reduced visibility Soiling surfaces of objects
Soil	• Short-term increased availability of nutrients for plant growth	• Lost soil structure • Lost nutrients through leaching and surface runoff • Increased erosion
Water quality		• Increased peak flood flows • Increased sediment and debris • Reduced infrastructure effectiveness • Impair M&I water use
Cultural heritage	• Consistent with cultural heritage	• Severe event could destroy cultural heritage
Carbon	• More frequent fires may limit fuel accumulation so future fires are less severe and emit less carbon	• Potentially large immediate release of sequestered carbon

The Venn and Calkin (2007) indicate that given the state of knowledge about fire effects on non-market values of forests and the wildfire preferences of society, it is unlikely that benefit-cost analysis in itself is appropriate for accommodating many important non-market values affected by wildfire.

Finally, a study by Womble and Doyle (2012) did not provide any monetary estimates of ecosystem services, but did indicate the market for wetland and

stream aquatic resources established in the 1980's is a mature and robust ecosystem service market in the United States which uses surrogate metrics such as acres or length to define bundles of ecosystem functions. Conceptually, ecosystem functions confer benefits to society and the concept of ecosystem functions translate into social value. Typical ecosystem functions that are also normally considered ecosystem services are carbon sequestration, nutrient (e.g., nitrogen, phosphorus) retention, flood attenuation, and soil production.

Ecosystem Service Values

Ecosystem services can be broadly defined as the benefits obtained as a result of ecosystem functions. The Millennium Ecosystem Assessment (2014) provides four categories of ecosystem services.

- Provisioning services such as the provision of food and fresh water
- Regulating services such as climate and disease regulation
- Supporting services such as soil formation and nutrient cycling
- Cultural services such as aesthetic and cultural heritage values

Examples of specific services provided within these categories would include carbon sequestration, water purification, ground and surface water flow regulation, erosion control, stream-bank stabilization, species preservation, and recreation/tourism (USDA, 2014).

One important issue associated with estimating the benefits associated with ecosystem services is determining the value that should be placed on the various services. Some of the services represent activities that can be valued using traditional types of economic analyses, such as recreation and water supply. Other types of services, such as species preservation, require sophisticated approaches such as contingent valuation to estimate value. One indicator of the value of ecosystem resources is the cost of infrastructure investments that would be required to provide those services, which can then be compared to the cost of protecting an ecosystem. Some market based values can also indicate value, such as private payments and public incentives to protect ecosystem services.

Other important technical issues in evaluating ecosystem benefits have been identified (Fischenich, et al., 2013). One important issue is assessing the relationship between how activities affect the environment and the ecological response to that change. If the effect of an environmental change on ecosystem services is not known, then it is impossible to value the benefits of the change. A second issue is selection of a quantifiable resource property to measure change, such as wetland acreage. Without this metric, the quantity that should be multiplied times per unit values is not known and benefits cannot be quantified.

Measurement of these ecosystem benefits is not possible for this appraisal level analysis because the relationship between the effects from the project proposals and ecosystem services is unknown. However, previous research can provide some general information on the value of different types of ecosystem services for

different geographical and biological areas. A summary of ecosystem services values as measured by willingness to pay are presented in TableV-6 (Executive Office of the President, 2011). The range of potential ecosystem benefits shown in tableV-6 is wide, indicating the importance of knowing the conditions that exist at a specific site.

Table V-6. - Range of estimated willingness to pay for ecosystem services

	Minimum $/acre/year				Maximum $/acre/year			
Biome	Provision-ing	Cultural	Regulating	Habitat	Provision-ing	Cultural	Regulating	Habitat
Inland wetlands	1	262	130	4	3,929	3,399	9,315	1,405
Rivers & Lakes	473	123	123	0	2,338	1,106	2,014	0
Woodlands	3	0	4	0	349	0	440	0
Grasslands	96	0	24	0	289	4	837	121

Source: Executive Office of the President, July 2011.

C. Benefits associated with the Tier 2 proposals

The potential resource benefits associated with the various AWSA Tier-2 proposals include: agricultural benefits from increased production due to increased water supplies, municipal and industrial (M&I) water supply benefits associated with meeting household and commercial water needs, recreation benefits associated with changes in surface water area and/or in-stream flows, and environmentally related benefits associated with changes in the quantity or quality of environmental resources (habitat, water quality, ability to support various species, etc.). Any change associated with a proposal that adversely affects these resources would represent an economic cost. Table V-7 shows the categories of benefits associated with each proposal.

It needs to be recognized that all benefits and costs are not quantifiable at the appraisal level because an appraisal analysis is based on existing data and previously completed studies. However, the inability to quantify some categories of benefits and costs does not imply that those categories are unimportant. In addition, several project proposals included discussions of project impacts as if they were benefits, when in fact they represent regional impacts. For example, income and employment associated with municipal water supplies are typically regional impacts. It should be noted that recreation benefits have been estimated for proposals that include reservoir storage. It is not known with certainty if recreation would be allowed at these sites and what type of recreation would occur. However, including a recreation component avoids a potential underestimation of benefits that have been identified in some of the project proposals. It should also be noted that any costs associated with the development of recreation facilities were not included in the cost estimates. As a result, project costs may be understated for those proposals that include a recreation component.

Table V-7. - Categories of benefits provided by each proposal

Proposal	Agricultural	M&I	Recreation	Other
GCWC Infrastructure and Reuse		X		X
Grant County Recharge and Reservoir		X	X	X
Deming Wastewater Reuse		X		X
SW New Mexico Regional Water Supply	X	X	X	
GBIC Diversion and Storage	X		X	
Hidalgo County Off-Stream	X	X	X	
GCC Municipal Conservation		X		X
Pleasanton Ditch Improvements	X			
Luna Ditch Improvements	X			
Sunset/New Mexico New Model Pipeline	X			
San Francisco Watershed Restoration	X			X
NMFIA Watershed Restoration	X	X		X
NMSU Watershed Restoration	X	X		X
GSWCD Forest Restoration				X
USFS Watershed Restoration				X

The primary sources of information used to estimate categories of benefits and the quantity of water provided by each project proposal or amount of resource supported by each proposal are the Tier-2 proposals, proposal supplements, and preliminary engineering reports. It needs to be recognized that this appraisal level analysis of benefits is based on the estimated quantity of water identified in the project proposals that would be provided by each proposal. Analysis and confirmation of the actual quantity of water that would result from each proposal is beyond the scope of this appraisal analysis. In some cases a range of water supplies are assumed based on the review of diversion proposals provided by the Reclamation Phoenix Area Office. Each of the proposal documents were reviewed for indications of the type and amount of resources influenced by the proposals. Project proposal descriptions and updates were obtained from the New Mexico Arizona Water Settlement Act web page at http://nmawsa.org/library. The following sections briefly outline the magnitude of changes in resources provided by each project proposal.

Grant County Water Commission Infrastructure and Reuse

The proposal identified 193 AF of water that would potentially be available for Hurley from a new well field. In addition, approximately 750 AF of water were described as additional water rights available as a product of reuse. Water from reuse has been described in various studies as having a value lower than other sources due to reduced quality, as having the same value as other sources because reuse can free up water that can be made available for uses that require higher quality, and as having a higher value due to greater reliability during times of drought compared to other traditional water sources. For the purposes of this analysis water made available from reuse and conservation is valued at the same rate as any other water source. Therefore, water supply benefits for 943 AF of water for M&I use is the basis for estimated water supply benefits. Any recreation benefits are urban based and, therefore, would be considered part of the

overall M&I benefits. Annual M&I project benefits would range from $149,900 to $1,061,000 with a best estimate of $688,400. The present value benefits over 50 years at a 3.5% discount rate range from $3.52 million to $24.89 million and a best estimate of $16.15 million.

Grant County Recharge and Reservoir

A small 90 acre reservoir is assumed for this proposal based on the upper level estimate of reservoir size presented in a December 2013 Preliminary Engineering Report. It is also assumed that some level of recreation could be supported by the lake. The proposal also indicated that 670 AF of additional water could be made available for Bayard and Santa Clara as a result of the project. The value of water for M&I purposes could range from $106,500 to $753,700 annually with a best estimate of $489,100 annually. The present value of M&I water supply benefits over 50 years could range from $2.50 million to $17.68 million, with a best estimate of $11.47 million.

In order to estimate potential recreation visitation at the reservoir, a representative number of visits per surface water acre or visits per unit of volume storage is needed. Bill Evans Lake would be a good candidate for estimating visitation. However, visitation data are not available for Bill Evans Lake. Caballo Lake State Park is used as a basis for estimating potential recreation use at the reservoir because visitation data are readily available. Caballo Lake has approximately 11,500 surface acres. Visitation at Caballo Lake is about 400,000 visitors annually. This translates into about 35 visits per surface acre. Therefore, it is estimated that visitation at the 90 acre lake would be about 3,200 visitors annually. Assuming a recreation value of about $46 to $90 per visit, the value of recreation could be $147,200 to $288,000 annually. The present value of recreation over 50 years would be $3.45 to $6.76 million. Total M&I and recreation benefits are estimated to range from $5.95 to $24.44 million.

Deming Wastewater Reuse

The amended Deming water reuse proposal indicates 600 AF of water per year could be made available for municipal water uses as a result of the proposed project. The November 2013 Preliminary Engineering Report Proposed Effluent Reuse Expansion (Deming Effluent Reuse PER) indicated high monthly demand averages that would equal about 920 AF per year. This is included as a potential upper end range of potential benefits. The Deming Effluent Reuse PER indicated a useful life of 20 years, which is used as the period of analysis for this proposal. Potential recreation benefits would be urban based and would therefore be considered part of the M&I benefits. Annual M&I water supply benefits are estimated to range from $95,400 to $1,035,000, with a best estimate if $671,600. The present value of benefits over the 20 year period of analysis are estimated to range from $1.36 million to $14.71 million, with a best estimate of $9.54 million.

Southwest New Mexico Regional Water Supply (Deming Surface Water Diversion)

The Deming Surface Water Diversion Tier-2 proposal identified the potential to provide up to 14,000 AF of additional M&I water supplies. An additional 5,000 AF were identified as potentially available as a result of the project that could be available for agricultural and/or environmental purposes that could provide benefits. The diversion and storage alternatives considered by the Bureau of Reclamation indicated water deliveries of 10,000 AF annually. The 10,000 acre-foot annual supply is used as a lower bound estimate of potential supplies. Based on agricultural values ranging from $23 to $144 per acre-foot and M&I values ranging from $159 to $1,125 per acre-foot, the annual agricultural water supply benefit could range from zero to $720,000 and the annual M&I water supply benefits could range from $1.59 million to $15.75 million, with a best estimate of $7.3 million. The present value of agricultural benefits over the 50 year period of analysis would be zero to $16.89 million and the present value of M&I benefits over 50 years would be $37.29 million to $369.42 million, with a best estimate of $171.23 million.

Mangas Dam would store approximately 29,450 AF of water. Caballo Lake State Park has approximately 400,000 visits annually and the reservoir stores approximately 344,000 AF of water. Based on Caballo Lake State Park visitation per acre-foot, Mangas Dam recreation could be about 34,200 visits annually. At a value of $46 to $90 per visit, the annual value of recreation could be $1.57 million to $3.08 million. The present value of recreation over 50 years could be $36.83 million to $72.24 million. The estimated range of total present value benefits for the Deming Surface Water Diversion proposal is $74.12 million to $458.55 million, with a best estimate of $225.77 million.

Gila Basin Irrigation Commission Diversion and Storage

The final Tier-2 proposal submitted by the Gila Basin Irrigation Commission in Grant County, New Mexico identified agricultural benefits associated with a maximum up 14,000 AF of agricultural water supplies. The Reclamation Phoenix Area Office review of the proposal indicated maximum storage of approximately 1,000 AF, which represents a limitation on the amount of water that could be used to provide agricultural benefits. The 1,000 acre-foot storage limit is used as a lower bound for agricultural benefits. The Reclamation Phoenix Area Office also indicated a maximum available annual supply of 10,000 AF for the Reclamation diversion alternatives. Assuming agricultural benefits of $23 to $144 per acre-foot, agricultural benefits would range from $23,000 to $2,016,000 annually. The estimated present value of benefits over 50 years, at a 3.5% discount rate, range from $0.54 million to $47.29 million. The high end of the range is likely to overstate benefits given the storage limitation. The best estimate of benefits is estimated using the average range of benefit values per acre-foot and the mid-point supply assuming 1,000 AF of storage and a maximum supply of 10,000 AF. The present value of average benefits is $10.77 million over 50 years.

Hidalgo County Off-Stream Storage

Benefits of up to 10,000 AF per year were identified in the Tier-2 proposal. As much as 1,000 AF per year in additional water supplies were identified in a proposal amendment, which could be used to enhance agricultural activity. Of the original 10,000 AF of water, 5,500 AF are identified for potential irrigation. The remaining 4,500 could be used for a variety of uses. For the purposes of this analysis M&I water use was assumed for the other type of water use. The amended 1,000 AF is identified for enhanced agricultural activity. The 10,000 acre-foot annual supply identified in the Reclamation diversion and storage alternatives is used as a lower bound estimate of potential supplies. M&I water supply values of $159 to $1,125 were used to estimate M&I benefits and values of $23 to $144 were used to estimate agricultural benefits. M&I water supply benefits were estimated to range from $715,500 to $5,062,500 annually or a present value over 50 years of $16.78 million to $118.74 million. Agricultural benefits were estimated to range from $126,500 to $936,000 annually, or a present value of $2.97 million to $21.95 million over 50 years.

Schoolhouse Canyon storage would be approximately 5,500 AF of water. Caballo Lake State Park has approximately 400,000 visits annually and the reservoir stores approximately 344,000 AF of water. Based on Caballo Lake State Park visitation per acre-foot, recreation could be about 6,400 visits annually. Using recreational values ranging from $46 to $90 per visit, the annual value of recreation could be $294,400 to $576,000. The present value of recreation over 50 years could range from $6.90 million to $13.51 million. The estimated total present value of all benefits over 50 years ranges from $26.65 million to $154.20 million. The best estimate of benefits is based on an assumed 10,000 AF of water supply, with 5,500 AF for irrigation and 4,500 AF for M&I use. The $144 per acre-foot value is used for irrigation, $730 per acre-foot is used for M&I, and the lower estimate is used for recreation benefits.

Gila Conservation Coalition Municipal Conservation

The GCC Municipal Conservation Tier-2 proposal identified an estimated 3,679 to 4,269 AF per year that could be available as a result of implementing the proposal. For the purposes of this analysis it is assumed that conservation will gradually occur until savings of 3,679 AF are realized in 10 years and 4,269 AF of savings are realized in 35 years. Benefits are assumed to accrue over 35 years based on the 2050 time frame included in project proposal. It should be noted that the project life of 35 years is based on the assumption that all benefits and costs would cease after 35 years. Generally, all alternatives/projects included in an economic analysis should be evaluated using the same period of analysis. In this case a 50 year period of analysis would include 35 years of benefits and costs and 15 years of zero benefits and costs. If it was assumed that some OM&R costs were spent to generate benefits to year 50, the discounted future benefits and costs would be relatively small and would have little impact on the estimates. This same discussion applies to all proposals with less than a 50 year life.

Assuming M&I benefits ranging from $159 to $1,125 per acre-foot, annual benefits are estimated to range from an annual value of $58,500 to $413,900 in year 1, an annual value of $585,000 to $4.14 million in year 10, and an annual value of $678,800 to $4.80 million in year 35. Present value benefits over 35 years at a 3.5% discount rate range from $9.87 million to $69.80 million. The best estimate of benefits is $45.29 million based on an M&I value of $730 per acre-foot.

Pleasanton Ditch Improvements

The Pleasanton East-side Ditch Company Tier-2 AWSA Proposal indicates 1,480 to 1,670 AF of additional water per year could be made available for irrigated agriculture. Assuming agricultural benefit values ranging from $23 to $144 per acre-foot, annual agricultural related benefits from the proposal would range from $34,000 to $240,500. The estimated present value benefits over 50 years would range from $797,500 to $5.64 million. The best estimate of benefits is based on the simple average of AF saved and the mid-point of irrigation values, which is equal to a present value of $3.08 million.

Luna Ditch Improvements

The Luna Irrigation Ditch Association Tier-2 AWSA Proposal indicates 419 AF of additional water per year could be made available for irrigated agriculture. Assuming agricultural benefit values ranging from $23 to $144 per acre-foot, annual agricultural related benefits from the proposal would range from $9,600 to $60,300. The estimated present value benefits over 50 years would range from $225,200 to $1.41 million. The best estimate is based on the mid-point of irrigation values, or a present value of $821,000.

Sunset/New Mexico New Model Pipeline

The Sunset/ New Mexico New Model Pipeline Tier-2 application indicates 2,040 to 2,950 AF of additional water per year could be made available for irrigated agriculture, depending on the year of implementation. Assuming agricultural benefit values ranging from $23 to $144 per acre-foot, annual agricultural related benefits from the proposal would range from $46,900 to $424,800. The estimated present value benefits over 50 years would range from $1.10 million to $9.96 million. The best estimate of benefits is based on the simple average of AF saved and the mid-point of irrigation values, which is equal to a present value of $4.89 million.

San Francisco Watershed Restoration

The Catron County Commission San Francisco Watershed Tier-2 application indicates 2,000 AF of water would be available for consumptive use as a result of the proposal and 2,042 to 3,063 AF of in stream flow benefits would be generated. For this analysis agricultural values are applied to potential water quantity benefits because the resources and activities that would be most affected by increased in-stream flows is not known. Assuming agricultural benefit values

ranging from $23 to $144 per acre-foot, annual benefits from the proposal would range from $93,000 to $729,100. The estimated present value benefits over 50 years would range from $2.18 million to $17.10 million.

NMFIA Watershed Restoration

The New Mexico Forest Industries Association Tier-2 application identified potential benefits equivalent to 173 AF of water for seven years. The type of benefit was not specified. Therefore, it was assumed that ½ of benefits are agricultural/in-stream flows and ½ are M&I related benefits. Agricultural related benefits were estimated to be $2,000 to $12,500 annually and M&I related benefits were estimated to be $13,800 to $97,300 annually. The estimated present value benefits over 7 years would range from $84,400 to $594,500 million.

NMSU Watershed Restoration

The New Mexico State University Tier-2 proposal described potential water saved from reduced evapotranspiration as a result of treating 1,500 acres of mixed conifer ponderosa and 500 acres of woodland juniper. Total water saved is described as beginning with 65 AF in year 1, increasing to nearly 300 AF in years 6 through 10, and decreasing to 32 AF by year 15. The type of benefit was not specified. Therefore, it was assumed that ½ of benefits are agricultural/in-stream flows and ½ are M&I related benefits. Project benefits associated with water that is made available for potential use range from $2,900 to $131,000 annually. Present value benefits assuming 15 years of improvement benefits at a 3.5% discount rate range from $209,400 to $1,460,000.

Grant Soil & Water Conservation District Forest Restoration and USFS Watershed Restoration

The specific benefits in terms of water saved or made available for use or acres benefited are not discussed in either the GSWCD Forest Restoration proposal or the USFS Watershed Restoration proposal. The GSWCD proposal provides a general discussion of benefits in terms of mitigation for water development activities and potential for environmental enhancement, but the effects are not quantified. The USFS proposal indicates there will be benefits in terms of reduced catastrophic fires, augmented stream flow, erosion prevention, ecosystem protection or enhancement, and water quality improvement. The extent of these effects are not quantified. Therefore, the benefits are not estimated for either of these proposals.

Summary of Benefits Quantified for the Tier-2 Proposals

The benefits estimated in the previous section are summarized below in Table V-8. The values in the column characterized as ”best” are based on benefit values that are most relevant for the study region, quantities of water that are likely to be provided, or midpoint benefit values. Data are not available at the appraisal level to predict future market conditions that could affect water values in the region or water supply conditions associated with each proposal which could be used to estimate the probability of different events occurring.

Table V-8. - Estimated quantified benefits for each proposal

Proposal	Low estimate of Benefits (millions)	High estimate of benefits (millions)	"Best" estimate of benefits (millions)
GCWC Infrastructure and Reuse	$3.52	$24.89	$16.15
Grant County Recharge and Reservoir	$5.95	$24.44	$11.62
Deming Wastewater Reuse	$1.36	$14.71	$9.54
SW New Mexico Regional Water Supply	$74.12	$458.55	$225.77
GBIC Diversion and Storage	$0.54	$47.29	$10.77
Hidalgo County Off-Stream	$26.65	$154.20	$102.53
GCC Municipal Conservation	$9.87	$69.80	$45.29
Pleasanton Ditch Improvements	$0.80	$5.64	$3.08
Luna Ditch Improvements	$0.23	$1.41	$0.82
Sunset/New Mexico New Model Pipeline	$1.10	$9.96	$4.89
San Francisco Watershed Restoration	$2.18	$17.10	$9.64
NMFIA Watershed Restoration	$0.10	$0.59	$0.34
NMSU Watershed Restoration	$0.21	$1.46	$0.83
GSWCD Forest Restoration	NA	NA	NA
USFS Watershed Restoration	NA	NA	NA

D. Appraisal level economic analysis of the benefits, costs, and regional impacts from the other configuration and storage options provided by Reclamation for ISC's consideration

Benefits Associated With Storage Alternatives Identified by the Bureau of Reclamation

Reclamation evaluated three possible combined diversion and storage alternatives and five individual storage alternatives that could be considered by the New Mexico Interstate Stream Commission in addition to the 15 Tier-2 proposals. The potential benefits associated with each of the Reclamation alternatives are described below.

Alternative 1- Diversion and storage at Greenwood and Sycamore Reservoirs

The Reclamation Alternative 1 proposal includes a diversion structure, approximately 144,000 feet of concrete lined canals, and two reservoirs that could store a total of 65,000 AF of water. The potential benefits associated with this alternative include agricultural and recreation benefits. For the purposes of this analysis it is assumed that 10,000 AF of additional water supplies will be made available on an annual basis and that the water supply benefits will be for agricultural production purposes. Additional water could be available as a result of the project for environmental purposes, but the extent of this potential benefit is unknown. Based on agricultural values ranging from $23 to $144 per acre-foot, the annual agricultural water supply benefit could be $230,000 to $1.44 million.

The present value of agricultural benefits over the 50 year period of analysis would be $5.39 million to $33.78 million.

Annual recreation visitation of 35 visits per reservoir surface acre is used to estimate recreation benefits as was used for the other storage alternatives. The total surface water acreage for Sycamore and Greenwood Reservoirs is 1,064 acres, which translates into 37,200 visits annually. Assuming a recreation value of $46 to $90 per visit, the value of recreation could be $1.71 million to $3.35 million annually. The present value of recreation over 50 years would be $40.11 million to $78.58 million. Total agricultural and recreation benefits are estimated to range from $45.50 million to $112.36 million.

Alternative 2 – Diversion and storage at Spar and Garcia Reservoirs
The Reclamation Alternative 2 proposal also includes a diversion structure, approximately 79,500 feet of concrete lined canals, and two reservoirs that could store approximately 10,000 AF of water. The potential benefits associated with this alternative include agricultural and recreation benefits. For the purposes of this analysis it is assumed that 10,000 AF of additional water supplies will be made available on an annual basis for agricultural purposes. Based on agricultural values ranging from $23 to $144 per acre-foot the annual agricultural water supply benefit could be $230,000 to $1.44 million. The present value of agricultural benefits over the 50 year period of analysis would be $5.39 million to $33.78 million.

Annual recreation visitation of 35 visits per reservoir surface acre is used to estimate recreation benefits as was used for the other storage alternatives. The total surface water acreage for Spar and Garcia Reservoirs is 239 acres, which translates into 8,400 visits annually. Assuming a recreation value of $46 to $90 per visit, the value of recreation could be $386,400 to $756,000 annually. The present value of recreation over 50 years would be $9.06 million to $17.73 million. Total agricultural and recreation benefits are estimated to range from $14.45 million to $51.51 million.

Alternative 3 – Diversion and storage at Mogollon and Winn Reservoirs
The Reclamation Alternative 3 proposal also includes a diversion structure, approximately 88,000 feet of concrete lined canals, and two reservoirs that could

store approximately 14,000 AF of water. The potential benefits associated with this alternative include agricultural and M&I water supply benefits and recreation benefits. For the purposes of this analysis it is assumed that 10,000 AF of additional water supplies will be made available on an annual basis for agricultural production. Based on agricultural values ranging from $23 to $144 per acre-foot, the annual agricultural water supply benefit could be $230,000 to $1.44 million. The present value of agricultural benefits over the 50 year period of analysis would be $5.39 million to $33.78 million.

Annual recreation visitation of 35 visits per reservoir surface acre is used to estimate recreation benefits as was used for the other storage alternatives. The total surface water acreage for Mogollon and Winn Reservoirs is 408 acres, which translates into 14,300 visits annually. Assuming a recreation value of $46 to $90 per visit, the value of recreation could be $657,000 to $1.28 million annually. The present value of recreation over 50 years would be $15.41 million to $30.02 million. Total agricultural and recreation benefits are estimated to range from $20.80 million to $63.80 million.

Reclamation single storage site options

Five potential single storage site options were identified by reclamation for analysis. These reservoirs include Greenwood, Winn, Spar, Pope, and Dam. All water supply benefits are assumed to be associated with agricultural production with values ranging from $23 to $144 per acre-foot. Estimated annual recreation use of 35 visits per surface water acre is assumed as was used for all of the Tier-2 proposals and the three Reclamation alternatives and recreation values were assumed to range from $46 to $90 per visit. TableV-9 shows the estimated range of annual agricultural and recreation benefits for the five single reservoir alternatives. Table V-10 shows the present value of benefits over the 50 year period of analysis.

Table V-9. - Estimated annual agricultural and recreation benefits for single reservoir alternatives

Reservoir	Annual Supply (acre-feet)	Surface Area (acres)	Estimated annual recreation visitation	Estimated annual agricultural benefits		Estimated annual recreation benefits	
				Low	High	Low	High
Greenwood	10,000	481	16,835	$230,000	$1,440,000	$774,400	$1,515,100
Winn	2,750	109	3,815	$63,300	$396,000	$175,500	$343,400
Spar	3,100	36	1,260	$71,300	$446,400	$58,000	$113,400
Pope	7,900	219	7,665	$181,700	$1,137,600	$352,600	$689,900
Dam	9,400	135	4,725	$216,200	$1,353,600	$217,400	$425,300

Table V-10. - Estimated agricultural, recreation, and total benefits over 50 years for single reservoir alternatives

Reservoir	Estimated agricultural benefits over 50 years (millions)		Estimated recreation benefits over 50 years (millions)		Estimated total benefits over 50 years (millions)	
	Low	High	Low	High	Low	High
Greenwood	$5.40	$33.78	$18.16	$35.54	$23.56	$69.32
Winn	$1.49	$9.29	$4.12	$8.06	$5.61	$17.35
Spar	$1.67	$10.47	$1.36	$2.66	$3.03	$13.13
Pope	$4.26	$26.68	$8.27	$16.18	$12.53	$42.86
Dam	$5.07	$31.75	$5.10	$9.98	$10.17	$41.73

Economic Cost of the AWSA Tier-2 Proposals and Reclamation Storage Alternatives

The P&G's indicate that all project costs and benefits should be based on the real cost of resources (or real exchange values). According to the P&G's, the general level of prices for outputs and inputs prevailing during or immediately preceding the planning period should be used for the entire period of analysis. In addition, all project costs and benefits must be evaluated in terms of a consistent base year. This avoids use of escalation factors that account for inflation over the planning period. If real prices, separate from inflation, would be expected to change over time, then those real changes can be incorporated into the analysis. For the purposes of this analysis the base year for project evaluation is 2013. Project costs include construction costs as well as operation, maintenance, and replacement (OM&R) costs.

An additional cost that must be accounted for is interest during construction (IDC), which represents the difference between funds appropriated for construction and the economic cost of capital invested in the project when the project is brought into service at the end of construction. The difference represents an economic cost that must be included in economic justification. IDC is based on one-half of the construction expenditures during a particular year plus all of the expenditures from previous years until the project is completed and brought into service. Total IDC is the total of the interest for each of the years. One-half of construction expenditures represent an approximation of a non-uniform annual expenditure amount. IDC is influenced by the magnitude of construction costs and the construction period. Greater construction costs and increased construction periods both lead to greater IDC.

Estimated costs of the Tier-2 proposals

Project cost information was obtained from the AWSA Tier-2 project proposals, revised preliminary engineering reports, or from Bureau of Reclamation cost estimates. The estimated engineering costs for most of the proposals included a

New Mexico Gross Receipts Tax (NMGRT), which is a state tax imposed on businesses for the sale of property, leasing or licensing of property, granting a right to use a franchise, performing services, and selling research and development services. Gross receipts represent the total amount of money or other consideration received from the above activities. The gross receipts tax rate varies throughout New Mexico. The NMGRT represents a redistribution of income or revenue from one party to another rather than an actual economic cost. Therefore, any NMGRT included in the cost estimates are deducted when estimating economic costs. Summaries of estimated project costs are presented below for each project proposal. All future costs are evaluated using the fiscal year 2013 project planning rate of 3.5% over a 50 year planning period unless otherwise indicated.

Grant County Water Commission (GCWC) Infrastructure and Reuse costs

The source of cost information for this proposal is the preliminary engineering report "Engineering Report: Gila (Grant County) Water Utilization Alternative (Well Field, Tanks and Piping" prepared by William J. Miller Engineers, Inc. in December 2013. Estimated project costs are presented in Table V-11.

Table V-11. - GCWC infrastructure and reuse costs

Feature	Estimated Cost	NMGRT	Estimated cost less NMGRT
Pipeline, booster station, storage tank	$8,387,200	$488,700	$7,898,500
Land and Right-of-Way	$1,433,500	$83,500	$1,350,000
Environmental and cultural resources	$112,600	$6,600	$106,000
Other costs	$1,088,400	$63,400	$1,025,000
Contingencies at 15% of cost	$1,653,200	$96,300	$1,556,900
Engineering	$1,162,800	$67,800	$1,095,000
Two wells	$2,586,000	$150,700	$2,435,300
Total	$16,423,700	$957,000	$15,466,700

Estimated IDC is based on an assumed 2 year construction period, construction costs that are divided evenly over the two year period. If project costs actually occur earlier than the equal distribution assumption, then IDC would be larger than estimated. If costs occurred later, then IDC would be smaller than estimated. IDC does not include the NMGRT because these taxes do not represent an economic cost. IDC is estimated to equal $2,269,500. The total estimated construction cost in 2013 dollars, including IDC, is $17,736,200.

OM&R is estimated in the William J. Miller Engineers, Inc. preliminary engineering report to be $505,300 annually. The present value of OM&R costs is $11,852,100. The OM&R cost is assumed to be the same throughout 50 year period, representing a real cost and not a cost that includes inflation. The present value of total project costs; including construction, IDC, and OM&R, is estimated to be $28,588,300.

Grant County Recharge and Reservoir costs
The source of cost information for this proposal is "Preliminary Engineering Report: Grant County Tier 2 AWSA Application Review" prepared by Bohannan Huston, Inc. in December 2013. Estimated project costs are presented in Table V-12.

Table V-12. - Grant County recharge and reservoir costs

Feature	Estimated Cost	NMGRT	Estimated cost less NMGRT
Reservoir construction and management	$15,054,000	$1,053,900	$14,000,100
Pipeline and booster station construction	$684,000	$47,900	$636,100
Design, permitting, etc.	$1,038,500	$72,800	$965,700
Land Acquisition	$105,000	$7,400	$97,600
Total	$16,881,500	$1,182,000	$15,699,500

IDC is based on an assumed 2 year construction period and is estimated to be $2,275,600. Total construction cost, including IDC, is $17,975,100. OM&R is estimated in the Bohannan Huston, Inc. preliminary engineering report to be $115,250 per year. The present value of OM&R costs is $2,703,300. The present value of total project costs is estimated to be $20,678,400.

Deming Wastewater Reuse, immediate implementation alternatives costs
The source of cost information for this proposal is "Preliminary Engineering Report: Proposed Effluent Reuse Expansion" prepared by Souder, Miller & Associates in November 2013. Estimated project costs are presented in TableV- 13.

IDC is based on one year of construction and is estimated to be $71,500. Total construction cost, including IDC, is $4,157,500. OM&R is estimated in the Souder, Miller & Associates preliminary engineering report to be $74,800 per year. The present value of OM&R costs over 20 years, which is the estimated project life for this proposal, is $1,063,100. The present value of total project costs is estimated to be $5,220,600.

Table V-13. - Deming wastewater reuse, immediate implementation alternatives costs

Feature	Estimated cost	NMGRT	Estimated cost less NMGRT
Replace booster pumps to golf course ponds	$761,700	$53,100	$708,600
Treatment using filters and UV	$704,700	$49,200	$655,500
Replace booster pumps at golf course	$711,900	$49,700	$662,200
New reuse distribution trunk line	$843,100	$58,800	$784,300
New reuse line for High School fields etc.	$224,300	$15,700	$208,600
New reuse line for Soccer fields etc.	$295,200	$20,600	$274,600
Sprinkler upgrades at gold course	$66,500	$4,600	$61,900
Professional services	$785,500	$55,200	$730,300
Total	$4,392,900	$306,900	$4,086,000

Southwest New Mexico Regional Water Supply costs

Cost information for this proposal was provided by the Reclamation Phoenix Area Office. Estimated project costs are presented in Table V-14.

Table V-14. - Southwest New Mexico regional Water supply

Feature	Estimated Cost	NMGRT	Estimated cost less NMGRT
Mangas Dam	$155,000,000	$5,636,000	$149,364,000
Infiltration gallery and pumping plant	$34,100,000	$1,096,000	$33,004,000
Mogollon Dam	$158,000,000	$6,014,000	$151,986,000
Pipeline to Deming	$156,000,000	$5,003,000	$150,997,000
Total	$503,100,000	$17,749,000	$485,351,000

IDC is based on an assumed 4 year construction period and an even distribution of costs over the 4 year period. IDC is estimated to be $35,031,000. Total construction cost, including IDC, is $520,382,000. OM&R is estimated by the Reclamation Phoenix Area Office to be $8,850,000 per year. The present value of OM&R costs is $207,582,000. The present value of total project costs is estimated to be $727,964,000.

An additional cost associated with the diversion and storage proposals is reimbursement of the Central Arizona Project (CAP) Fixed Operations, Maintenance and Replacement Charge and the CAP Pumping Energy Charge for water delivered to downstream users in exchange for New Mexico diversions. The current rate is $146 per acre-foot. This value is applied to diversions over the project life of the diversion and storage proposals. The P&G's indicate that the prices used to evaluate benefits and costs should reflect the real exchange values during, or immediately preceding, the period of a analysis. Prices immediately preceding the date of project evaluation should be used for the entire period of analysis. Therefore, the cost of $146 per acre-foot is used to value the water charge. This translates into an annual cost of $1,460,000 to $2,044,000 for CAP water. The present value of the water cost is $34.25 million to $47.94 million.

Including the water charge, the total cost of the Southwest New Mexico Regional Water Supply proposal would range from $762.21 million to $775.90 million.

Gila Basin Irrigation Commission Proposal costs

Cost information for the Gila Basin Irrigation Commission proposal was provided by the Reclamation Phoenix Area Office. Estimated project costs are presented in Table V-15.

Table V-15. - Gila Basin Irrigation Commission proposal costs

Feature	Estimated Cost	NMGRT	Estimated cost less NMGRT
Upper diversion structure	$9,300,000	$299,000	$9,001,000
Gila Farms diversion structure	$10,800,000	$347,000	$10,453,000
Connection ditches	$4,900,000	$178,000	$4,722,000
Upsize existing ditches	$1,000,000	$32,000	$968,000
Storage ponds	$3,800,000	$125,000	$3,675,000
Pipeline recharge	$10,900,000	$350,000	$10,550,000
Infiltration gallery	$1,100,000	$35,000	$1,065,000
Total	$41,800,000	$1,366,000	$40,434,000

IDC is based on an assumed 2 year construction period and an even distribution of costs over both years. IDC is estimated to be $4,848,000. Total construction cost, including IDC, is $45,282,000. OM&R is estimated by the Reclamation Phoenix Area Office to be $585,000 per year. The present value of OM&R costs is $13,722,000. The present value of total project costs is estimated to be $59,004,000.

The CAP Fixed Operations, Maintenance and Replacement Charge, and Pumping Energy Charge would range from $146,000 to $2,044,000 annually depending on the assumed amount of water diversion. The present value of the water cost is $3.42 million to $47.94 million. Including the water charge, the total cost of the Gila Basin Irrigation Commission proposal would range from $62.42 million to $106.94 million.

Hidalgo County Off-Stream Proposal costs

Cost information for the Hidalgo County Off-Stream proposal was provided by the Reclamation Phoenix Area Office. Estimated project costs are presented Table V-16.

Table V-16. - Hidalgo County off-stream proposal costs

Feature	Estimated Cost	New Mexico Gross Receipts Tax (NMGRT)	Estimated cost less NMGRT
Diversion and conveyance structures	$115,000,000	$4,300,000	$110,700,000
Schoolhouse Dam	$105,000,000	$4,020,000	$100,980,000
Virden Dam	$14,700,000	$470,000	$14,230,000
Total	$234,700,000	$8,790,000	$225,910,000

IDC is based on an assumed 4 year construction period and an even distribution of costs over the 4 year period. IDC is estimated to be $17,155,000. Total construction cost, including IDC, is $243,065,000. OM&R is estimated by the Reclamation Phoenix Area Office to be $1,530,000 per year. The present value of OM&R costs is $35,887,000. The present value of total project costs is estimated to be $278,952,000.

The CAP Fixed Operations, Maintenance and Replacement Charge, and Pumping Energy Charge would range from $1,460,000 to $1,606,000 annually depending on the assumed amount of water diversion. The present value of the water cost is $34.25 million to $37.67 million. Including the water charge, the total cost of the Hidalgo County Off-Stream proposal would range from $313.20 million to $316.62 million.

Gila Conservation Coalition (GCC) Municipal Conservation

The source of cost information for this proposal is the merged Municipal Conservation to Reduce Net Depletions to Groundwater proposal. The proposal discusses the costs of several different conservation programs. The total cost of implementation of the programs included in the proposal was estimated to be about $10,900,000 or $11,800,000 in 2013 dollars. No IDC is assigned to this proposal.

Pleasanton Eastside Ditch costs

The source of cost information for this proposal is a Preliminary Engineering Assessment for Pleasanton Eastside Ditch prepared by Portage, Inc. in January 2014. The Engineering Assessment identified 4 possible improvement alternatives. Estimated project costs for each of the identified alternatives are presented in Table V-17.

Table V-17. - Pleasanton eastside ditch costs

Alternative	Estimated cost	NMGRT	Estimated cost less NMGRT
1 – 30” HDPE	$2,040,700	$108,700	$1,932,000
2 – 36” HDPE	$2,661,800	$141,800	$2,520,000
3 – 36” CMP	$1,830,700	$97,500	$1,733,200
4 = 36” HDPE and ditch	$2,536,200	$135,100	$2,401,100

IDC is calculated assuming construction is completed in one year. IDC is estimated to be $33,800 for alternative 1, $44,100 for alternative 2, $30,300 for alternative 3, and $42,000 for alternative 4. Total construction cost, including IDC, is estimated to be $1,965,800 for alternative 1, $2,564,100 for alternative 2, $1,763,500 for alternative 3, and $2,443,100 for alternative 4.

Annual OM&R costs are not provided in the Portage, Inc. Engineering Assessment or in the Pleasanton Ditch Tier-2 application. However, some annual costs could be anticipated for this project. The April 2011 Tier – 1 application completed for the Luna Irrigation Ditch Association indicated annual OM&R costs equal to 1.15% of construction costs. Using 1.15% of construction cost as a basis for estimating annual OM&R costs for Pleasanton Ditch, the estimated OM&R would range from $19,900 to $29,000 annually. The present value of OM&R costs is $466,800 to $680,200. The present value of total project costs are estimated to be $2,486,500 for alternative 1, $3,244,300 for alternative 2, $2,230,300 for alternative 3, and $3,090,500 for alternative 4.

Luna Irrigation Ditch costs

The source of cost information for this proposal is a Preliminary Engineering Assessment for Luna Irrigation Ditch prepared by Portage, Inc. in January 2014. The Engineering Assessment identified 2 alternatives. Estimated project costs for each of the identified alternatives are presented in Table V-18.

Table V-18. - Luna irrigation ditch costs

Alternative	Estimated cost	NMGRT	Estimated cost less NMGRT
1 – Conventional river diversion	$1,363,700	$64,500	$1,299,200
2 – Subsurface collection system	$1,365,300	$65,100	$1,300,200

IDC is calculated assuming construction is completed in one year. IDC is estimated to be $22,700 for alternative 1 and $22,800 for alternative 2. Total construction cost, including IDC, is $1,321,900 for alternative 1 and $1,323,000 for alternative 2.

Annual OM&R costs are not provided in the Portage, Inc. Engineering Assessment. However, the April 2011 Tier – 1 application completed for the

Luna Irrigation Ditch Association indicated annual OM&R costs equal to $15,000 or 1.15% of estimated construction costs. Using $15,000 per year as the estimate of annual OM&R, the present value of OM&R costs is $351,800. The present value of total project costs for alternative 1 are estimated to be $1,673,700 and $1,674,800 for alternative 2.

Sunset/New Mexico Pipeline Costs

The source of cost information for this proposal is a Preliminary Engineering Assessment for Sunset Canal prepared by Portage, Inc. in January 2014. The Engineering Assessment identified 4 possible alternatives. Estimated project costs for each of the identified alternatives are presented in Table V-19.

Table V-19. - Sunset/New Mexico pipeline costs

Alternative	Estimated Cost	NMGRT	Estimated cost less NMGRT
1 – Sunset Canal, 42” and 36” pipe	$9,110,100	$551,000	$8,559,100
2 – Sunset Canal, 48” and 42” pipe	$11,305,900	$683,800	$10,622,100
3 – New Model Canal, 36” pipe	$3,792,500	$229,400	$3,563,100
4 – New Model Canal, 42” pipe	$4,777,500	$288,900	$4,488,600

IDC is calculated assuming construction is completed in one year. IDC is estimated to be $149,800 for alternative 1, $185,900 for alternative 2, $62,400 for alternative 3, and $78,600 for alternative 4. Total construction cost, including IDC, is estimated to be $8,708,900 for alternative 1, $10,808,000 for alternative 2, $3,625,500 for alternative 3, and $4,567,200 for alternative 4.

Annual OM&R costs are not provided in the Portage, Inc. Engineering Assessment. However, assuming some annual costs are equal to 1.15% of construction costs as indicated in the April 2011 Tier – 1 application completed for the Luna Irrigation Ditch Association, estimated OM&R would range from $41,000 to $122,200 annually. The present value of OM&R costs over 50 years is $961,700 to $2,866,300. The present value of total project costs are estimated to be $11,016,900 for alternative 1, $13,674,300 for alternative 2, $4,587,200 for alternative 3, and $5,77,500 for alternative 4.

San Francisco Watershed Restoration

Information for the cost of the San Francisco Watershed Restoration proposal was obtained from a modified Tier-2 proposal amended in March of 2013. The proposal indicated a total project cost of $12,091,000. Approximately $4,650,600 (38.5% of total cost) was attributed to irrigation system construction. The remaining $7,440,400 (61.5% of total cost) was attributed to administration, overhead, monitoring, and re-vegetation. No specific O&M was indicated. However, it is stated that the reoccurring operation and maintenance of the upgraded irrigation systems should be minimal and will be the responsibility of the private owner. No IDC is assigned to this proposal. The NMGRT was not

specifically mentioned in the discussion of costs, so it is assumed that the tax is not included in the cost estimate.

New Mexico Forest Industry Association (NMFIA) Watershed Restoration
The costs associated with the NMFIA watershed restoration proposal were obtained from the final Tier-2 proposal. The proposal provided annual costs over the 10 year project period. These costs are summarized in Table V-20. The table shows categories of costs, annual costs, and costs discounted to the present . The present value of project costs is $1,974,500. No IDC is assigned to this proposal.

Table V-20. - NMFIA watershed restoration costs

Year	Administrative	Operational	Maintenance	Planning, NEPA, restoration	Total cost	Total discounted cost
1	-	-	-	$200,000	$200,000	$193,200
2	$7,000	$70,000	$15,500	$75,000	$167,500	$156,400
3	$7,000	$70,000	$18,000	$615,000	$710,000	$640,400
4	$7,000	$70,000	$15,500	$540,000	$632,500	$551,200
5	$7,000	$70,000	$15,500	-	$92,500	$77,900
6	$7,000	$70,000	$18,000	-	$95,000	$77,300
7	$7,000	$70,000	$15,500	-	$92,500	$72,700
8	$7,000	$70,000	$15,500	-	$92,500	$70,200
9	$7,000	$70,000	$15,500	-	$92,500	$67,900
10	$7,000	$70,000	$18,000	-	$95,000	$67,300
Total	$70,000	$630,000	$147,000	$1,430,000	$2,270,000	$1,974,500

New Mexico State University (NMSU) Watershed Protection
The costs associated with the NMSU watershed protection proposal were obtained from the final Tier-2 proposal. The proposal provided annual costs over the 10 year project period. These costs are summarized in Table V-21. The table shows annual and discounted costs . The present value of project costs is $1,851,200. No IDC is assigned to this proposal.

Table V-21. - NMSU watershed protection costs

Year	Approximate Cost	Discounted cost
1	$477,400	$461,300
2	$217,000	$202,600
3	$217,000	$195,700
4	$217,000	$189,100
5	$195,300	$164,500
6	$173,600	$141,200
7	$130,200	$102,300
8	$130,200	$98,900
9	$130,200	$95,500
10	$282,100	$200,000
Total	**$2,170,200**	**$1,851,200**

Grant Soil & Water Conservation District (GSWCD) Forest Restoration

The costs associated with the GSWCD forest restoration proposal were obtained from the December 2011 Tier-2 proposal. The proposal provided an estimate of the total implementation cost by year for three basic categories of costs in 2011 dollars. The total estimated implementation cost of the proposal by year and category is presented in Table V- 22. The total estimated present value cost of project costs is $1,112,900. No IDC is assigned to this proposal.

Table V-22. - GSWCD forest restoration costs by type of cost and year

Year	Administrative	Operational	Maintenance	Total cost In 2011 $'s	Total cost in 2013 $'s	Total cost discounted
1	$2,000	$104,250	$4,000	$110,250	$114,100	$110,200
2	$2,000	$256,750	$4,000	$262,750	$271,900	$253,900
3	$2,000	$106,750	$4,000	$112,750	$116,700	$105,300
4	$2,000	$106,750	$4,000	$112,750	$116,700	$101,700
5	$2,000	$106,750	$4,000	$112,750	$116,700	$98,300
6	$2,000	$106,750	$4,000	$112,750	$116,700	$94,900
7	$2,000	$106,750	$4,000	$112,750	$116,700	$91,700
8	$2,000	$106,750	$4,000	$112,750	$116,700	$88,600
9	$2,000	$106,750	$4,000	$112,750	$116,700	$85,600
10	$2,000	$106,750	$4,000	$112,750	$116,700	$82,700
Total	$20,000	$1,215,000	$40,000	$1,275,000	$1,319,600	$1,112,900

U.S. Forest Service (USFS) Watershed Restoration

The costs associated with the USFS watershed restoration proposal were obtained from the December 2011 Tier-2 proposal. The proposal provided an estimate of the total implementation costs for two projects. The first indicated implementation over 5 years and the second was implemented over 10 years. The distribution of costs assuming equal expenditures over the implementation period is shown in Table V-23. The total estimated present value implementation cost of the proposal is $7,062,800 in 2013 dollars. No IDC is assigned to this proposal.

Table V-23. - USFS watershed restoration costs by type of cost and year

Year	Project 1	Project 2	Total cost In 2011 $'s	Total cost in 2013 $'s	Total cost Discounted
1	$201,200	$740,000	$941,200	$974,100	$909,400
2	$201,200	$740,000	$941,200	$974,100	$878,600
3	$201,200	$740,000	$941,200	$974,100	$848,900
4	$201,200	$740,000	$941,200	$974,100	$820,200
5	$201,200	$740,000	$941,200	$974,100	$792,500
6	$0	$740,000	$740,000	$765,900	$602,000
7	$0	$740,000	$740,000	$765,900	$581,600
8	$0	$740,000	$740,000	$765,900	$562,000
9	$0	$740,000	$740,000	$765,900	$543,000
10	$0	$740,000	$740,000	$765,900	$524,600
Total	$1,006,000	$7,400,000	$8,406,000	$8,700,000	$7,062,800

Summary of AWSA Tier-2 Project Proposal Costs and Cost Effectiveness

The estimated construction costs and present values of OM&R for each project proposal are presented in Table V-24. The cost estimates are the most recent available, but are from a variety of sources. Therefore, they are not necessarily consistent in assumptions and approaches across all proposals. In addition, project cost estimates for the diversion alternatives (Southwest New Mexico Regional Water Supply, GBIC Diversion and Storage, and Hidalgo County Off-Stream Storage) do not include the reimbursement of CAP Fixed Operations, Maintenance and Replacement Charge and the CAP Pumping Energy Charge for water delivered to downstream users in exchange for New Mexico diversions. The current rate is $146 per acre-foot. Including these charges as part of project costs would increase the cost of the Southwest New Mexico Regional Water Supply and the GBIC Diversion and Storage proposals by approximately $47.94 million and the cost of the Hidalgo County Off-Stream proposal by approximately $37.67 million.

The costs presented in Table V-24 can be combined with the estimated water delivered or saved for each project proposal to estimate the average cost per acre-foot. This is a cost-effectiveness approach, where the cost per acre-foot provides a consistent measure that can be compared across all proposals. It should be noted that cost-effectiveness does not consider differences in the value of water as an output. Therefore, cost-effectiveness is not equivalent to cost-benefit analysis. The estimated cost per acre-foot of water for each proposed project is presented in Table V-25.

Table V-24. - Estimated project costs for each Tier-2 proposal

Proposal	Construction Cost including IDC (millions)	Present value of OM&R costs (millions)	Present value of CAP water related costs (millions)	Total Project costs (millions)
GCWC Infrastructure and Reuse	$16.74	$11.85	NA	$28.59
Grant County Recharge and Reservoir	$17.98	$2.70	NA	$20.68
Deming Wastewater Reuse	$4.16	$1.06	NA	$5.22
SW New Mexico Regional Water Supply	$520.38	$207.58	$34.25 to $47.94	$762.21 to $775.90
GBIC Diversion and Storage	$45.28	$13.72	$3.42 to $47.94	$62.42 to $106.94
Hidalgo County Off-Stream	$243.06	$35.89	$34.25 to $37.67	$313.20 to $316.62
GCC Municipal Conservation	-	-	NA	$11.80
Pleasanton Ditch Improvements	$1.76 - $2.56	$0.47 - $0.68	NA	$2.23 - $3.24
Luna Ditch Improvements	$1.32	$0.35	NA	$1.67
Sunset/New Mexico New Model Pipeline	$3.63 - $10.80	$0.96 - $2.87	NA	$4.59 - $13.67
San Francisco Watershed Restoration	-	-	NA	$12.09
NMFIA Watershed Restoration	-	-	NA	$1.97
NMSU Watershed Restoration	-	-	NA	$1.85
GSWCD Forest Restoration	-	-	NA	$1.11
USFS Watershed Restoration	-	-	NA	$7.06

Table V-25. - Estimated cost per acre-foot for each Tier-2 project proposal

Proposal	Present value of total project costs (millions)	Estimated acre-feet delivered or saved over project life	Present value cost per acre-foot
GCWC Infrastructure and Reuse	$28.59	47,150	$606.36
Grant County Recharge and Reservoir			
Deming Wastewater Reuse	$20.68	33,500	$617.31
SW New Mexico Regional Water Supply	$5.22	15,200	$343.42
GBIC Diversion and Storage	$762.21 to $775.90	600,000 to 950,000	$816.74 to $1,270.35
	$62.42 to $106.94	50,000 to 700,000	$152.77 to $1,248.40
Hidalgo County Off-Stream	$313.20 to $316.62	550,000	$569.45 to $575.67
GCC Municipal Conservation	$11.80	139,090	$84.84
Pleasanton Ditch Improvements	$2.23 - $3.24	78,750	$28.32 to $41.14
Luna Ditch Improvements		20,950	$79.71
Sunset/New Mexico New Model Pipeline	$1.67 $4.59 - $13.67	124,750	$36.79 to $109.58
San Francisco Watershed Restoration	$12.09	227,625	$53.11
NMFIA Watershed Restoration	$1.97	1,211	$1,626.75
NMSU Watershed Restoration	$1.85	2,991	$618.52
GSWCD Forest Restoration	$1.11	Not estimated	Not estimated
USFS Watershed Restoration	$7.06	Not estimated	Not estimated

Estimated costs of the Reclamation Storage Alternatives and Cost Effectiveness

Project cost information was obtained from the Reclamation assessment of three additional storage alternatives plus five additional single reservoir options. The estimated engineering costs included NMGRT, which as discussed in the previous section does not represent an economic cost. Therefore, the 6.2% NMGRT is deducted for taxable items in the Reclamation cost estimates to represent economic costs. Summaries of estimated project costs are presented below in Table V-26 for each project proposal.

Table V-26. - Estimated construction cost for Reclamation storage alternatives

Storage Alternative	Estimated construction cost (millions)	Approximate NMGRT at 6.2% (millions)	Construction cost less NMGRT (millions)
Alternative 1 – Greenwood & Sycamore	$598.45	$34.93	$563.52
Alternative 2 – Spar & Garcia	$294.37	$17.18	$277.19
Alternative 3 – Mogollon & Winn	$307.30	$17.93	$289.37
Greenwood Reservoir	$280.00	$16.34	$263.66
Winn Reservoir	$83.30	$4.86	$78.44
Spar Reservoir	$162.00	$9.54	$152.46
Pope Reservoir	$234.00	$13.66	$220.34
Dam Reservoir	$307.00	$17.92	$289.08

IDC plus the present value of OM&R costs must be added to the estimated construction cost less NMGRT to capture the full economic cost of the three Reclamation storage alternatives and the five individual storage alternatives identified by Reclamation. Table V- 27 shows IDC and the annual OM&R costs used to estimate project costs for the Reclamation alternatives. IDC is based on an assumed 4 year construction period with costs distributed evenly over the 4 years. This is the same construction period used for the Tier-2 diversion alternatives.

Table V-27. - Estimated IDC and annual OM&R cost for Reclamation storage alternatives

Storage Alternative	Estimated IDC (millions)	Estimated annual OM&R costs (millions)	Present value of OM&R costs over 50 years (milions)
Alternative 1 – Greenwood & Sycamore	$40.68	$4.47	$104.85
Alternative 2 – Spar & Garcia	$20.00	$2.53	$59.34
Alternative 3 – Mogollon & Winn	$20.88	$2.68	$62.86
Greenwood Reservoir	$19.03	$1.56	$36.59
Winn Reservoir	$5.67	$0.78	$18.30
Spar Reservoir	$11.00	$0.99	$23.22
Pope Reservoir	$15.91	$1.69	$39.64
Dam Reservoir	$20.87	$1.91	$44.80

The present value of total project costs and the cost per acre-foot for the Reclamation alternatives are presented in Tables V-28 and V-29.

Table V-28. - Estimated total project cost for the Reclamation storage alternatives

Storage Alternative	Construction cost Including IDC (millions)	Present value of annual OM&R costs (millions)	Present value of CAP water related costs (millions)	Total project cost (millions)
Alternative 1 – Greenwood & Sycamore	$604.2	$104.9	$34.25	$743.35
Alternative 2 – Spar & Garcia	$297.2	$59.3	$34.25	$390.75
Alternative 3 – Mogollon & Winn	$310.3	$62.9	$34.25	$407.45
Greenwood Reservoir	$282.7	$36.6	$34.25	$353.55
Winn Reservoir	$84.1	$18.3	$9.42	$111.82.4
Spar Reservoir	$163.5	$23.2	$10.62	$197.32
Pope Reservoir	$236.2	$39.6	$27.05	$302.85
Dam Reservoir	$310.0	$44.8	$32.19	$386.99

Table V-29. - Estimated cost per acre-foot for each Reclamation storage alternative

Proposal	Present value of total project costs (millions)	Estimated acre-feet delivered over project life	Present value cost per acre-foot*
Alternative 1 – Greenwood & Sycamore	$743.35	500,000	$1,487
Alternative 2 – Spar & Garcia	$390.75	500,000	$782
Alternative 3 – Mogollon & Winn	$407.45	500,000	$815
Greenwood Reservoir	$353.55	500,000	$707
Winn Reservoir	$111.82	137,500	$813
Spar Reservoir	$197.32	155,000	$1,273
Pope Reservoir	$302.85	395,000	$767
Dam Reservoir	$386.99	470,000	$823

Comparison of Project Proposal Benefits and Costs

The estimated benefits and costs presented above can be combined to provide an appraisal level comparison of costs and benefits. Positive net benefits, or benefits exceeding costs, indicate a project is justifiable from an economic perspective. The cost-benefit comparisons for the project proposals are presented in Table V-30 and figures V-1 and V-2. As previously discussed in the benefits section, the values in the column characterized as ”best” are based on midpoint benefit values or values that are most relevant for the study region rather than on a probability of being most accurate.

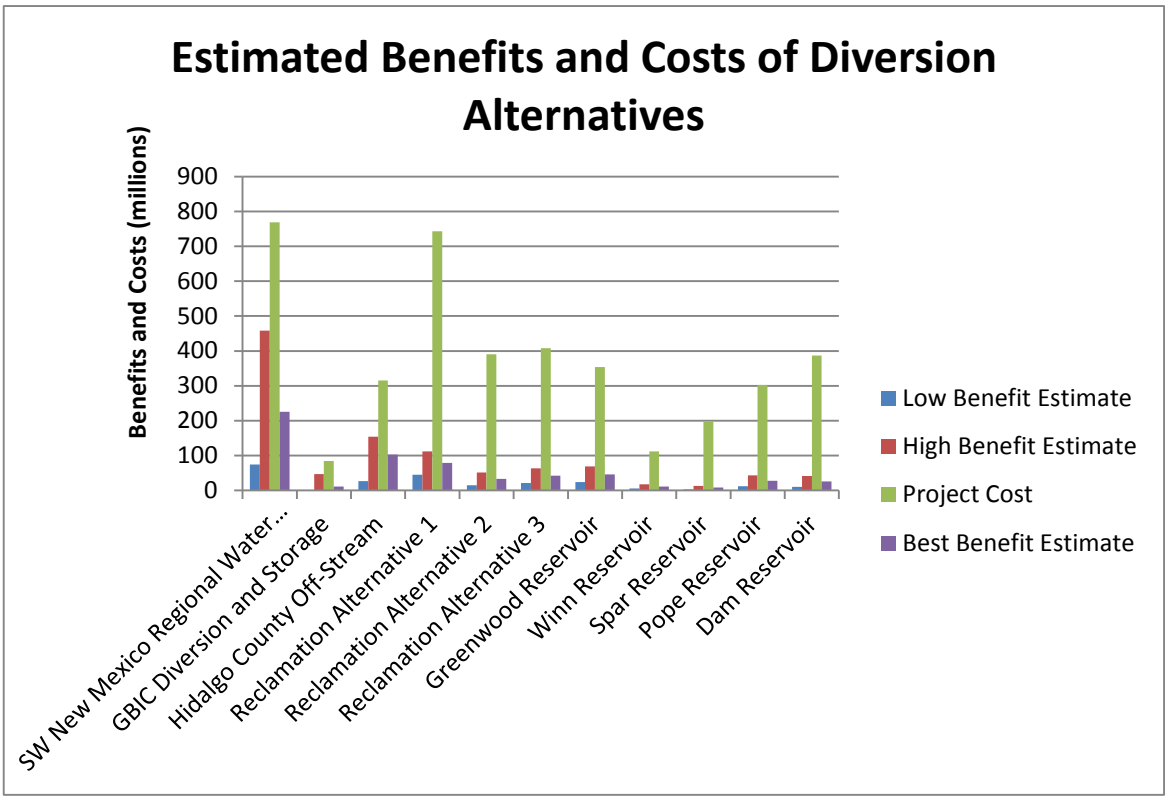

Figure V-1 – Estimated benefits and costs of all diversion proposals and alternatives

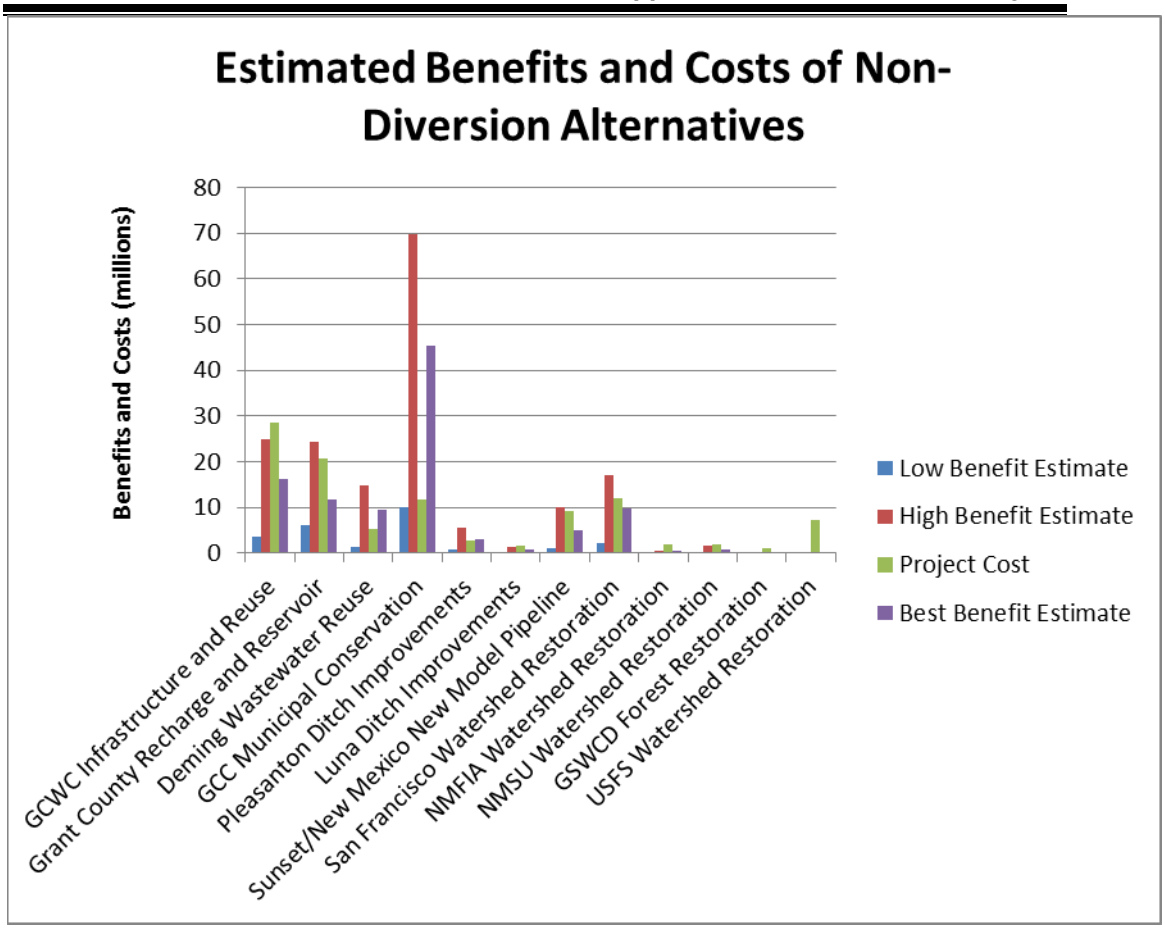

Figure V-2 – Estimated benefits and costs of non-diversion proposals and alternatives

Regional Economic Impacts from Construction, OM&R, and Project Output

The primary purpose of a regional impact analysis is to evaluate the effect of a project on income, employment, and the value of output produced on the immediate region in which the proposed project is located. This section addresses how each of the various Tier-2 proposals could affect the regional economy. For the purposes of this analysis it is assumed that the effects associated with each proposal represent incremental impacts, or impacts that would occur in addition to what would exist without a project. The regional impacts that are evaluated in this analysis include:

- Short-term impacts from construction expenditures,
- Long-term impacts from OM&R expenditures,
- Changes in the value of crop production resulting from increased irrigation water supply,
- Changes in recreation visitation and related expenditures associated with storage facilities.

Regional impacts are not estimated for M&I water supplies because it is not possible to accurately translate M&I deliveries into specific types and values of output. M&I water could be used for household consumption, as an input for businesses and industrial production, for irrigation of public parks, and other purposes. Each of these types of use would have very

Table V-30. - Estimated project benefits and costs for each proposal and Reclamation alternative

Proposal/Reclamation Alternative	Quantified project benefits (millions)	Total project costs (millions)	Project benefits minus project costs (millions)	Best estimate of benefits minus costs (millions)
GCWC Infrastructure and Reuse	$3.52 to $24.89	$28.59	-$25.07 to -$3.70	-$12.44
Grant County Recharge and Reservoir	$5.95 to $24.44	$20.68	-$14.73 to $3.76	-$9.06
Deming Wastewater Reuse	$1.36 to $14.71	$5.22	-$3.86 to $9.49	$4.32
SW New Mexico Regional Water Supply*	$74.12 to $458.55	$762.21 - $775.90	-$688.09 to -$317.35	-$536.44
GBIC Diversion and Storage*	$0.54 to $47.29	$62.42 - $106.94	-$61.88 to -$59.65	-$51.65
Hidalgo County Off-Stream*	$26.65 to $154.2	$313.20 – 316.62	-$286.55 to -$162.42	-$210.67
GCC Municipal Conservation	$9.87 to $69.80	$11.80	-$1.93 to $58.00	$33.49
Pleasanton Ditch Improvements	$0.80 to $5.64	$2.23 - $3.24	-$1.43 to $2.40	$0.85
Luna Ditch Improvements	$0.23 to $1.41	$1.67	-$1.44 to -$0.26	-$0.85
Sunset/New Mexico New Model Pipeline	$1.10 to $9.86	$4.59 - $13.67	-$3.81 to -$3.89	-$3.85
San Francisco Watershed Restoration	$2.18 to $17.10	$12.09	-$9.91 to $5.01	-$2.45
NMFIA Watershed Restoration	$0.10 to $0.59	$1.97	-$1.87 to -$1.38	-$1.63
NMSU Watershed Restoration	$0.21 to $1.46	$1.85	-$1.64 to -$0.39	-$1.02
GSWCD Forest Restoration	-	$1.11	-	-
USFS Watershed Restoration	-	$7.06	-	-
Reclamation Alternative 1*	$45.50 to $112.36	$743.35	-$697.85 to -$630.99	-$664.42
Reclamation Alternative 2*	$14.45 to $51.51	$390.75	-$376.30 to -$339.24	-$357.77
Reclamation Alternative 3*	$20.80 to $63.80	$407.45	-$386.65 to -$343.65	-$365.15
Greenwood Reservoir*	$23.56 to $69.32	$353.55	-$329.99 to -$284.23	-$307.11
Winn Reservoir*	$5.61 to $17.35	$111.82	-$106.21 to -$94.47	-$100.34
Spar Reservoir*	$3.03 to $13.13	$197.32	-$194.29 to -$184.19	-$189.24
Pope Reservoir*	$12.53 to $42.86	$302.85	-$290.32 to -$259.99	-$275.15
Dam Reservoir*	$10.17 to $41.73	$386.99	-$376.82 to -$345.26	-$361.04

different regional impacts that cannot be estimated with any degree of accuracy. However, what can be said is that excluding these M&I water supply impacts will understate the regional impacts associated with water supplies produced by each proposal.

The regional impact area defined for this analysis includes Catron, Grant, Luna, and Hidalgo Counties. The individual projects do not span all four counties. However, there are economic linkages between the four counties which create a region of impact.

It should be noted that regional economic impacts are not equivalent to economic benefits. Economic benefit is a measure of well-being from the perspective of all of society while regional economic impacts are a measure of changes in factors such as income and value of output produced from the perspective of a local community or region. Any project or program that results in increased spending in a region will increase economic activity and generate some level of positive regional impacts but will not necessarily generate economic benefits. Therefore, regional impacts cannot be added to economic benefits as a measure of total benefit.

Sources of data used to estimate regional impacts
The data used to estimate the construction and OM&R categories of regional impacts were obtained from specific proposal documents when available. Agricultural and recreation related impacts are based on representative revenues and expenditures that would be expected for the types of activities that would be supported by the proposed projects.

Construction and OM&R
Construction expenditure and OM&R cost data were obtained from the preliminary engineering reports, supplemental project cost estimates, and Tier-2 proposals used in the previous section to estimate economic costs. The appropriate costs for use in estimating short-term construction related impacts exclude IDC and the NMGRT. IDC represents an economic cost that would not actually be spent in the region. The NMGRT represents funds that go to the State of New Mexico as a whole. Some of these funds will come back to the region in terms of state expenditures, but for the purposes of this analysis it is assumed that the NMGRT represents a leakage of funds out of the study region.

Another issue associated with the estimation of regional impacts from construction is the proportion of construction expenditures that are actually spent in the impact region. Inputs necessary for construction that are not purchased within the impact region do not generate regional impacts. The purchasing patterns for project construction are not known. For the purposes of this analysis it is assumed that one-half of construction expenditures actually occur within the impact region. It is assumed that all OM&R expenditures occur within the region

because of the relatively large proportion of these costs represented by labor, energy, and other relatively small purchases that could be purchased locally.

Agricultural Production

Regional impacts from agricultural production occur as a result of input requirements and income/revenues generated by agricultural activities. The value of agricultural output produced as a result of available irrigation water supplies in the study area is based on cost and return estimates for farms and ranches in Grant and Catron Counties (New Mexico State University, 2014). For the purposes of the regional impact analysis the gross value of farm production associated with an acre-foot of water supply is multiplied by the incremental number of AF of water provided for each proposal to estimate the change in final demand for agricultural products from which impacts can be estimated. Cost and return estimates for alfalfa and alfalfa establishment, permanent pasture and pasture establishment, and livestock for Grant and Catron Counties indicated a gross return of $63,921 from agricultural sales in 2012 dollars or about $64,800 in 2013 dollars. The cost and return estimates indicated slightly over 177 AF of water would be supplied for the farm operation budgeted, or an average return of $366 per acre-foot of irrigation water supplied in 2013 dollars. This revenue per acre-foot of water is used to translate agricultural water supplies associated with each proposal into gross returns from which regional impacts can be estimated.

Recreation

Regional impacts from recreation are based on estimates of recreational expenditures per recreation day obtained from the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (Survey of Recreation) for New Mexico (U.S. Fish and Wildlife Service, 2014). A recreation day is defined as a visit by one individual to a recreation area for recreation purposes during any reasonable portion or all of a 24 hour period. The Survey of Recreation for New Mexico indicated an average of 3 days per trip for New Mexico residents for wildlife watching. Therefore, 3 days of expenditures is assumed for each recreation trip or visit to a recreation site.

It is assumed that expenditures from fishing and wildlife watching activities are representative of expenditures that would occur as a result of changes in recreation associated with the project proposals. It is recognized that other types of recreation, such as boating and hunting, occur in the region. However, without visitation estimates by specific activity more precise estimates of expenditures is not possible.

The Survey of Recreation for New Mexico indicated total trip related fishing expenditures of a little over $234 million and about 3.9 million recreation days of fishing, or expenditures of about $60 per day. Assuming an average of 3 days per trip, fishing expenditures are estimated to be about $180 per trip. Nearly one-half of trip related expenditures are for transportation (primarily gasoline), some of

which could be purchased outside of the study area. Assuming one-half of transportation related expenditures are not in the study region, recreation expenditures would be about $136 per trip for fishing. The Survey of Recreation also indicates total trip related expenditures for wildlife watching of $146.9 million and participation of 5.96 million days, or $24.65 per day and $73.95 per trip. A little over 26% of wildlife watching expenditures are for transportation related expenditures. Assuming one-half of transportation expenditures occur outside of the region, recreation expenditures are about $64 per trip. The average recreation expenditure per trip for fishing and wildlife viewing is $100 per trip or per visit in 2011 dollars or $103.50 in 2013 dollars.

Method for estimating regional impacts

The regional economic impacts from each project proposal are analyzed using the IMPLAN (IMpact analysis for PLANing) model. IMPLAN version 3.0 is used to estimate regional impacts. The model represents 2011 conditions and the base year data is 2013. The IMPLAN model is based on national estimates of flows of commodities used by industries and commodities produced by industries. The flow of commodities to industry from producers and consumers, as well as consumption of the factors of production from outside the region, is represented within IMPLAN. These also account for the percentage of expenditures in each category within the region and expenditures that would flow outside the region.

In order to estimate the regional economic impacts associated with each proposal, estimates of changes in expenditures for goods and services were input into the IMPLAN model. IMPLAN sectors were matched up as closely as possible with each expenditure category. The expenditure categories, IMPLAN sector, and sector description used to estimate impacts are shown in Table V-31. Three IMPLAN sectors were used for recreation expenditures, where one-third of expenditures were attributed to each sector.

Table V-31. - IMPLAN sectors used to estimate regional impacts

Expenditure	IMPLAN sector	IMPLAN sector description
Construction	36	Construction of other new nonresidential structures
OM&R	39	Maintenance and repair construction of nonresidential structures
Recreation	324	Retail – food and beverage
	326	Retail – Gasoline station
	411	Hotels and motels, including casino hotels
Agriculture	10	Other crop farming
Restoration	16	Logging

The impacts associated with each of the alternatives are measured in terms of changes in industry output, employee compensation, and employment. Industry output is a measure of the value of industry's total production. Industry output is

directly comparable to Gross Regional Product. Employee compensation represents wages and benefits paid to employees.

Regional Impact Results from Construction and OM&R Expenditures

A range of impacts is shown for those proposals that include more than one alternative and cost estimate. The estimated impacts are divided into short-term impacts that would occur only during the project construction period and long-term impacts that would occur over the life of the project. Long-term impacts result from OM&R expenditures, agricultural production, and recreation expenditures. The estimated short-term regional impacts from construction are presented in Table V-32 for those project proposals that included a construction component. The number of jobs represents full time or part time jobs generated by the expenditures. Impacts associated with restoration projects are shown in Table V-33 for the entire period of implementation and for each year assuming impacts are uniform over time. Table V-34 shows annual impacts that would occur for the life of the project as a result of OM&R expenditures, assuming the estimated OM&R expenditures would not change over time.

Table V-32. - One-time short-term regional impacts from construction

Proposal/Reclamation Alternative	Cost excluding NMGRT	Value of output	Labor Income	Number of Jobs
GCWC Infrastructure and Reuse	$15,466,700	$9,945,700	$3,450,600	109
Grant County Recharge and Reservoir	$15,699,500	$10,095,400	$3,502,500	110
Deming Wastewater Reuse	$4,086,000	$2,627,500	$911,600	29
SW New Mexico Regional Water Supply	$485,351,000	$312,099,000	$108,281,000	3,414
GBIC Diversion and Storage	$40,434,000	$26,001,000	$9.021,000	284
Hidalgo County Off-Stream	$225,910,000	$145,269,000	$50,400,000	1,589
Pleasanton Ditch Improvements (low)	$1,733,200	$1,114,500	$386,700	12
Pleasanton Ditch Improvements (high)	$2,520,000	$1,620,500	$562,200	18
Luna Ditch Improvements (low)	$1,299,200	$835,400	$289,800	9
Luna Ditch Improvements (high)	$1,300,200	$836,100	$290,100	9
Sunset Pipeline (low)	$3,563,100	$2,291,200	$794,900	25
Sunset pipeline (high)	$10,622,100	$6,830,400	$2,369,800	75
Reclamation Alternative 1	$563,520,000	$362,364,000	$125,721,000	3,963
Reclamation Alternative 2	$277,190,000	$178,244,000	$61,841,000	1,949
Reclamation Alternative 3	$289,370,000	$186,076,000	$64,558,000	2,035
Greenwood Reservoir	$263,660,000	$169,543,000	$58,822,000	1,855
Winn Reservoir	$78,440,000	$50,440,000	$17,500,000	552
Spar Reservoir	$152,460,000	$98,037,000	$34,014,000	1,073
Pope Reservoir	$220,340,000	$141,687,000	$49,158,000	1,550
Dam Reservoir	$289,080,000	$185,889,000	$64,493,000	2,033

Table V-33. - Regional impacts for conservation and restoration proposals over implementation period and annual equivalent impacts

Proposal	Impact period	Cost excluding NMGRT	Value of output	Labor income	Number of Jobs
GCC Municipal Conservation	20 years	$11,800,000	$15,455,100	$5,938,200	189
GCC Municipal Conservation	Annual	$590,000	$772,800	$296,900	9.5
San Francisco Watershed Restoration	10 years	$12,091,000	$15,549,900	$5,395,000	170
San Francisco Watershed Restoration	Annual	$1,209,100	$1,555,000	$539,500	17
NMFIA Watershed Restoration	10 years	$2,270,000	$3,671,400	$2,681,800	29
NMFIA Watershed Restoration	Annual	$227,000	$367,100	$268,200	3
NMSU Watershed Restoration	10 years	$2,170,200	$3,510,000	$2,563,900	28
NMSU Watershed Restoration	Annual	$217,000	$351,000	$256,400	3
SWCD Forest Restoration	10 years	$1,319,600	$2,330,600	$1,702,400	19
SWCD Forest Restoration	Annual	$132,000	$233,100	$170,200	2
USFS Watershed Restoration	10 years	$8,700,000	$14,080,100	$10,284,700	113
USFS Watershed Restoration	Annual	$870,000	$1,408,000	$1,028,500	11

TableV-34. - Long-term annual regional impacts from OM&R expenditures

Proposal/Reclamation Alternative	Annual OM&R Expenditures	Value of output	Labor income	Number of Jobs
GCWC Infrastructure and Reuse	$505,300	$661,800	$254,300	8
Grant County Recharge and Reservoir	$115,250	$150,900	$58,000	2
Deming Wastewater Reuse	$74,800	$97,700	$37,600	1
SW New Mexico Regional Water Supply	$8,850,000	$12,472,000	$4,453,000	142
GBIC Diversion and Storage	$585,000	$766,000	$294,000	9
Hidalgo County Off-Stream	$1,530,000	$2,003,900	$770,000	25
Pleasanton Ditch Improvements (low)	$19,900	$26,100	$10,000	0.3
Pleasanton Ditch Improvements (high)	$29,000	$38,000	$14,600	0.5
Luna Ditch Improvements	$15,000	$19,600	$7,500	0.2
Sunset Pipeline (low)	$41,000	$53,700	$20,600	0.7
Sunset pipeline (high)	$122,200	$160,100	$61,500	2
Reclamation Alternative 1	$4,470,200	$5,855,000	$2,250,000	72
Reclamation Alternative 2	$2,529,000	$3,312,400	$1,272,700	41
Reclamation Alternative 3	$2,687,100	$3,519,500	$1,352,300	43
Greenwood Reservoir	$1,560,400	$2,043,000	$785,000	25
Winn Reservoir	$780,000	$1,022,000	$393,000	13
Spar Reservoir	$990,000	$1,297,000	$498,000	16
Pope Reservoir	$1,690,000	$2,213,000	$851,000	27
Dam Reservoir	$1,910,000	$2,501,600	$961,200	31

The IMPLAN model provides model year data for economic conditions in the impact region. According to IMPLAN baseline data for the four county region, gross regional product was approximately $2.28 billion, labor income was about $1.30 billion, and total employment was 27,400 jobs. Gross regional product is comparable to the value of output.

The Southwest New Mexico Regional Water Supply proposal, or Deming Surface Water Diversion proposal, has the highest one-time construction cost impact of the Tier-2 proposals which is equivalent to approximately 12% of gross regional product in one year, 7.3% of one year of income, and 10.9% of employment in one year. The Reclamation Alternative 1 has a one-time construction cost impact equal to approximately 16% of gross regional product in one year, 9.7% of one year of income, and 14.5% of employment in one year. These impacts are significant, but it needs to be stressed that the impacts represent very short-term one time impacts. The longer term impacts presented in Tables V-33 and V-34 represent impacts are much less than 1% of annual output, income, and employment in the region. For example, annual OM&R impacts from the Southwest New Mexico Regional Water Supply proposal represent about 0.36% of annual gross regional product. In summary, the larger construction projects would be expected to have noticeable and significant regional impacts during the 1 to 4 year construction period, but the long term impacts will be quite small.

Regional Impact Results from Agricultural Production and Increased Recreation

The estimated regional impacts from agricultural output and recreation associated with the project proposals is based on the agricultural revenue and recreation expenditure estimates presented above and the estimates of irrigation water supply and recreation visitation provided by each project proposal. The gross revenue and expenditure data are then input into IMPLAN to estimate annual regional impacts associated with project output. The estimates of revenues and expenditures for each proposal are presented in Table V-35.

Table V-35. - Impacts of project proposals on agricultural revenue and recreation expenditures

Proposal/Reclamation Alternative	Agricultural output		Recreation	
	Acre-feet	Estimate annual gross crop revenue	Estimated annual visits	Estimated Expenditures
GCWC Infrastructure and Reuse	NA	NA	NA	NA
Grant County Recharge and Reservoir	NA	NA	3,200	$320,000
Deming Wastewater Reuse	NA	NA	NA	NA
SW New Mexico Regional Water Supply	5,000	$1,830,000	34,200	$3,420,000
GBIC Diversion and Storage	1,000 -14,000	$366,000 - $5,124,000	NA	NA
Hidalgo County Off-Stream	6,500	$2,379,000	6,400	$640,000
GCC Municipal Conservation	NA	NA	NA	NA
Pleasanton Ditch Improvements	1,480-1,670	$541,700 - $611,200	NA	NA
Luna Ditch Improvements	419	$153,400	NA	NA
Sunset/New Mexico New Model Pipeline	2,040-2,950	$746,600 - $1,079,700	NA	NA
San Francisco Watershed Restoration	2,000	$732,000	NA	NA
NMFIA Watershed Restoration	173	$63,300	NA	NA
NMSU Watershed Restoration	300	$109,800	NA	NA
GSWCD Forest Restoration	NA	NA	NA	NA
USFS Watershed Restoration	NA	NA	NA	NA
Reclamation Alternative 1	10,000	$3,660,000	37,200	$3,720,000
Reclamation Alternative 2	10,000	$3,660,000	8,400	$840,000
Reclamation Alternative 3	10,000	$3,660,000	14,300	$1,430,000

Proposal/Reclamation Alternative	Agricultural output		Recreation	
	Acre-feet	Estimate annual gross crop revenue	Estimated annual visits	Estimated Expenditures
Greenwood Reservoir	10,000	$3,660,000	16,800	$1,680,000
Winn Reservoir	2,750	$1,006,500	3,800	$380,000
Spar Reservoir	3,100	$1,134,600	1,300	$130,000
Pope Reservoir	7,900	$2,891,400	7,700	$770,000
Dam Reservoir	9,400	$3,440,400	4,700	$470,000

NA = Water supply impacts are not expected for this activity

For those diversion alternatives where CAP related reimbursement is made, it is assumed that the cost of the reimbursement represents a reduction in regional expenditures that must be subtracted from revenues associated with project output. The reduction in annual expenditures is estimated to equal $146 multiplied by the AF of water diverted for use, ranging from $400,000 to $2.04 million depending on the proposal or alternative. The estimated regional impacts are then presented in Table V- 36.

Table V-36. - Impacts of changes in annual agricultural revenue and recreation expenditures on the regional economy for proposals where changes in spending are estimated

Proposal/Reclamation Alternative	Value of output	Labor income	Number of Jobs
Grant County Recharge and Reservoir	$201,200	$56,400	2
SW New Mexico Regional Water Supply	$972,300	$194,700	13
GBIC Diversion and Storage	$430,100 - $6,021,900	$202,200 -$2,830,600	3 - 48
Hidalgo County Off-Stream	$1,198,500	$676,500	7
Pleasanton Ditch Improvements	$830,400 - $936,900	$433,500 - $489,100	6
Luna Ditch Improvements	$235,200	$122,700	2
Sunset/New Mexico New Model Pipeline	$1,114,500 - $1,655,100	$597,400 - $864,000	8 – 11
San Francisco Watershed Restoration	$1,122,100	$585,700	8
NMFIA Watershed Restoration	$97,000	$50,700	1
NMSU Watershed Restoration	$168,300	$87,900	1
Reclamation Alternative 1	$7,274,500	$2,674,900	57
Reclamation Alternative 2	$5,834,600	$2,271,300	42
Reclamation Alternative 3	$5,463,700	$2,167,300	39
Greenwood Reservoir	$5,991,800	$2,315,400	44
Winn Reservoir	$1,599,200	$623,700	12
Spar Reservoir	$1,616,800	$651,300	11
Pope Reservoir	$4,389,800	$1,734,000	31
Dam Reservoir	$4,939,500	$1,983,200	35

Table V-36 shows that the annual impact on the regional economy of agricultural production and recreation visitation associated with the project proposals ranges from essentially zero to a 0.32% increase in gross regional product, a zero to 0.22% increase in labor income, and a zero to 0.21% increase in employment depending on the proposal or alternative evaluated . The largest regional impact from a non-diversion alternative equals a 0.07% increase in gross regional product, a 0.07% increase in labor income, and a 0.04% increase in employment. The annual regional economic impacts from the proposed projects relative to the regional economy are fairly small, particularly for the non-diversion alternatives.

However, impacts related to M&I water supply output are not included in the regional impact estimates. Therefore, long-term annual impacts from the proposals are likely to be underestimated. The long-term regional impacts shown as a percentage of gross regional product, income and employment are presented in Table V-37.

Table V-37. - Impacts of changes in expenditures as a percentage of gross regional product, income, and employment

Proposal/Reclamation Alternative	Change in value of Output as a percentage Of Gross Regional Output	Change in income as a percentage of regional income	Change in employment as a percentage of regional employment
Grant County Recharge and Reservoir	0.01%	0.00%	0.01%
SW New Mexico Regional Water Supply	0.04%	0.02%	0.05%
GBIC Diversion and Storage	0.02% to 0.26%	0.02% to 0.22%	0.01% to 0.18%
Hidalgo County Off-Stream	0.05%	0.05%	0.03%
Pleasanton Ditch Improvements	0.04%	0.03% to 0.04%	0.02%
Luna Ditch Improvements	0.01%	0.01%	0.01%
Sunset/New Mexico New Model Pipeline	0.05% to 0.07%	0.05% to 0.07%	0.03% to 0.04%
San Francisco Watershed Restoration	0.05%	0.05%	0.03%
NMFIA Watershed Restoration	0.00%	0.00%	0.00%
NMSU Watershed Restoration	0.01%	0.01%	0.00%
Reclamation Alternative 1	0.32%	0.21%	0.21%
Reclamation Alternative 2	0.26%	0.18%	0.15%
Reclamation Alternative 3	0.24%	0.17%	0.14%
Greenwood Reservoir	0.26%	0.18%	0.16%
Winn Reservoir	0.07%	0.05%	0.04%
Spar Reservoir	0.07%	0.05%	0.04%
Pope Reservoir	0.19%	0.13%	0.11%
Dam Reservoir	0.22%	0.15%	0.13%

Role of Financial Feasibility

This evaluation has focused on two specific types of analyses, economic feasibility and regional economic impacts. Economic feasibility is based on a comparison of the benefits and costs associated with a project or plan. Benefits are defined as an improvement in social welfare from providing a good or service while costs represent the value of resources used to produce goods and services, with both measured in dollars. Typically, if the economic benefits of a project are greater than the costs, then the project is considered economically feasible. A regional economic impact analysis is distinct from an analysis of economic feasibility because a regional analysis evaluates the effects on a specific region rather than the effects on all of society (the nation as a whole). Regional economic impacts are measured in terms of changes in regional income, employment, and the value of goods and services in the region.

Another type of analysis that is relevant to a discussion of project feasibility, but is not included as a part of this evaluation, is financial feasibility. An analysis of financial feasibility evaluates the ability of those who benefit from the project to pay for the project. Determining financial feasibility requires knowledge of the

project capital costs and annual costs that need to be repaid, who will be responsible for paying the costs of the project, the proportion of the project costs that will be paid by each of those responsible for payment, the terms of repayment, and how much each of the responsible parties can afford to pay for the project. Project costs may be repaid through monthly user fees, retirement of debt incurred to build the project, tax assessments, or through other funding methods.

If the costs that need to be repaid for a project are less than the ability to pay of the project beneficiaries, then the project is considered financially feasible. If required repayment is greater than ability to pay, then the project would not be considered financially feasible. If project costs are determined to be greater than the ability of water users to pay for a project, then imposing the cost of project repayment will result in financial hardship to water users. A study by the American Water Works Association (AWWA) evaluated future drinking water infrastructure needs and identified affordability as the primary challenge in meeting infrastructure needs and identified the existence of an affordability gap, which is the difference between what needs to be spent on infrastructure and what water users can actually afford (AWWA, 2001).

The repayment arrangements associated with any potential Tier 2 project are unknown at this time. Typically the determination of repayment would be based on an analysis of the benefits that would accrue to different types of project purposes, the project costs associated with facilities that generate the different types of benefits and combinations of benefits, identification of the different groups benefiting from the projects, and allocating costs to those groups based on the benefits received from the project. However, the process that would be implemented to allocate costs to project beneficiaries and the costs that would need to be allocated are not known, so financial feasibility cannot be evaluated at this time.

Summary and Caveats

This analysis presents appraisal level estimates of the benefits, costs, and regional impacts for 15 AWSA Tier-2 proposals and eight possible storage alternatives evaluated by the Bureau of Reclamation. It is very important to recognize that not all of the benefits and costs that could be attributed to each proposal or alternative have been quantified. One reason for the lack of quantification in some cases is the unknown effect of a proposal or alternative on a resource. For example, a watershed restoration project may be expected to have erosion control benefits but the tons of erosion avoided and the extent to which this would affect ecosystem habitats is unknown. Another example could be the potential in-stream flow benefits to fisheries and stream habitats from storage alternatives which could time releases to improve flows during drought periods. As a final example, ecosystem disturbances could occur as a result of facilities being built in sensitive areas. Another reason for the lack of quantification is the unknown link between a resource and economic activity or value. In other words, a proposal may

improve an environmental characteristic, but the extent to which that characteristic supports an activity or provides value to society is unknown.

The categories of benefits that were quantified in this analysis are agricultural production, municipal and industrial water use, and reservoir based recreation. The basis for estimating these benefits is the water supply provided for each of these uses in AF, surface water acreage, or storage volume. Sections on environmental and ecosystem service values were included in this analysis to provide an indicator of the potential magnitude of benefits associated with the unquantified benefit categories. The quantified benefits compared to costs indicate that the high capital, OM&R, and CAP reimbursement costs associated with the large diversion alternatives result in a negative net present value. Most of the reuse, conservation, and watershed restoration also showed negative net benefits. However, the range of net benefits for some of these alternative included positive values.

A regional impact analysis was completed to evaluate the potential effect of each proposal or alternative on income, employment, and the value of output produced in the region. Regional impacts are separate and distinct from economic benefits and cannot be added together to represent project benefits. However, regional impacts are important in understanding the effect of a project on those that are directly impacted. The results of the regional impact analysis indicate that after the initial short-term regional impacts associated with construction, the long-term effects will be fairly minor.

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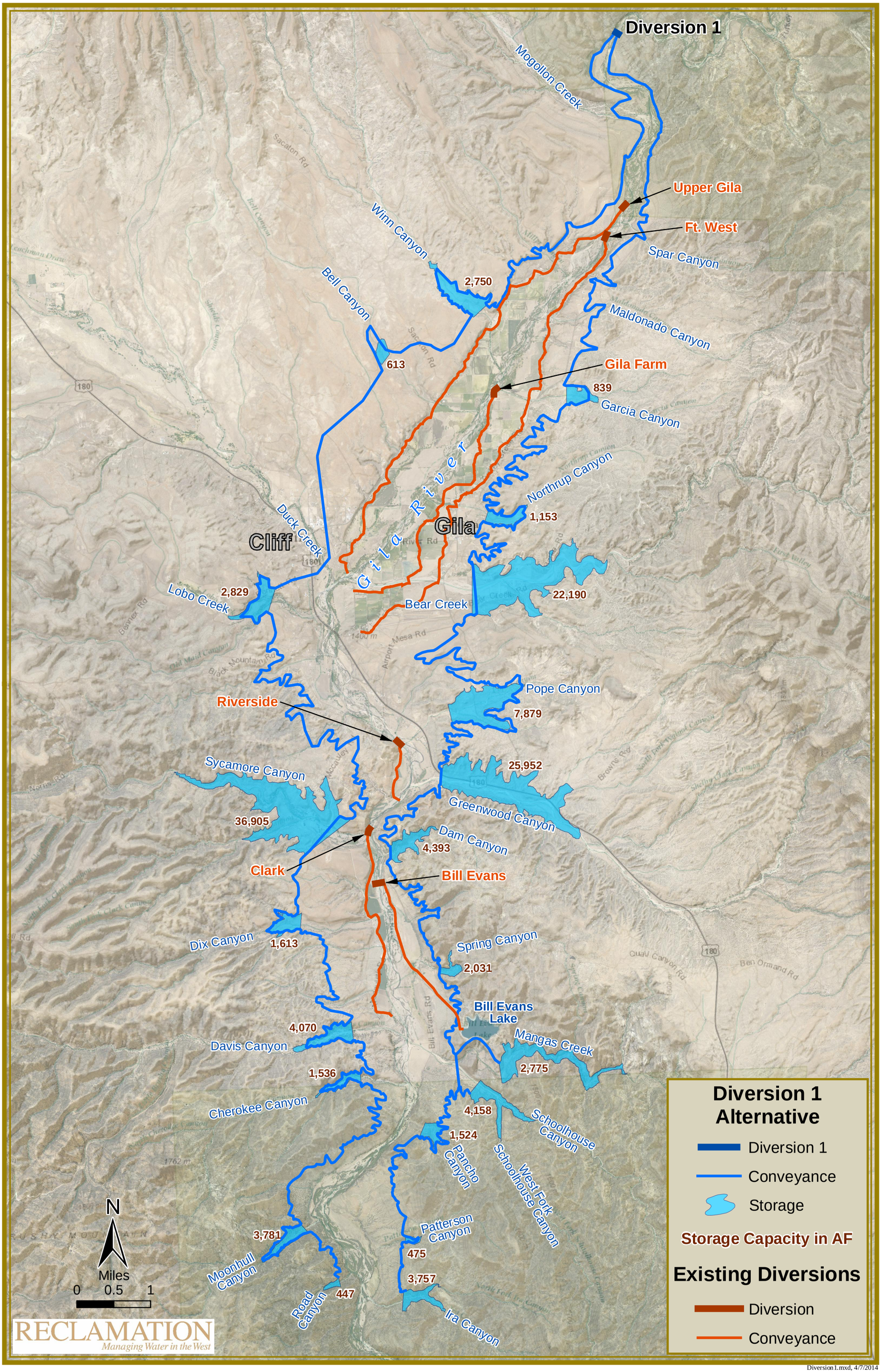
Appendix A – Maps and Storage Reservoir



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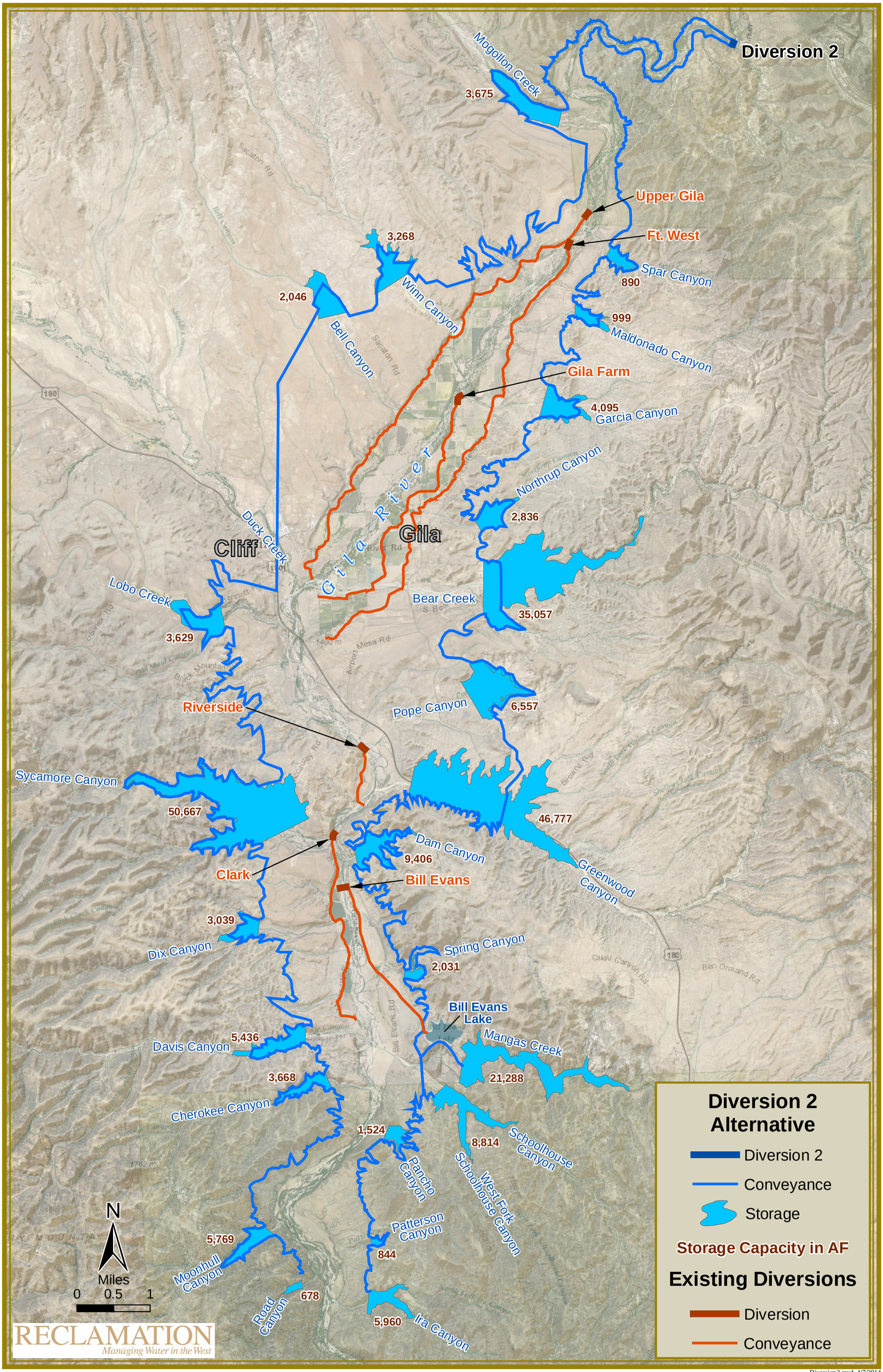

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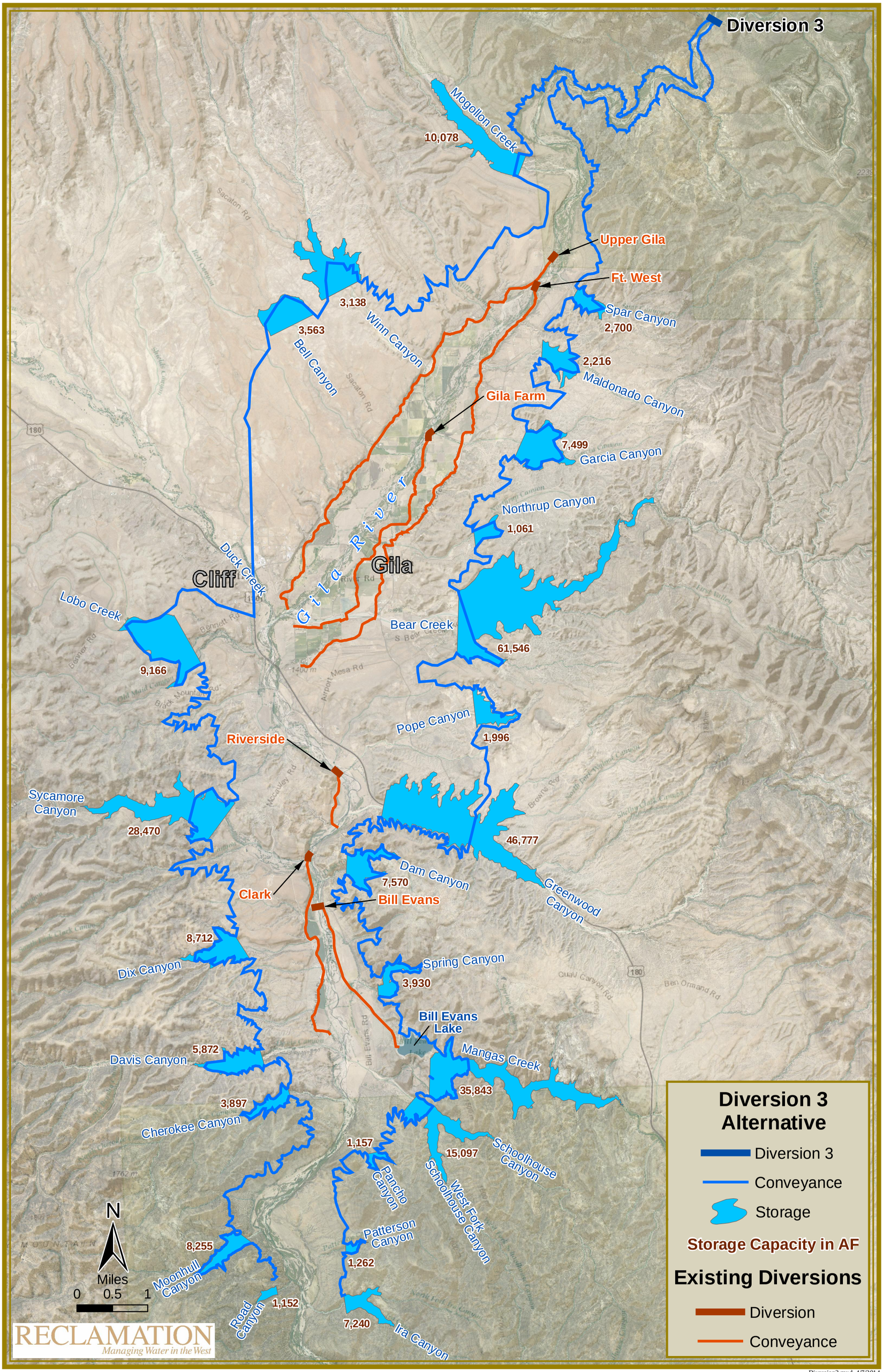

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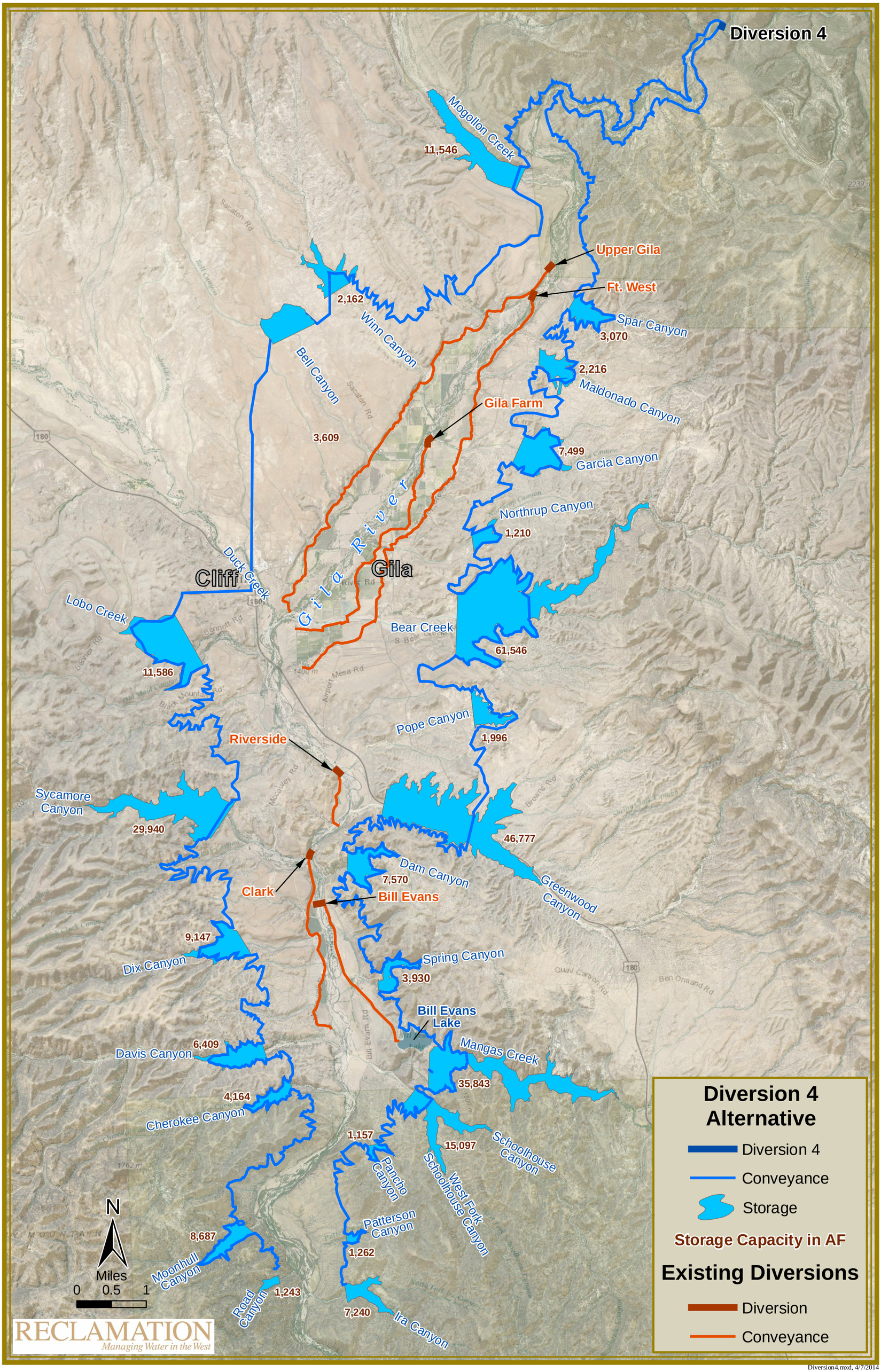

Diversion4.mxd, 4/7/2014

Storage Reservoirs - West of Gila River											
Tributary Name	**Diversion Point**	**Conveyance Length (FT)**	**Elevation Loss (FT)**	**Canal Inlet Invert Elevation (MSL-FT)**	**Dam Crest Elevation (MSL-FT)**	**Storage Volume (AC-FT)**	**Dam Length (FT)**	**Thalweg (MSL-FT)**	**Top of Sediment Elevation (MSL-FT)**	**Height of Dam (FT)**	**Top of Storage (MSL-FT)**
Mogollon Creek[1]	1					0					
	2	28,686	9	4,725	4,738	3,657	1,545	4,660	4,670	78	4,725
	3	40,077	12	4,762	4,775	10,078	2,033	4,664	4,674	111	4,762
	4	41,760	13	4,766	4,779	11,546	2,176	4,664	4,674	115	4,766
Winn Canyon	1	35,393	11	4,657	4,670	2,750	1,502	4,589	4,599	81	4,657
	2	81,421	24	4,710	4,723	2,603	3,268	4,674	4,684	49	4,710
	3	66,967	24	4,750	4,763	3,138	3,317	4,684	4,694	79	4,750
	4	66,796	24	4,755	4,768	2,162	3,869	4,697	4,707	71	4,755
Bell Canyon	1	52,993	16	4,652	4,665	613	1,312	4,592	4,602	73	4,652
	2	95,212	29	4,705	4,718	2,046	2,743	4,659	4,669	59	4,705
	3	87,859	30	4,744	4,757	3,653	4,224	4,685	4,695	72	4,744
	4	88,050	31	4,748	4,761	3,609	4,293	4,690	4,700	71	4,748
Lobo Creek	1	70,541	44	4,624	4,637	2,829	2,200	4,528	4,538	109	4,624
	2	111,738	68	4,666	4,679	3,629	1,953	4,579	4,589	100	4,666
	3	102,332	71	4,703	4,716	9,166	4,837	4,593	4,603	123	4,703
	4	98,732	71	4,708	4,721	11,586	4,946	4,593	4,603	128	4,708
Sycamore Canyon 1	1	118,944	58	4,610	4,623	36,905	4,391	4,437	4,447	186	4,610
	2	174,851	87	4,647	4,660	50,667	4,871	4,450	4,460	210	4,647
	3	150,488	86	4,688	4,701	28,470	3,640	4,498	4,508	203	4,688
	4	144,595	85	4,694	4,707	29,940	3,630	4,503	4,513	204	4,694

Storage Reservoirs - West of Gila River											
Tributary Name	**Diversion Point**	**Conveyance Length (FT)**	**Elevation Loss (FT)**	**Canal Inlet Invert Elevation (MSL-FT)**	**Dam Crest Elevation (MSL-FT)**	**Storage Volume (AC-FT)**	**Dam Length (FT)**	**Thalweg (MSL-FT)**	**Top of Sediment Elevation (MSL-FT)**	**Height of Dam (FT)**	**Top of Storage (MSL-FT)**
Sycamore Canyon 2[2]	1	118,944	58	4,610	4,583	21,494	3,352	4,434	4,444	149	4,570
	2	174,851	87	4,647	4,583	21,494	3,352	4,434	4,444	149	4,570
	3	150,488	86	4,688	4,583	21,494	3,352	4,434	4,444	149	4,570
	4	144,595	85	4,694	4,583	21,494	3,352	4,434	4,444	149	4,570
Dix Canyon 1	1	124,427	67	4,601	4,614	1,613	1,384	4,525	4,535	89	4,601
	2	210,985	97	4,637	4,650	3,039	1,550	4,538	4,548	112	4,637
	3	178,407	98	4,676	4,689	8,712	2,367	4,526	4,536	163	4,676
	4	171,603	99	4,680	4,693	9,147	2,415	4,526	4,536	167	4,680
Dix Canyon 2[2]	1	124,427	67	4,601	4,583	3,570	1,470	4,460	4,470	123	4,570
	2	210,985	97	4,637	4,583	3,570	1,470	4,460	4,470	123	4,570
	3	178,407	98	4,676	4,583	3,570	1,470	4,460	4,470	123	4,570
	4	171,603	99	4,680	4,583	3,570	1,470	4,460	4,470	123	4,570
Davis Canyon	1	144,897	73	4,595	4,608	4,070	1,707	4,475	4,485	133	4,595
	2	234,609	105	4,629	4,642	5,436	1,366	4,496	4,506	146	4,629
	3	209,382	108	4,666	4,679	5,872	1,474	4,534	4,544	145	4,666
	4	204,062	109	4,670	4,683	6,409	1,526	4,535	4,545	148	4,670
Cherokee Canyon	1	158,285	77	4,591	4,604	1,536	820	4,476	4,486	128	4,591
	2	251,275	110	4,624	4,637	3,668	1,303	4,467	4,477	170	4,624
	3	228,261	113	4,661	4,674	3,897	652	4,498	4,508	176	4,661
	4	220,406	114	4,665	4,678	4,164	669	4,498	4,508	180	4,665

Storage Reservoirs - West of Gila River											
Tributary Name	**Diversion Point**	**Conveyance Length (FT)**	**Elevation Loss (FT)**	**Canal Inlet Invert Elevation (MSL-FT)**	**Dam Crest Elevation (MSL-FT)**	**Storage Volume (AC-FT)**	**Dam Length (FT)**	**Thalweg (MSL-FT)**	**Top of Sediment Elevation (MSL-FT)**	**Height of Dam (FT)**	**Top of Storage (MSL-FT)**
Moonhull Canyon	1	189,392	86	4,582	4,595	3,781	865	4,397	4,407	198	4,582
	2	283,938	119	4,615	4,628	5,769	1,051	4,397	4,407	231	4,615
	3	264,574	124	4,650	4,663	8,255	1,158	4,401	4,411	262	4,650
	4	251,169	123	4,656	4,669	8,687	1,177	4,403	4,413	266	4,656
Road Canyon	1	204,267	91	4,577	4,590	447	754	4,446	4,456	144	4,577
	2	299,751	124	4,610	4,623	678	747	4,468	4,478	155	4,610
	3	277,255	128	4,646	4,659	1,152	816	4,483	4,493	176	4,646
	4	267,159	128	4,651	4,664	1,243	826	4,485	4,495	179	4,651

[1] Cannot convey water into the storage reservoir from Diversion 1

[2] Alternate dam site location chosen by analyzing contours

Storage Reservoirs - East of Gila River											
Tributary Name	**Diversion Point**	**Conveyance Length (FT)**	**Elevation Loss (FT)**	**Canal Inlet Invert Elevation (MSL-FT)**	**Dam Crest Elevation (MSL-FT)**	**Storage Volume (AC-FT)**	**Dam Length (FT)**	**Thalweg (MSL-FT)**	**Top of Sediment Elevation (MSL-FT)**	**Height of Dam (FT)**	**Top of Storage (MSL-FT)**
Spar Canyon[1]	1	18,860	6	4,662		0					
	2	38,307	11	4,723	4,736	890	783	4,658	4,668	78	4,723
	3	50,176	15	4,759	4,772	2,700	1,038	4,654	4,664	118	4,759
	4	51,469	15	4,764	4,777	3,070	1,097	4,655	4,665	122	4,764
Maldonado Canyon[1]	1	31,482	9	4,659		0					
	2	54,228	16	4,718	4,731	999	1,339	4,658	4,668	73	4,718
	3	66,429	20	4,754	4,748	2,216	1,478	4,658	4,668	90	4,735
	4	67,026	20	4,759	4,748	2,216	1,478	4,658	4,668	90	4,735
Garcia Canyon	1	40,660	12	4,656	4,669	839	1,464	4,606	4,616	63	4,656
	2	69,752	21	4,713	4,726	4,095	2,838	4,628	4,638	98	4,713
	3	83,624	25	4,749	4,762	7,499	2,648	4,647	4,657	115	4,749
	4	97,341	29	4,750	4,763	7,499	2,648	4,647	4,657	116	4,750
Northrup	1	70,285	21	4,647	4,660	1,153	890	4,577	4,587	83	4,647
	2	95,652	29	4,705	4,718	2,836	1,191	4,613	4,623	105	4,705
	3	109,435	33	4,741	4,754	1,061	1,580	4,677	4,687	77	4,741
	4	118,112	35	4,744	4,757	1,210	1,603	4,677	4,687	80	4,744
Bear Creek	1	91,406	27	4,641	4,654	22,190	4,058	4,539	4,549	115	4,641
	2	109,161	33	4,701	4,714	35,057	3,931	4,575	4,585	139	4,701
	3	120,940	36	4,738	4,751	61,546	4,793	4,578	4,588	173	4,738
	4	129,673	39	4,740	4,753	61,546	4,793	4,578	4,588	175	4,740

Storage Reservoirs - East of Gila River											
Tributary Name	**Diversion Point**	**Conveyance Length (FT)**	**Elevation Loss (FT)**	**Canal Inlet Invert Elevation (MSL-FT)**	**Dam Crest Elevation (MSL-FT)**	**Storage Volume (AC-FT)**	**Dam Length (FT)**	**Thalweg (MSL-FT)**	**Top of Sediment Elevation (MSL-FT)**	**Height of Dam (FT)**	**Top of Storage (MSL-FT)**
Pope Canyon	1	113,750	42	4,626	4,633	7,879	1,498	4,507	4,517	126	4,620
	2	129,860	45	4,689	4,702	6,557	3,241	4,588	4,598	114	4,689
	3	144,038	52	4,722	4,735	1,996	2,969	4,647	4,657	88	4,722
	4	174,675	56	4,723	4,736	1,996	2,969	4,647	4,657	89	4,723
Greenwood Canyon[3]	1	136,600	49	4,619	4,632	25,952	1,412	4,456	4,466	176	4,619
	2	141,786	48	4,686	4,673	46,777	2,083	4,467	4,477	206	4,660
	3	156,407	55	4,719	4,673	46,777	2,083	4,467	4,477	206	4,660
	4	187,270	60	4,719	4,673	46,777	2,083	4,467	4,477	206	4,660
Dam Canyon	1	149,025	56	4,612	4,625	4,393	1,078	4,436	4,446	189	4,612
	2	172,919	62	4,672	4,685	9,406	1,715	4,438	4,448	247	4,672
	3	182,415	69	4,705	4,718	7,570	1,739	4,494	4,504	224	4,705
	4	213,278	74	4,705	4,718	7,570	1,739	4,494	4,504	224	4,705
Spring Canyon[1]	1	166,285	64	4,604							
	2	210,918	74	4,660	4,640	2,031	608	4,481	4,491	159	4,627
	3	218,139	80	4,694	4,680	3,930	757	4,481	4,491	199	4,667
	4	249,002	85	4,694	4,680	3,930	757	4,481	4,491	199	4,667
Mangas Creek	1	191,720	73	4,595	4,608	9,432	1,462	4,472	4,482	136	4,595
	2	241,266	83	4,651	4,664	21,288	1,613	4,472	4,482	192	4,651
	3	241,465	87	4,687	4,700	35,843	2,868	4,473	4,483	227	4,687
	4	272,328	92	4,687	4,700	35,843	2,868	4,473	4,483	227	4,687
Schoolhouse Canyon	1	178,160	74	4,594	4,607	4,158	1,291	4,473	4,483	134	4,594
	2	231,128	86	4,648	4,661	8,814	1,595	4,477	4,487	184	4,648
	3	251,984	92	4,682	4,695	15,097	1,849	4,474	4,484	221	4,682
	4	282,847	97	4,682	4,695	15,097	1,849	4,474	4,484	221	4,682

Storage Reservoirs - East of Gila River											
Tributary Name	**Diversion Point**	**Conveyance Length (FT)**	**Elevation Loss (FT)**	**Canal Inlet Invert Elevation (MSL-FT)**	**Dam Crest Elevation (MSL-FT)**	**Storage Volume (AC-FT)**	**Dam Length (FT)**	**Thalweg (MSL-FT)**	**Top of Sediment Elevation (MSL-FT)**	**Height of Dam (FT)**	**Top of Storage (MSL-FT)**
Pancho Canyon	1	187,290	77	4,591	4,604	1,524	1,086	4,475	4,485	129	4,591
	2	236,908	88	4,646	4,612	1,524	1,086	4,475	4,485	137	4,599
	3	271,430	101	4,673	4,686	1,157	1,036	4,546	4,556	140	4,673
	4	302,293	106	4,673	4,686	1,157	1,036	4,546	4,556	140	4,673
Patterson Canyon	1	201,850	81	4,587	4,600	475	650	4,462	4,472	138	4,587
	2	259,128	95	4,639	4,652	844	742	4,468	4,478	184	4,639
	3	285,755	105	4,669	4,682	1,262	1,001	4,477	4,487	205	4,669
	4	316,618	110	4,669	4,682	1,262	1,001	4,477	4,487	205	4,669
Ira Canyon	1	208,550	83	4,585	4,598	3,757	1,524	4,398	4,408	200	4,585
	2	267,583	97	4,637	4,650	5,960	1,674	4,410	4,420	240	4,637
	3	294,050	107	4,667	4,680	7,240	1,471	4,423	4,433	257	4,667
	4	324,913	112	4,667	4,680	7,240	1,471	4,423	4,433	257	4,667
Mangas Creek	Pumped				4,733	29,444	1,009	4,513	4,523	220	4,720
Virden					3,797	57	690	3,758	3,768	39	3,784

[1] Cannot convey water into the storage reservoir from Diversion 1

[3] Storage elevation is limited by terrain for conveyances from diversion 2,3,and 4

Storage Reservoirs - West of Gila River											
Tributary Name	**Diversion Point**	**Conveyance Length (FT)**	**Elevation Loss (FT)**	**Canal Inlet Invert Elevation (MSL-FT)**	**Dam Crest Elevation (MSL-FT)**	**Storage Volume (AC-FT)**	**Dam Length (FT)**	**Thalweg (MSL-FT)**	**Top of Sediment Elevation (MSL-FT)**	**Height of Dam (FT)**	**Top of Storage (MSL-FT)**
Sycamore Canyon 2[2]	1	118,944	58	4,610	4,583	21,494	3,352	4,434	4,444	149	4,570
	2	174,851	87	4,647	4,583	21,494	3,352	4,434	4,444	149	4,570
	3	150,488	86	4,688	4,583	21,494	3,352	4,434	4,444	149	4,570
	4	144,595	85	4,694	4,583	21,494	3,352	4,434	4,444	149	4,570
Dix Canyon 1	1	124,427	67	4,601	4,614	1,613	1,384	4,525	4,535	89	4,601
	2	210,985	97	4,637	4,650	3,039	1,550	4,538	4,548	112	4,637
	3	178,407	98	4,676	4,689	8,712	2,367	4,526	4,536	163	4,676
	4	171,603	99	4,680	4,693	9,147	2,415	4,526	4,536	167	4,680
Dix Canyon 2[2]	1	124,427	67	4,601	4,583	3,570	1,470	4,460	4,470	123	4,570
	2	210,985	97	4,637	4,583	3,570	1,470	4,460	4,470	123	4,570
	3	178,407	98	4,676	4,583	3,570	1,470	4,460	4,470	123	4,570
	4	171,603	99	4,680	4,583	3,570	1,470	4,460	4,470	123	4,570
Davis Canyon	1	144,897	73	4,595	4,608	4,070	1,707	4,475	4,485	133	4,595
	2	234,609	105	4,629	4,642	5,436	1,366	4,496	4,506	146	4,629
	3	209,382	108	4,666	4,679	5,872	1,474	4,534	4,544	145	4,666
	4	204,062	109	4,670	4,683	6,409	1,526	4,535	4,545	148	4,670
Cherokee Canyon	1	158,285	77	4,591	4,604	1,536	820	4,476	4,486	128	4,591
	2	251,275	110	4,624	4,637	3,668	1,303	4,467	4,477	170	4,624
	3	228,261	113	4,661	4,674	3,897	652	4,498	4,508	176	4,661
	4	220,406	114	4,665	4,678	4,164	669	4,498	4,508	180	4,665

Appendix B – Cost Estimates

- **Gila Basin Irrigation Commission Proposal**
- **City of Deming Proposal**
- **Hidago County Proposal**
- **Bureau of Reclamation Proposal (alternatives)**
- **Miscellaneous Cost Estimates**

Gila Basin Irrigation Commission Proposal

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Downstream Diversion Stucture
GBIC Proposal

PROJECT:
AZ-NM WSA Proposals - Appraisal Level

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Jun-14**

FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[GBIC Diversion Dam Revision.xlsx]Downstream GBIC

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		diversion and care of stream	86-68140		ls		$390,000.00
		concrete in diversion dam	86-68140	2,100	cy	$820.00	$1,722,000.00
		(includes 200,000 lb reinforcement and 592 tons cement)					
		galvanized steel sluice gate, 10' w x 8' h		1	ea	$150,000.00	$150,000.00
		galvanized steel canal gate, 5' w x 6' h		2	ea	$37,000.00	$74,000.00
		Abutments:					
		compacted embankment		70,400	cy	$10.00	$704,000.00
		12 ft tall x 12 ft wide top w/ 2:1 slopes					
		Riprap		8,800	cy	$80.00	$704,000.00
		2 ft thick embankment protection					
		Slurry Wall		4,080	cy	$400.00	$1,632,000.00
		2.5 ft wide by 10 ft deep					
		Subtotal					$5,376,000.00
		Mobilization @ 5%			LS		$269,000.00
		Subtotal w/ Mobilization					$5,645,000.00
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$960,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$350,000.00
		Contract Cost					$6,955,000.00
		Construction Contingencies @ 25%			LS		$1,739,000.00
		Field Cost					$8,694,000.00
		Non- Contract Cost @ 25%			LS		$2,174,000.00
		Construction Cost (Unit Price Level June 2013)					$10,870,000.00

QUANTITIES		**PRICES**	
BY	**CHECKED**	**BY**	**CHECKED**
Henry Corretjer	Jeffrey P. Riley, P.E.	Henry Corretjer	Jeffrey P. Riley, P.E.
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
June, 2014	June, 2014	June, 2014	June, 2014

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Upstream Diversion Stucture
GBIC Proposal

PROJECT:
AZ-NM WSA Proposals - Appraisal Level

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Mar-14**

FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[GBIC Diversion Dam Revision.xlsx]Downstream GBIC

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		diversion and care of stream	86-68140		ls		$390,000.00
		concrete in diversion dam	86-68140	2,100	cy	$820.00	$1,722,000.00
		(includes 200,000 lb reinforcement and 592 tons cement)					
		galvanized steel sluice gate, 10' w x 8' h		1	ea	$150,000.00	$150,000.00
		galvanized steel canal gate, 5' w x 6' h		2	ea	$37,000.00	$74,000.00
		Abutments:					
		compacted embankment		5,600	cy	$10.00	$56,000.00
		12 ft tall x 12 ft wide top w/ 2:1 slopes					
		furnish and install steel sheet piles		1,100	ton	$2,025.00	$2,227,500.00
		350 ft long by 36 ft tall, PZ22					
		ASTM A572, 3/8" min. thickness,					
		min. section modulus = 18 ci/ft of wall					
		Subtotal					$4,620,000.00
		Mobilization @ 5%			LS		$231,000.00
		Subtotal w/ Mobilization					$4,851,000.00
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$825,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$301,000.00
		Contract Cost					$5,977,000.00
		Construction Contingencies @ 25%			LS		$1,494,000.00
		Field Cost					$7,471,000.00
		Non- Contract Cost @ 25%			LS		$1,868,000.00
		Construction Cost (Unit Price Level June 2013)					$9,340,000.00

QUANTITIES		**PRICES**	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED June, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

TIER 2 PROPOSAL - GILA BASIN IRRIGATION COMMISSION (GBIC)
INFILTRATION GALLERY - Collection system for water stored in alluvium.
Discharge up to 12.7 cfs into Gila River upstream of Gila Farm Diversion.

PROJECT: **New Mexico AWSA Tier 2 Proposal Analysis**
Gila Basin Irrigation Commission (GBIC) Proposal

WOID:		**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Nov-13**

FILE: V:\PROJECTS\New Mexico FOIA\GBIC Proposal\GBIC Cost Estimates\[GBIC Infiltration Gallery Collector .xlsx]Template Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		General Sitework					
		Install array of slotted pipe approximately 8 feet deep to collect water					
		within the saturated alluvium. Pipe aligned parallel to the river					
		with 1200ft spacing between pipe. (3 Rows). Pipes are sized					
		to provide optimal flow and reduced cost. System sized to					
		provide 12.7 CFS for diversion at Gila Farm Diversion.					
		Excavation and Trenching					
	1	Fly wheel trencher, 24" wide trench, 9' deep, light soil		15,430	yd^3	$0.55	$8,500.00
	2	Backfill trench, F.E Loader, Wheel Mtd.		15,430	yd^3	$2.00	$31,000.00
		Infiltration Gallery Pipe					
	3	4" Slotted HDPE Pipe, Single Wall		2,240	LF	$2.10	$4,700.00
	4	6" Slotted HDPE Pipe, Single Wall		3,890	LF	$2.70	$10,500.00
	5	8" Slotted HDPE Pipe, Single Wall		6,580	LF	$4.40	$29,000.00
	6	12" Slotted HDPE Pipe, Single Wall		23,530	LF	$7.30	$170,000.00
	7	15" Solid HDPE Pipe, Dual Wall, Smooth inside		27,550	LF	$9.90	$270,000.00
		Vaults and Control Valves					
	8	Vaults		1	LS	$5,000.00	$5,000.00
	9	PVC Control Valves		8	EA	$480.00	$3,800.00
		Subtotal					$530,000.00
		Mobilization @ 5%			LS		$27,000.00
		Subtotal w/ Mobilization					$560,000.00
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$95,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$35,000.00
		Contract Cost					$690,000.00
		Construction Contingencies @ 25%			LS		$175,000.00
		Field Cost					$870,000.00
		Non- Contract Cost @ 25%			LS		$220,000.00
		Construction Cost (Unit Price Level June 2013)					$1,100,000.00

QUANTITIES		**PRICES**	
BY	**CHECKED**	**BY**	**CHECKED**
Henry Corretjer	Jeff Riley, P.E.	Henry Corretjer	Jeff Riley, P.E.
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
11/25/13	12/14/13	11/25/13	12/14/13

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET _ 1_ OF _1 _

FEATURE: TIER 2 PROPOSAL - GILA BASIN IRRIGATION COMMISSION (GBIC) ON-FARM STORAGE PONDS - 10 small storage reservoirs	**PROJECT:** New Mexico AWSA Tier 2 Proposal Analysis Gila Basin Irrigation Commission (GBIC) Proposal
	WOID: ; **ESTIMATE LEVEL:** Appraisal
	REGION: LC ; **UNIT PRICE LEVEL:** Sep-13
	FILE: V:\SHARED\Jeff Riley\Gila Diversion\Appraisal Report\Estimates\GBIC\[GBIC On-Farm Storage Ponds with Lining.xlsx]Template Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		General Sitework					
		Construct 10 storage ponds, each with capacity of approximately					
		30 ac-ft, fed by existing ditches, with slide gates to control flow					
		into the ponds. Stored water will be released into distribution					
		piping or ditches using slide gates.					
		High Density Polyethylene Pipe, 40' lengths					
		18" Pipe (Inlet from Ditch to Basin)		800	LF	$67.00	$54,000.00
		12" Pipe (Outlet from Storage Basin)		800	LF	$41.00	$33,000.00
		Slide Gate, Steel self contained					
		including anchor bolts and grout					
		18" by 18" Inlet Gate		10	Ea	$5,300.00	$53,000.00
		12" by 12" Outlet Gate		10	Ea	$5,100.00	$51,000.00
		"On-Farm" Excavation, 2 Acres X 15' deep					
		10 On-farm storage basins					
		Excavation, Common Earth, Hydraulic, crawler mtd., 3.5 CY Cap.		484,000	CY	$1.30	$630,000.00
		(48400 CY Storage Pond)					
		Pond Membrane Lining, 60 mil thick		939,100	SF	$1.74	$1,630,000.00
		(93910 SF per Pond)					
		Install Pipe					
		18" Pipe Trench, 4' deep					
		Excavation, Common Earth, 4' to 6' Deep, .5 C.Y. Excavator		1,470	CY	$6.00	$8,900.00
		Backfill, F.E. Loader, Wheel Mtd., 1 C.Y. bucket		1,200	CY	$8.00	$9,600.00
		Embedment to OD + 3",		220	CY	$41.00	$9,000.00
		12" Pipe Trench, 4' deep					
		Excavation, Common Earth, 4' to 6' Deep, .5 C.Y. Excavator		1,200	CY	$6.00	$7,200.00
		Backfill, F.E. Loader, Wheel Mtd., 1 C.Y. bucket		1,030	CY	$8.00	$8,200.00
		Embedment to OD + 3",		140	CY	$41.00	$5,700.00
		Concrete Erosion Control at Discharge Points					
		Slab on grade, no finish, 4" thick		160	CY	$185.00	$30,000.00
		Embankment, 3/4 Perimeter Length of Storage Pond					
		8' height, 12' wide top, 2:1 sides, 10 ponds					
		Compacted Embankment, 6" Lifts, 3 passes vibrating roller		54,240	CY	$18.00	$980,000.00
		Subtotal					$2,530,000.00
		Mobilization @ 5%			LS		$126,500.00
		Subtotal w/ Mobilization					$2,700,000.00
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$459,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$167,400.00
		Contract Cost					$3,300,000.00
		Construction Contingencies @ 25%			LS		$825,000.00
		Field Cost					$4,100,000.00
		Non- Contract Cost @ 25%			LS		$1,025,000.00
		Construction Cost (Unit Price Level June 2013)					$5,100,000.00

QUANTITIES		PRICES	
BY Henry Corretjer	**CHECKED** Jeff Riley, P.E.	**BY** Henry Corretjer	**CHECKED** Jeff Riley, P.E.
DATE PREPARED 11/19/13	**PEER REVIEW / DATE** 11/19/13	**DATE PREPARED** 11/19/13	**PEER REVIEW / DATE** 11/19/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
TIER 2 PROPOSAL - GILA BASIN IRRIGATION COMMISSION (GBIC)
ON-FARM STORAGE PONDS - 10 small storage reservoirs

PROJECT: **New Mexico AWSA Tier 2 Proposal Analysis**
Gila Basin Irrigation Commission (GBIC) Proposal

WOID:		**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Sep-13**

FILE: V:\PROJECTS\New Mexico FOIA\GBIC Proposal\GBIC Cost Estimates\[GBIC On-Farm Storage Ponds.xlsx]Template Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		General Sitework					
		Construct 10 storage ponds, each with capacity of approximately					
		30 ac-ft, fed by existing ditches, with slide gates to control flow					
		into the ponds. Stored water will be released into distribution					
		piping or ditches using slide gates.					
		High Density Polyethylene Pipe, 40' lengths					
		18" Pipe (Inlet from Ditch to Basin)		800	LF	$67.00	$54,000.00
		12" Pipe (Outlet from Storage Basin)		800	LF	$41.00	$33,000.00
		Slide Gate, Steel self contained					
		including anchor bolts and grout					
		18" by 18" Inlet Gate		10	Ea	$5,300.00	$53,000.00
		12" by 12" Outlet Gate		10	Ea	$5,100.00	$51,000.00
		"On-Farm" Excavation, 2 Acres X 15' deep					
		10 On-farm storage basins					
		Excavation, Common Earth, Hydraulic, crawler mtd., 3.5 CY Cap.		484,000	CY	$1.30	$630,000.00
		(48400 CY Storage Pond)					
		Install Pipe					
		18" Pipe Trench, 4' deep					
		Excavation, Common Earth, 4' to 6' Deep, .5 C.Y. Excavator		1,470	CY	$6.00	$8,900.00
		Backfill, F.E. Loader, Wheel Mtd., 1 C.Y. bucket		1,200	CY	$8.00	$9,600.00
		Embedment to OD + 3",		220	CY	$41.00	$9,000.00
		12" Pipe Trench, 4' deep					
		Excavation, Common Earth, 4' to 6' Deep, .5 C.Y. Excavator		1,200	CY	$6.00	$7,200.00
		Backfill, F.E. Loader, Wheel Mtd., 1 C.Y. bucket		1,030	CY	$8.00	$8,200.00
		Embedment to OD + 3",		140	CY	$41.00	$5,700.00
		Concrete Erosion Control at Discharge Points					
		Slab on grade, no finish, 4" thick		160	CY	$185.00	$30,000.00
		Embankment, 3/4 Perimeter Length of Storage Pond					
		8' height, 12' wide top, 2:1 sides, 10 ponds					
		Compacted Embankment, 6" Lifts, 3 passes vibrating roller		54,240	CY	$18.00	$980,000.00
		Subtotal					$1,900,000.00
		Mobilization @ 5%			LS		$95,000.00
		Subtotal w/ Mobilization					$2,000,000.00
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$340,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$125,000.00
		Contract Cost					$2,450,000.00
		Construction Contingencies @ 25%			LS		$610,000.00
		Field Cost					$3,050,000.00
		Non- Contract Cost @ 25%			LS		$760,000.00
		Construction Cost (Unit Price Level June 2013)					$3,800,000.00

QUANTITIES		**PRICES**	
BY	**CHECKED**	**BY**	**CHECKED**
Henry Corretjer	Jeff Riley, P.E.	Henry Corretjer	Jeff Riley, P.E.
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
11/19/13	11/19/13	11/19/13	11/19/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _1 _ OF _1 _

FEATURE:
TIER 2 PROPOSAL - GILA BASIN IRRIGATION DISTRICT (GBIC) PIPE RECHARGE SYSTEM - Store diverted Gila River water in unsaturated alluvium in floodplain.

PROJECT: New Mexico AWSA Tier 2 Proposal Analysis
Gila Basin Irrigation Commission (GBIC) Proposal

WOID:		**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Sep-13**
FILE:	V:\PROJECTS\New Mexico FOIA\GBIC Proposal\GBIC Cost Estimates\[GBIC Recharge System.xlsx]Template Sheet 1		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		General Sitework					
		Install array of slotted pipe to recharge water into					
		unsaturated alluvium. Piping mostly placed in farm fields,					
		avoiding roads, residences, etc. 10-foot pipe spacing,					
		4-foot depth.					
		Pipe, HDPE, Perforated					
		4" Pipe		1,524,600	LF	$2.10	$3,200,000.00
		Excavation and Backfill - Pipe Trenching					
		Chain Trencher, 40 H.P. operator riding		1,524,600	LF	$1.40	$2,150,000.00
		8" wide trench and backfill, 48" depth					
		Knife Gate, PVC Body, SS Paddle, 20 PSI Max					
		4" Knife Gate		31	Ea	$100.00	$3,100.00
		Subtotal					$5,350,000.00
		Mobilization @ 5%			LS		$270,000.00
		Subtotal w/ Mobilization					$5,650,000.00
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$960,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$350,000.00
		Contract Cost					$6,950,000.00
		Construction Contingencies @ 25%			LS		$1,750,000.00
		Field Cost					$8,700,000.00
		Non- Contract Cost @ 25%			LS		$2,200,000.00
		Construction Cost (Unit Price Level June 2013)					$10,900,000.00

QUANTITIES		**PRICES**	
BY	**CHECKED**	**BY**	**CHECKED**
Henry Corretjer	Jeff Riley, P.E.	Henry Corretjer	Jeff Riley, P.E.
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
10/25/13	11/19/13	10/25/13	11/19/13

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 1 OF 1

FEATURE:	**PROJECT:** New Mexico AWSA Tier 2 Proposal Analysis Gila Basin Irrigation Commission (GBIC) Proposal
TIER 2 PROPOSAL - GILA BASIN IRRIGATION DISTRICT (GBIC) **RECOVERY WELLS IN LIEU OF INFILTRATION GALLERY** **Cost estimate for one 50-Foot deep water recovery well. 19 wells required to match 12.7 cfs infiltration gallery discharge. Discharge into Gila River or ditches associated with Gila Farm Diversion.**	**WOID:** / **ESTIMATE LEVEL:** Appraisal **REGION:** LC / **UNIT PRICE LEVEL:** **FILE:** V:\PROJECTS\New Mexico FOIA\GBIC Proposal\GBIC Cost Estimates\[GBIC Well.xlsx]Template Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		General Sitework					
		Work Consist of Drilling a 10"-12" hole approximately 50' deep.					
		An 8" casing and 6" pump will be furnished and installed.					
		The design flowrate is 300 gal/min maximum.					
		Drill Rig Charges:					
	1	Rig Mileage		250	miles	$15.00	$3,750.00
	2	Rig Hourly Rate		12	hr	$230.00	$2,760.00
	3	Standby		2	hr	$250.00	$500.00
	4	Crew per diem (3 man)		21	day	$100.00	$2,100.00
	5	Backhoe Rental (mud pit)		1	day	$300.00	$300.00
	6	Water Truck (4000-gal)		1	wk	$2,000.00	$2,000.00
		Mud-Rotary Drilling:					
	6	Drill, Furnish, Install, & Cement min. 14-in. dia. surface casing		20	ft	$250.00	$5,000.00
	7	Drill 6-1/4-in dia. pilot hole, mud-rotary		30	ft	$40.00	$1,200.00
	8	Drill/ream min. 12-1/2-in. dia. hole, mud-rotary		30	ft	$55.00	$1,650.00
		Well Installation:					
	9	Furnish & Install 8-inch dia. wire-wound mild-steel well screen.		20	ft	$40.00	$800.00
	10	Furnish & Install 8-inch dia. mild-steel well casing		30	ft	$20.00	$600.00
	11	Furnish & Install Silica Sand Filter Pack (~12 cf)		1	LS	$900.00	$900.00
	12	Well Development		12	hr	$300.00	$3,600.00
	13	Install Well Pump		8	hr	$250.00	$2,000.00
	14	Pump Test (Specific Capacity)		8	hr	$300.00	$2,400.00
		Wellhead Completion:					
	15	Furnish & Install Standard Concrete Slab & Well Seal		2	yd^3	$600.00	$1,200.00
	16	Reinforcement - Welded Wire Fabric, galvanized (6x6, W2.9xW2.9		36	SF	$0.88	$32.00
		Furnish & Install Wellhead Seal/Cap		1	ea	$500.00	$500.00
		Well Pump:					
	17	3-phase 15-20 hp 6-inch submersible deep well pump		1	ea	$2,600.00	$2,600.00
	18	3-phase 15-20 hp 6-inch motor		1	ea	$2,800.00	$2,800.00
	19	3-inch Schedule 40 Galv. Steel Drop Pipe (T&C)		2	ea	$540.00	$1,080.00
	20	4-wire 10-4 (#10) submersible pump cable		1	ea	$750.00	$750.00
	21	3-inch check valve		1	ea	$340.00	$340.00
	22	15-hp 460V 3 PH Pump Control Panel		1	ea	$1,150.00	$1,150.00
	23	8-inch Well Cap		1	ea	$110.00	$110.00
	24	3-inch pitless adapter		1	ea	$500.00	$500.00
		Subtotal					$41,000.00
		Mobilization @ 5%			LS		$2,050.00
		Subtotal w/ Mobilization					$43,000.00
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$7,300.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$2,700.00
		Contract Cost					$53,000.00
		Construction Contingencies @ 25%			LS		$13,500.00
		Field Cost					$67,000.00
		Non- Contract Cost @ 25%			LS		$17,000.00
		Construction Cost for one well (Unit Price Level June 2013)					$84,000.00

QUANTITIES		PRICES	
BY Brad Prudhom	**CHECKED**	**BY** Brad Prudhom	**CHECKED**
DATE PREPARED 01/06/12	**PEER REVIEW / DATE**	**DATE PREPARED** 01/06/12	**PEER REVIEW / DATE**

City of Deming Proposal

ESTIMATE WORKSHEET

FEATURE:

TIER 2 PROPOSAL - City of Deming
Recovery Wells
Cost estimate for one 50-Foot deep water recovery well. 27 wells required to provide 17.9 cfs into Mangas Reservoir .

PROJECT: **New Mex AWSA Tier 2 Proposal Analysis**
New Mexico Regional Water Supply
(Deming) Proposal

WOID:
ESTIMATE LEVEL: **Appraisal**
REGION: **LC**
UNIT PRICE LEVEL:
FILE: V:\PROJECTS\New Mexico FOIA\Deming Proposal\Deming\[Deming Well Field.xlsx]Template Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		General Sitework					
		Work Consist of Drilling a 10"-12" hole approximately 50' deep.					
		An 8" casing and 6" pump will be furnished and installed.					
		The design flowrate is 300 gal/min maximum.					
		Drill Rig Charges:					
	1	Rig Mileage		250	miles	$15.00	$3,750.00
	2	Rig Hourly Rate		12	hr	$230.00	$2,760.00
	3	Standby		2	hr	$250.00	$500.00
	4	Crew per diem (3 man)		21	day	$100.00	$2,100.00
	5	Backhoe Rental (mud pit)		1	day	$300.00	$300.00
	6	Water Truck (4000-gal)		1	wk	$2,000.00	$2,000.00
		Mud-Rotary Drilling:					
	6	Drill, Furnish, Install, & Cement min. 14-in. dia. surface casing		20	ft	$250.00	$5,000.00
	7	Drill 6-1/4-in dia. pilot hole, mud-rotary		30	ft	$40.00	$1,200.00
	8	Drill/ream min. 12-1/2-in. dia. hole, mud-rotary		30	ft	$55.00	$1,650.00
		Well Installation:					
	9	Furnish & Install 8-inch dia. wire-wound mild-steel well screen.		20	ft	$40.00	$800.00
	10	Furnish & Install 8-inch dia. mild-steel well casing		30	ft	$20.00	$600.00
	11	Furnish & Install Silica Sand Filter Pack (~12 cf)		1	LS	$900.00	$900.00
	12	Well Development		12	hr	$300.00	$3,600.00
	13	Install Well Pump		8	hr	$250.00	$2,000.00
	14	Pump Test (Specific Capacity)		8	hr	$300.00	$2,400.00
		Wellhead Completion:					
	15	Furnish & Install Standard Concrete Slab & Well Seal		2	yd^3	$600.00	$1,200.00
	16	Reinforcement - Welded Wire Fabric, galvanized (6x6, W2.9xW2.9		36	SF	$0.88	$32.00
		Furnish & Install Wellhead Seal/Cap		1	ea	$500.00	$500.00
		Well Pump:					
	17	3-phase 15-20 hp 6-inch submersible deep well pump		1	ea	$2,600.00	$2,600.00
	18	3-phase 15-20 hp 6-inch motor		1	ea	$2,800.00	$2,800.00
	19	3-inch Schedule 40 Galv. Steel Drop Pipe (T&C)		2	ea	$540.00	$1,080.00
	20	4-wire 10-4 (#10) submersible pump cable		1	ea	$750.00	$750.00
	21	3-inch check valve		1	ea	$340.00	$340.00
	22	15-hp 460V 3 PH Pump Control Panel		1	ea	$1,150.00	$1,150.00
	23	8-inch Well Cap		1	ea	$110.00	$110.00
	24	3-inch pitless adapter		1	ea	$500.00	$500.00
		Subtotal					$41,000.00
		Mobilization @ 5%			LS		$2,050.00
		Subtotal w/ Mobilization					$43,000.00
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$7,300.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$2,700.00
		Contract Cost					$53,000.00
		Construction Contingencies @ 25%			LS		$13,500.00
		Field Cost					$67,000.00
		Non- Contract Cost @ 25%			LS		$17,000.00
		Construction Cost for one well (Unit Price Level June 2013)					$84,000.00

QUANTITIES		PRICES	
BY Brad Prudhom	**CHECKED**	**BY** Brad Prudhom	**CHECKED**
DATE PREPARED 01/06/12	**PEER REVIEW / DATE**	**DATE PREPARED** 01/06/12	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Gila River Diversion
Water Treatment Plant

PROJECT:
New Mexico-Arizona Water Settlement Act

WOID: **A252F** | **ESTIMATE LEVEL:** **APPRAISAL**

REGION: | **UNIT PRICE LEVEL:** **Oct-13**

FILE: C:\Users\hcorretjer\Downloads\[Gila WTP costs may 2014.xlsx]Deming WTP-1
Deming WTP-1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	W001	Deming WTP		2,231,850	gpd	$3.00	$6,695,550.00
		2,500 ac ft/yr					
		SUBTOTAL THIS SHEET					**$6,695,550.00**

QUANTITIES		PRICES	
BY Doreen Song	**CHECKED** Jeff Riley	**BY** Doreen Song	**CHECKED** Jeff Riley
DATE PREPARED 05/30/14	**PEER REVIEW / DATE** 05/28/14	**DATE PREPARED** 05/28/14	**PEER REVIEW / DATE** 05/28/14

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:		
Gila River Diversion Water Treatment Plant	AZ-NM WSA Proposals - Appraisal Level		
	WOID: A252F	ESTIMATE LEVEL:	Appraisal
	REGION: LC	UNIT PRICE LEVEL:	Oct-13
	FILE: C:\Users\hcorretjer\Downloads\[Gila WTP costs may 2014.xlsx]Deming WTP-1 Worksheet: Deming WTP-2		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal - Sheet 1					$6,695,550.00
		Subtotal					$6,695,550.00
		Mobilization	5%	+/-	ls		$335,000.00
		Subtotal with Mobilization					$7,030,550.00
		Contract Cost Allowances (Sum of):	17%	+/-	ls		$1,195,000.00
		Design Contingencies, 17% (+/-)					
		APS, 0% (+/-). Type of procurement: Sealed bid, full and open competiton					
		Special Taxes (e.g., TERO, Triba, and/or Gross Receipts):					
		TERO Tax					
		New Mexico Gross Receipts Tax	6.2%				$436,000.00
		CONTRACT COST					$8,661,550.00
		Construction Contingencies	25%				$2,165,000.00
		FIELD COST					$10,826,550.00
		Non-Contract Costs (assumed value)	25%				$2,707,000.00
		CONSTRUCTION COST (Unit Price Level October 2013)					**$13,533,550.00**

QUANTITIES		PRICES	
BY Doreen Song	**CHECKED** Jeff Riley	**BY** Doreen Song	**CHECKED** Jeff Riley
DATE PREPARED 05/30/14	**PEER REVIEW / DATE** 05/28/14	**DATE PREPARED** 05/28/14	**PEER REVIEW / DATE** 05/28/14

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Gila River Diversion
Water Treatment Plant

PROJECT:
New Mexico-Arizona Water Settlement Act

WOID: **A252F** | **ESTIMATE LEVEL:** **APPRAISAL**

REGION: | **UNIT PRICE LEVEL:** **Oct-13**

FILE: C:\Users\hcorretjer\Downloads\[Gila WTP costs may 2014.xlsx]Deming WTP-1
Silver City WTP-1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	W001	Silver Cities/Mining Communities WTP		6,695,550	gpd	$3.00	$20,086,650.00
		7,500 ac ft/yr					
		SUBTOTAL THIS SHEET					**$20,086,650.00**

QUANTITIES		PRICES	
BY Doreen Song	**CHECKED** Jeff Riley	**BY** Doreen Song	**CHECKED** Jeff Riley
DATE PREPARED 05/30/14	**PEER REVIEW / DATE** 05/28/14	**DATE PREPARED** 05/28/14	**PEER REVIEW / DATE** 05/28/14

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Gila River Diversion
Water Treatment Plant

PROJECT:
AZ-NM WSA Proposals - Appraisal Level

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**

FILE: C:\Users\hcorretjer\Downloads\[Gila WTP costs may 2014.xlsx]Deming WTP-1
Worksheet: Silver City WTP-2

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal - Sheet 1					$20,086,650.00
		Subtotal					$20,086,650.00
		Mobilization	5%	+/-	ls		$1,004,000.00
		Subtotal with Mobilization					$21,090,650.00
		Contract Cost Allowances (Sum of):	17%	+/-	ls		$3,585,000.00
		Design Contingencies, 17% (+/-)					
		APS, 0% (+/-). Type of procurement: Sealed bid, full and open competiton					
		Special Taxes (e.g., TERO, Triba, and/or Gross Receipts):					
		TERO Tax					
		New Mexico Gross Receipts Tax	6.2%				$1,308,000.00
		CONTRACT COST					$25,983,650.00
		Construction Contingencies	25%				$6,496,000.00
		FIELD COST					$32,479,650.00
		Non-Contract Costs (assumed value)	25%				$8,120,000.00
		CONSTRUCTION COST (Unit Price Level October 2013)					**$40,599,650.00**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
Doreen Song	Jeff Riley	Doreen Song	Jeff Riley
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
05/30/14	05/28/14	05/28/14	05/28/14

ESTIMATE WORKSHEET

FEATURE: TIER 2 PROPOSAL - CITY OF DEMINIG Part 3 PIPELINE FROM MANGAS CREEK RESERVOIR TO CITY OF DEMING PIPELINE, PUMPING PLANTS, PRV's, AND POWERLINES	**PROJECT:** New Mex AWSA Tier 2 Proposal Analysis New Mexico Regional Water Supply (Deming) Proposal
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION: LC
	UNIT PRICE LEVEL: SEP 13
	FILE: V:\PROJECTS\New Mexico FOIA\Deming Proposal\Deming\[Deming Pipeline.xlsx]Template Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		General Sitework					
		Work consists of installing pipeline from Mangas Creek Reservoir					
		to Deming, NM. Cost estimate includes Excavation, Backfill,					
		Pressure reducing stations, Pumping plants and Power lines.					
		Pipeline, Mortor Lined Steel					
		Cement Lined, Bell and Spigot Joint w/ Gasket					
	1	24" Pipe- Sta. 100+00 - Sta. 2010+23		191,023	LF	$110.00	21,000,000
	2	14" Pipe Sta. 2010+23 - Sta. 3929+80		191,857	LF	$60.00	11,500,000
		Excavation and Backfill					
		60% Rock Assumed					
	3	Excavation, Rock Ripping(55%)		433,154	CY	$25.00	11,000,000
	4	Excation, Rock Blasting(5%)		39,378	CY	$70.00	3,000,000
	5	Excavation, Common Earth (40%), 4' to 6' Deep, .5 C.Y. Excavator		315,021	CY	$6.00	2,000,000
	6	Backfill, F.E. Loader, Wheel Mtd., 1 C.Y. bucket		620,695	CY	$8.00	5,000,000
	7	Embedment to OD + 3",		136,948	CY	$41.00	5,500,000
		Pressure reducing Stations					
	8	In-line PRV, 24" Diameter		1	Ea	$80,000.00	80,000
	9	In-line PRV, 14" Diameter		1	Ea	$46,000.00	46,000
		Pumping Plants (450 ft Head Max)					
		and Supplemental Components					
	10	13.8 cfs		5	Ea	$1,290,000.00	6,500,000
	11	Forebay Tanks, 10' Diameter - 20' Tall		5	Ea	$76,300.00	380,000
	12	Air Chamber Tank, Steel, Spherical, 20' Dia., 5 Required		305,000	LBS	$6.00	2,000,000
	13	Intake at Mangas Reservoir		1	LS	$1,500,000.00	1,500,000
	14	**Power Lines**		10	Mi	$254,000.00	2,500,000
		Subtotal Construction Costs					72,000,000
	15	SCADA systems/controls @ 1%			LS		720,000
	16	Cathodic Protection @ 1%			LS		720,000
	17	Pipeline Crossings @ 2%			LS		1,450,000
		Subtotal					75,000,000
	18	Mobilization @ 5%			LS		3,750,000
		Subtotal w/ Mobilization					$79,000,000.00
		Contract Cost Allowances:					
	19	Design Contigencies @ 17%			LS		$13,500,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$5,000,000.00
	20	**Contract Cost**					$97,500,000.00
		Construction Contingencies @ 25%			LS		$24,000,000.00
		Field Cost					$121,500,000.00
		Lands and Right-of-Way Costs		879	Acre	$5,000.00	$4,395,000.00
		Non- Contract Cost @ 25%			LS		$30,000,000.00
		Construction Cost (Unit Price Level June 2013)					$155,895,000.00

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
HENRY CORRETJER	Jeffrey P. Riley, P.E.	HENRY CORRETJER	Jeffrey P. Riley, P.E.
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
12/24/13	12/24/13	12/24/13	12/24/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	**PROJECT:** New Mex AWSA Tier 2 Proposal Analysis New Mexico Regional Water Supply (Deming) Proposal
TIER 2 PROPOSAL - CITY OF DEMINIG	
Operation, Maintenance, and Replacement (OM&R)	**WOID:** / **ESTIMATE LEVEL:**
	REGION: / **UNIT PRICE LEVEL:**
	FILE: V:\PROJECTS\New Mexico FOIA\Deming Proposal\Deming\[Deming OM&R.xls]Template Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Yearly OM&R estimated costs:					
	1	Diversion dam and conveyance		1	LS	$700,000.00	$700,000.00
	2	Storage dams (Mogollon and Mangas)		1	LS	$2,580,000.00	$2,580,000.00
	3	Wellfield and pipeline		1	LS	$3,000,000.00	$3,000,000.00
		(2.5 % of wellfield and pipeline field costs)					
		Total OM&R yearly cost					**$6,280,000.00**

QUANTITIES		PRICES	
BY Henry Corretjer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED 12/30/13	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:
Gila River Diversion Mogollan Dam Embankment Dam APPRAISAL LEVEL	New Mexico-Arizona Water Settlement Act
	WOID: A252F — ESTIMATE LEVEL: APPRAISAL
	REGION: — UNIT PRICE LEVEL:
	FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates (Autosaved).xlsx]Sycamore 6

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Embankment:					
	S015	a. Excavation - Foundation	86-68313	207,000	yd^3	$7.30	$1,511,100.00
		(Assume 10% rock / 90% common)					
	S016	b. Excavation - Key Trench	86-68313	82,000	yd^3	$18.50	$1,517,000.00
		(Assume 25% rock / 75% common)					
	S017	c. Dewatering - Key Trench	86-68313	1	ls	$570,000.00	$570,000.00
		(1,800-ft line of well points)					
	S018	d. Zone 1 - Fine-grained impervious core	86-68313	427,000	yd^3	$7.10	$3,031,700.00
		(From silt/clay borrow on-site)					
	S019	e. Zone 2 - Sand Filter	86-68313	72,000	yd^3	$54.00	$3,888,000.00
		(From commercial source)					
	S020	f. Zone 3 - Gravel Drain	86-68313	31,000	yd^3	$61.00	$1,891,000.00
		(From commercial source)					
	S021	g. Zone 4 - Miscellaneous Shell Material	86-68313	697,000	yd^3	$6.50	$4,530,500.00
		(From excavation and borrow on-site)					
	S022	h. Riprap Bedding - Gravel and Cobbles	86-68313	17,000	yd^3	$57.00	$969,000.00
		(From commercial source)					
	S023	i. Riprap	86-68313	36,000	yd^3	$86.00	$3,096,000.00
		(From off-site quarry)					
	S024	j. Geocomposite	86-68313	124,000	ft^2	$1.10	$136,400.00
		(Plastic geodrain between two geotextiles, see Red Willow Dam mod)					
	S025	k. Shotcrete	86-68313	36,000	ft^2	$5.90	$212,400.00
		(Sprayed-applied, nonreinforced)					
		l. Blanket Grouting					
	S026	Drilling (10-ft-deep-holes)	86-68313	13,500	lin ft	$29.00	$391,500.00
	S027	Cement (Assume 2 sacks/ft of hole)	86-68313	27,000	sacks	$32.00	$864,000.00
		m. Curtain Grouting					
	S028	Drilling (70-ft-deep-holes)	86-68313	8,100	lin ft	$24.00	$194,400.00
	S029	Cement (Assume 2 sacks/ft of hole)	86-68313	16,000	sacks	$37.00	$592,000.00
	S030	n. Toe Drain	86-68313	1,300	lin ft	$145.00	$188,500.00
		(2-ft dia perforated SDR HDPE pipe)					
	S031	o. Inspection Wells	86-68313	3	ea	$16,500.00	$49,500.00
		(concrete, 6-ft dia., 15-ft deep, w/covers)					
		SUBTOTAL THIS SHEET					**$23,633,000.00**

QUANTITIES		PRICES	
BY Bob Dewey	**CHECKED** Chris Gemperline	**BY**	**CHECKED**
DATE PREPARED 04/02/14	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:
Gila River Diversion Mogollan Dam Embankment Dam APPRAISAL LEVEL	New Mexico-Arizona Water Settlement Act
	WOID: A252F — ESTIMATE LEVEL: APPRAISAL
	REGION: — UNIT PRICE LEVEL:
	FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates (Autosaved).xlsx]Sycamore 6

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal - Sheet 1					$23,633,000.00
		Subtotal - Sheet 2					$54,828,750.00
		Subtotal					**$78,460,000.00**
		Mobilization @ 5%			LS		$3,920,000.00
		Subtotal w/ Mobilization					**$82,380,000.00**
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$14,000,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$5,110,000.00
		Contract Cost					**$101,490,000.00**
		Construction Contingencies @ 25%			LS		$25,370,000.00
		Field Cost					**$126,860,000.00**
		Non- Contract Cost @ 25%			LS		$31,720,000.00
		Construction Cost (Unit Price Level June 2013)					**$158,580,000.00**

QUANTITIES		PRICES	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Gila River Diversion
Mangas Dam
Embankment Dam

PROJECT: New Mexico-Arizona Water Settlement Act

WOID:	A252F	**ESTIMATE LEVEL:**	Appraisal
REGION:	LC	**UNIT PRICE LEVEL:**	Oct-13

FILE: C:\JZ- Files\2013 JWZ Estimates\AWSA - New Mexico\[Total Est- AZ-NM Water Settlement Act- 11-27-13.xlsx]BOR-1-Dmg Sum

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Embankment:					
	D040	a. Excavation - Foundation	86-68313	120,000	yd^3	$7.30	$876,000.00
		(Assume 10% rock / 90% common)					
	D041	b. Excavation - Key Trench	86-68313	43,000	yd^3	$18.50	$795,500.00
		(Assume 25% rock / 75% common)					
	D042	c. Dewatering - Key Trench	86-68313	1	ls	$280,000.00	$280,000.00
		(800-ft line of well points)					
	D043	d. Zone 1 - Fine-grained impervious core	86-68313	230,000	yd^3	$7.10	$1,633,000.00
		(assumes silt/clay borrow within 1 mile, no processing)					
	D044	e. Zone 2 - Sand Filter	86-68313	44,000	yd^3	$54.00	$2,376,000.00
		(From commercial source)					
	D045	f. Zone 3 - Gravel Drain	86-68313	18,000	yd^3	$61.00	$1,098,000.00
		(From commercial source)					
	D046	g. Zone 4 - Miscellaneous Shell Material	86-68313	420,000	yd^3	$6.50	$2,730,000.00
		(From excavation and borrow on-site)					
	D047	h. Riprap Bedding - Gravel and Cobbles	86-68313	9,000	yd^3	$57.00	$513,000.00
		(From commercial source)					
	D048	i. Riprap	86-68313	19,000	yd^3	$86.00	$1,634,000.00
		(From off-site quarry)					
	D049	j. Geocomposite	86-68313	68,000	ft^2	$1.10	$74,800.00
		(Plastic geodrain between two geotextiles, see Red Willow Dam mod)					
	D050	k. Shotcrete	86-68313	25,000	ft^2	$5.90	$147,500.00
		(Sprayed-applied, nonreinforced)					
		l. Blanket Grouting					
	D051	Drilling (10-ft-deep-holes)	86-68313	7,000	lin ft	$29.00	$203,000.00
	D052	Cement (Assume 2 sacks/ft of hole)	86-68313	14,000	sacks	$32.00	$448,000.00
		m. Curtain Grouting					
	D053	Drilling (70-ft-deep-holes)	86-68313	4,600	lin ft	$24.00	$110,400.00
	D054	Cement (Assume 2 sacks/ft of hole)	86-68313	9,100	sacks	$37.00	$336,700.00
	D055	n. Toe Drain	86-68313	600	lin ft	$145.00	$87,000.00
		(2-ft dia perforated SDR HDPE pipe)					
	D056	o. Inspection Wells	86-68313	2	ea	$16,500.00	$33,000.00
		(concrete, 6-ft dia., 15-ft deep, w/covers)					
		SUBTOTAL THIS SHEET					**$13,375,900.00**

QUANTITIES		PRICES	
BY Bob Dewey	**CHECKED** Chris Gemperline	**BY** G. Zander	**CHECKED** MC 11/27/13
DATE PREPARED 08/30/13	**PEER REVIEW / DATE** Chris Gemperline 8/30/13	**DATE PREPARED** 11/27/13	**PEER REVIEW / DATE** DOD for TH 11/27/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _2_ OF _3_ 7

FEATURE:	PROJECT:
Gila River Diversion Mangas Dam Spillway and Outlet Works for Embankment	New Mexico-Arizona Water Settlement Act
	WOID: A252F — ESTIMATE LEVEL: Appraisal
	REGION: LC — UNIT PRICE LEVEL: Oct-13
	FILE: C:\JZ- Files\2013 JWZ Estimates\AWSA - New Mexico\[Total Est- AZ-NM Water Settlement Act- 11-27-13.xlsx]BOR-1-Dmg Sum

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Gated Spillway:					
	D057	a. Excavation	86-68130	330,000	CY	$28.00	$9,240,000.00
		(Assume 90% Rock / 10% Common)					
	D058	b. Concrete	86-68130	20,500	CY	$730.00	$14,965,000.00
		(4,500 psi, includes approach channel,					
		gate house, chute, and stilling basin)					
	D059	c. Reinforcement	86-68130	3,045,000	lbs	$1.45	$4,415,250.00
		(Assumed 150 lbs/cy)					
	D060	d. Two - 50'x50' Fixed Wheel Gates	86-68130	1	LS	$8,800,000.00	$8,800,000.00
		(See Guernsey Dam N. Gated Spillway)					
		(Inc. all controls and metalwork)					
	D061	e. Grout Curtain at Gate Structure	86-68130	800	LF	$70.00	$56,000.00
		(1 Row @ 10' Center @ 50' deep each)					
		(Assume 16 setups, 2" Dia holes, 1 sack/lf cement)					
	D062	f. Rock Bolts - 60ksi, 1" Dia. 30' Long	86-68130	6,900	LF	$59.00	$407,100.00
		(Fully cement grout)					
		(2" Dia. Holes, 1 sack/lf cement)					
		Outlet Works:					
	D063	a. Concrete	86-68130	1,400	CY	$620.00	$868,000.00
		(4,500 psi, includes inlet structure, conduit,					
		gate house structure, and stilling basin)					
	D064	b. Reinforcement	86-68130	210,000	lbs	$1.45	$304,500.00
		(Assumed 150 lbs/cy)					
	D065	c. One - 5'x5' regulating gate	86-68130	1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
	D066	d. One - 5'x5' emergency gate	86-68130	1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
		SUBTOTAL THIS SHEET					**$39,575,850.00**

QUANTITIES		PRICES	
BY Jason Schneider	CHECKED Elisabeth Cohen	BY JZ G. Zander	CHECKED MC 11/28/13
DATE PREPARED 08/26/13	PEER REVIEW / DATE Elisabeth Cohen 8/26/13	DATE PREPARED 11/27/13	PEER REVIEW / DATE DCB for TH 11/27/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Gila River Diversion
Mangas Dam

Summary Sheet

PROJECT:

AZ-NM WSA Proposals - Appraisal Level

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**

FILE: C:\JZ- Files\2013 JWZ Estimates\AZ-NM-Water Settlement Act\[Total Est- AZ-NM Water Settlement Act- 12-16-13.xlsx]BOR-6-SumSht

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal Sheet 1 =					$13,375,900.00
		Subtotal Sheet 2 =					$39,575,850.00
		Subtotal					$52,951,750.00
		Mobilization	5%	+/-			$2,600,000.00
		Subtotal with Mobilization					**$55,551,750.00**
		Contract Cost Allowances (Sum of):	17%	+/-			$9,448,250.00
		Design Contingencies, 17% (+/-)					
		APS, 0% (+/-). Type of procurement: Sealed bid, full and open competition					
		Special Taxes (e.g., TERO, Tribal, and/or Gross Receipts):					
		TERO Tax	0.0%	+/-			$0.00
		New Mexico Gross Receipts Tax	6.2%	+/-			$4,000,000.00
		CONTRACT COST					**$69,000,000.00**
		Construction Contingencies	25%	+/-			$17,000,000.00
		FIELD COST					**$86,000,000.00**
		Non-Contract Costs (assumed value)	25%	+/-			$24,000,000.00
		CONSTRUCTION COST (Unit Price Level October 2013)					**$110,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
See Previous Sheets	See Previous Sheets	G. Zander	12/16/13
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
See Previous Sheets	See Previous Sheets	12/16/13	12/16/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	**PROJECT:** New Mex AWSA Tier 2 Proposal Analysis New Mexico Regional Water Supply (Deming) Proposal
TIER 2 PROPOSAL - CITY OF DEMINIG	
Land Cost	**WOID:** / **ESTIMATE LEVEL:** Appraisal
	REGION: LC / **UNIT PRICE LEVEL:** Dec-13
	FILE: V:\PROJECTS\New Mexico FOIA\Deming Proposal\Deming\[Deming Land Cost.xls]Template Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Land Cost for Reservoir and Canal Alignment					
	1	Mogollon Creek Canal and Reservoir		1	LS	$270,000.00	$270,000.00
	2	Mangas Creek Reservoir		1	LS	$20,000.00	$20,000.00
		Total Land cost					**$290,000.00**

QUANTITIES		PRICES	
BY Henry Corretjer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED 12/30/13	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:	
Gila River Diversion Infiltration Gallery- Bed Mounted 350 cfs	New Mexico-Arizona Water Settlement Act	
	WOID: A252F	ESTIMATE LEVEL: APPRAISAL
	REGION:	UNIT PRICE LEVEL: Oct-13
	FILE: V:\SHARED\Henry Corretjer\Gila River\New Mexico PDFs\Deming Proposal\Deming Cost Estimates\[Infiltration Infiltration Gallery 350 cfs-1	

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Embankment:					
	W001	Excavation	86-68313	303,900	yd^3	$7.30	$2,218,470.00
	W002	Gravel Filter Pack	86-68313	38,800	yd^3	$61.00	$2,366,800.00
		(From commercial source)					
	W003	Backfill	86-68313	253,900	yd^3	$6.50	$1,650,350.00
		(From excavation and borrow on-site)					
	W004	36" Collection pipes	86-68313	42,700	lf	$42.00	$1,793,400.00
		(3-ft dia perforated SDR HDPE pipe)					
		SUBTOTAL THIS SHEET					**$8,029,020.00**

QUANTITIES		PRICES	
BY Henry Corretjer	**CHECKED** Jeff Riley	**BY** Henry Corretjer	**CHECKED** Jeff Riley
DATE PREPARED 05/30/14	**PEER REVIEW / DATE** 02/12/14	**DATE PREPARED** 02/12/14	**PEER REVIEW / DATE** 02/12/14

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Gila River Diversion
Infiltration Gallery- Bed Mounted
350 cfs

PROJECT:
AZ-NM WSA Proposals - Appraisal Level

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**

FILE: V:\SHARED\Henry Corretjer\Gila River\New Mexico PDFs\Deming Proposal\Deming Cost Estimates\[Infiltration gallery cost est 350 115.xlsx]Infiltration Gallery 350 cfs-2
Worksheet: Infiltration Gallery 350 cfs-2

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal - Sheet 1					$8,029,020.00
		Subtotal					$8,029,020.00
		Mobilization	5%	+/-	ls		$401,000.00
		Subtotal with Mobilization					$8,430,020.00
		Contract Cost Allowances (Sum of):	17%	+/-	ls		$1,433,000.00
		Design Contingencies, 17% (+/-)					
		APS, 0% (+/-). Type of procurement: Sealed bid, full and open competiton					
		Special Taxes (e.g., TERO, Triba, and/or Gross Receipts):					
		TERO Tax					
		New Mexico Gross Receipts Tax	6.2%				$523,000.00
		CONTRACT COST					$10,386,020.00
		Construction Contingencies	25%				$2,597,000.00
		FIELD COST					$12,983,020.00
		Non-Contract Costs (assumed value)	25%				$3,246,000.00
		CONSTRUCTION COST (Unit Price Level October 2013)					**$16,229,020.00**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
Henry Corretjer	Jeff Riley	Henry Corretjer	Jeff Riley
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
05/30/14	02/12/14	02/12/14	02/12/14

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Gila River Diversion
Infiltration Gallery- Bed Mounted
115 cfs

PROJECT:
New Mexico-Arizona Water Settlement Act

WOID: A252F | **ESTIMATE LEVEL:** APPRAISAL
REGION: | **UNIT PRICE LEVEL:** Oct-13
FILE: V:\SHARED\Henry Corretjer\Gila River\New Mexico PDFs\Deming Proposal\Deming Cost Estimates\[Infiltration Infiltration Gallery 115 cfs-1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Embankment:					
	W001	Excavation	86-68313	99,900	yd^3	$7.30	$729,270.00
	W002	Gravel Filter Pack	86-68313	12,700	yd^3	$61.00	$774,700.00
		(From commercial source)					
	W003	Backfill	86-68313	83,400	yd^3	$6.50	$542,100.00
		(From excavation and borrow on-site)					
	W004	36" Collection pipes	86-68313	14,000	lf	$42.00	$588,000.00
		(3-ft dia perforated SDR HDPE pipe)					
		SUBTOTAL THIS SHEET					**$2,634,070.00**

QUANTITIES		PRICES	
BY Henry Corretjer	**CHECKED** Jeff Riley	**BY** Henry Corretjer	**CHECKED** Jeff Riley
DATE PREPARED 05/30/14	**PEER REVIEW / DATE** 02/12/14	**DATE PREPARED** 02/12/14	**PEER REVIEW / DATE** 02/12/14

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Gila River Diversion
Infiltration Gallery- Bed Mounted
115 cfs

PROJECT:
AZ-NM WSA Proposals - Appraisal Level

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**

FILE: V:\SHARED\Henry Corretjer\Gila River\New Mexico PDFs\Deming Proposal\Deming Cost Estimates\[Infiltration gallery cost est 350 115.xlsx]Infiltration Gallery 115 cfs-1
Worksheet: Infiltration Gallery 115 cfs-2

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal - Sheet 1					$2,634,070.00
		Subtotal					$2,634,070.00
		Mobilization	5%	+/-	ls		$132,000.00
		Subtotal with Mobilization					$2,766,070.00
		Contract Cost Allowances (Sum of):	17%	+/-	ls		$470,000.00
		Design Contingencies, 17% (+/-)					
		APS, 0% (+/-). Type of procurement: Sealed bid, full and open competiton					
		Special Taxes (e.g., TERO, Triba, and/or Gross Receipts):					
		TERO Tax					
		New Mexico Gross Receipts Tax	6.2%				$171,000.00
		CONTRACT COST					$3,407,070.00
		Construction Contingencies	25%				$852,000.00
		FIELD COST					$4,259,070.00
		Non-Contract Costs (assumed value)	25%				$1,065,000.00
		CONSTRUCTION COST (Unit Price Level October 2013)					**$5,324,070.00**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
Henry Corretjer	Jeff Riley	Henry Corretjer	Jeff Riley
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
05/30/14	02/12/14	02/12/14	02/12/14

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Conveyance Features
Deming Proposal

PROJECT:
AZ-NM WSA Proposals - Appraisal Level

WOID:	A252F	**ESTIMATE LEVEL:**	Appraisal
REGION:	LC	**UNIT PRICE LEVEL:**	Oct-13

FILE: C:\JZ- Files\2013 JWZ Estimates\AWSA - New Mexico\[Total Est- AZ-NM Water Settlement Act- 11-27-13.xlsx]Opt-1-Mngs-Sum

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	D001	diversion and care of stream	86-68140	1	ls	$390,000.00	$390,000.00
	D002	concrete in diversion dam	86-68140	2,100	cy	$820.00	$1,722,000.00
		(includes 200,000 lb reinforcement and 592 tons cement)					
	D003	galvanized steel sluice gate, 10'w x 8'h		1	ea	$150,000.00	$150,000.00
	D004	galvanized steel canal gate, 5'w x 6'h		2	ea	$37,000.00	$74,000.00
		constructing 350 cfs canal to Mogollon canyon					
		(canal length = 28,686 lf)					
	D005	excavation (assumes 90% common, 10% rock)		147,000	cy	$6.60	$970,200.00
	D006	embankments		147,000	cy	$6.90	$1,014,300.00
	D007	compacting embankments		38,000	cy	$3.10	$117,800.00
	D008	trimming		97,000	sy	$6.60	$640,200.00
	D009	unreinf. concrete canal lining		8,400	cy	$320.00	$2,688,000.00
	D010	joints in canal lining		130,000	lf	$1.85	$240,500.00
		culvert (15 ea)					
	D011	concrete in transitions		80	cy	$1,050.00	$84,000.00
		(includes 7,000 lb reinforcement and 23 tons cement)					
	D012	furnishing, laying symbol pipe - 36D25		1,230	lf	$145.00	$178,350.00
		SUBTOTAL THIS SHEET					**$8,269,350.00**

QUANTITIES		PRICES	
BY K. Sayer	**CHECKED** G. Ledezma	**BY** G. Zander	**CHECKED** MC 11/27/13
DATE PREPARED June, 2013	**PEER REVIEW / DATE** Tim Brown 7/25/13	**DATE PREPARED** 11/27/13	**PEER REVIEW / DATE** DCQ 11/27/13 For TH

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Conveyance Features
Deming Proposal

Summary Sheet

PROJECT: AZ-NM WSA Proposals - Appraisal Level

WOID:	A252F	**ESTIMATE LEVEL:**	Appraisal
REGION:	LC	**UNIT PRICE LEVEL:**	Oct-13

FILE: C:\JZ- Files\2013 JWZ Estimates\AZ-NM-Water Settlement Act\[Total Est- AZ-NM Water Settlement Act- 12-16-13.xlsx]BOR-1-Dmg Sum

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal Sheet 1 =					$8,269,350.00
		Subtotal					**$8,269,350.00**
		Mobilization	5%	+/-			$410,000.00
		Subtotal with Mobilization					**$8,679,350.00**
		Contract Cost Allowances (Sum of):	17%	+/-			$1,690,650.00
		Design Contingencies, 17% (+/-)					
		APS, 0% (+/-). Type of procurement: Sealed bid, full and open competition					
		Special Taxes (e.g., TERO, Tribal, and/or Gross Receipts):					
		TERO Tax	0.0%	+/-			$0.00
		New Mexico Gross Receipts Tax	6.2%	+/-			$630,000.00
		CONTRACT COST					**$11,000,000.00**
		Construction Contingencies	25%	+/-			$2,500,000.00
		FIELD COST					**$13,500,000.00**
		Non-Contract Costs (assumed value)	25%	+/-			$3,500,000.00
		CONSTRUCTION COST (Unit Price Level October 2013)					**$17,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY See Previous Sheets	**CHECKED** See Previous Sheets	**BY** G. Zander	**CHECKED** MC 12/16/13
DATE PREPARED See Previous Sheets	**PEER REVIEW / DATE** See Previous Sheets	**DATE PREPARED** 12/16/13	**PEER REVIEW / DATE** 12/16/13

Hidalgo County Proposal

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

TIER 2 PROPOSAL - HIDALGO COUNTY
Virden Dam
Embankment Dam

PROJECT:

New Mexico AWSA Tier 2 Proposal Analysis
Hidalgo County Proposal

WOID: | **ESTIMATE LEVEL:** APPRAISAL

REGION: LC | **UNIT PRICE LEVEL:** Dec-13

FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Embankment:					
		a. Excavation - Foundation		46,600	yd^3	$7.30	$340,180.00
		(Assume 10% rock / 90% common)					
		b. Excavation - Key Trench		43,700	yd^3	$18.50	$808,450.00
		(Assume 25% rock / 75% common)					
		c. Dewatering - Key Trench		1	ls	$250,000.00	$250,000.00
		(700-ft line of well points)					
		d. Zone 1 - Fine-grained impervious core		86,500	yd^3	$7.10	$614,150.00
		(From silt/clay borrow on-site)					
		e. Zone 2 - Sand Filter		20,300	yd^3	$54.00	$1,096,200.00
		(From commercial source)					
		f. Zone 3 - Gravel Drain		5,900	yd^3	$61.00	$359,900.00
		(From commercial source)					
		g. Zone 4 - Miscellaneous Shell Material		53,600	yd^3	$6.50	$348,400.00
		(From excavation and borrow on-site)					
		h. Riprap Bedding - Gravel and Cobbles		3,300	yd^3	$57.00	$188,100.00
		(From commercial source)					
		i. Riprap		7,400	yd^3	$86.00	$636,400.00
		(From off-site quarry)					
		j. Geocomposite		28,900	ft^2	$1.10	$31,790.00
		(Plastic geodrain between two geotextiles, see Red Willow Dam mod)					
		k. Shotcrete		26,200	ft^2	$5.90	$154,580.00
		(Sprayed-applied, nonreinforced)					
		l. Blanket Grouting					
		Drilling (10-ft-deep-holes)		9,700	lin ft	$29.00	$281,300.00
		Cement (Assume 2 sacks/ft of hole)		19,400	sacks	$32.00	$620,800.00
		m. Curtain Grouting					
		Drilling (70-ft-deep-holes)		4,800	lin ft	$24.00	$115,200.00
		Cement (Assume 2 sacks/ft of hole)		9,600	sacks	$37.00	$355,200.00
		n. Toe Drain		700	lin ft	$145.00	$101,500.00
		(2-ft dia perforated SDR HDPE pipe)					
		o. Inspection Wells		2	ea	$16,500.00	$33,000.00
		(concrete, 6-ft dia., 15-ft deep, w/covers)					
SUBTOTAL THIS SHEET							**$6,335,150.00**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
Henry Corretjer	Jeff Riley, P.E.	Henry Corretjer	Jeff Riley, P.E.
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
12/30/13	01/06/14	12/30/13	01/06/14

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:
TIER 2 PROPOSAL - HIDALGO COUNTY Virden Dam Spillway and Outlet Works for Embankment	New Mexico AWSA Tier 2 Proposal Analysis Hidalgo County Proposal
	WOID: / ESTIMATE LEVEL: APPRAISAL
	REGION: LC / UNIT PRICE LEVEL: Dec-13
	FILE: V:\SHARED\Henry Corretjer\Gila River\[Virden Dam Embankment Dam Calculator.xlsx]Summary Sheet

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Uncontrolled Spillway (30 feet wide):					
		a. Excavation		0	CY	$28.00	$0.00
		(Assume 90% Rock / 10% Common)					
		b. Concrete		90	CY	$730.00	$65,700.00
		(4,500 psi, includes approach channel,					
		gate house, chute, and stilling basin)					
		c. Reinforcement		14,000	lbs	$1.45	$20,300.00
		(Assumed 150 lbs/cy)					
		d. Grout Curtain at Gate Structure		150	LF	$70.00	$10,500.00
		(1 Row @ 10' Center @ 50' deep each)					
		(Assume 3 setups, 2" Dia holes, 1 sack/lf cement)					
		Outlet Works:					
		a. Concrete		370	CY	$620.00	$229,400.00
		(4,500 psi, includes inlet structure, conduit,					
		gate house structure, and stilling basin)					
		b. Reinforcement		56,000	lbs	$1.45	$81,200.00
		(Assumed 150 lbs/cy)					
		c. One - 5'x5' regulating gate		1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
		d. One - 5'x5' emergency gate		1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
		SUBTOTAL THIS SHEET					**$927,100.00**

QUANTITIES		PRICES	
BY Henry Corretjer	**CHECKED** Jeff Riley, P.E.	**BY** Henry Corretjer	**CHECKED** Jeff Riley, P.E.
DATE PREPARED 12/30/13	**PEER REVIEW / DATE** 01/06/14	**DATE PREPARED** 12/30/13	**PEER REVIEW / DATE** 01/06/14

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:
TIER 2 PROPOSAL - HIDALGO COUNTY Virden Dam Summary Sheet	New Mexico AWSA Tier 2 Proposal Analysis Hidalgo County Proposal
	WOID: / ESTIMATE LEVEL: APPRAISAL
	REGION: LC / UNIT PRICE LEVEL: Dec-13
	FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal Sheet 1=					$6,335,150.00
		Subtotal Sheet 2=					$927,100.00
		Subtotal					**$7,260,000.00**
		Mobilization @ 5%			LS		$360,000.00
		Subtotal w/ Mobilization					**$7,620,000.00**
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$1,300,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$470,000.00
		Contract Cost					**$9,390,000.00**
		Construction Contingencies @ 25%			LS		$2,350,000.00
		Field Cost					**$11,740,000.00**
		Non- Contract Cost @ 25%			LS		$2,940,000.00
		Construction Cost (Unit Price Level June 2013)					**$14,680,000.00**

QUANTITIES		PRICES	
BY Henry Corretjer	**CHECKED** Jeff Riley, P.E.	**BY** Henry Corretjer	**CHECKED** Jeff Riley, P.E.
DATE PREPARED 12/30/13	**PEER REVIEW / DATE** 01/06/14	**DATE PREPARED** 12/30/13	**PEER REVIEW / DATE** 01/06/14

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	**PROJECT:** New Mex AWSA Tier 2 Proposal Analysis New Mexico Regional Water Supply (Hidalgo) Proposal
TIER 2 PROPOSAL - HIDALGO	
Operation, Maintenance, and Replacement (OM&R)	**WOID:** / **ESTIMATE LEVEL:**
	REGION: / **UNIT PRICE LEVEL:**
	FILE: C:\Users\hcorretjer\Downloads\[Hidalgo OM&R.xls]Template Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Yearly OM&R estimated costs:					
	1	Diversion dam and conveyance		1	LS	$480,000.00	$480,000.00
	2	Storage dams (Schoolhouse and Virden)		1	LS	$1,050,000.00	$1,050,000.00
		Total OM&R yearly cost					**$1,530,000.00**

QUANTITIES		PRICES	
BY Henry Corretjer	**CHECKED** Jeff Riley, P.E.	**BY** Henry Corretjer	**CHECKED** Jeff Riley, P.E.
DATE PREPARED 12/30/13	**PEER REVIEW / DATE** 01/06/14	**DATE PREPARED** 12/30/13	**PEER REVIEW / DATE** 01/06/14

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	**PROJECT:** New Mex AWSA Tier 2 Proposal Analysis New Mexico Regional Water Supply (Hidalgo) Proposal
TIER 2 PROPOSAL - HIDALGO	
Land Cost	**WOID:** / **ESTIMATE LEVEL:** Appraisal
	REGION: LC / **UNIT PRICE LEVEL:** Dec-13
	FILE: C:\Users\hcorretjer\Downloads\[Hidalgo Land Cost.xls]Template Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Land Cost for Reservoir and Canal Alignment					
	1	Schoolhouse Creek Canal and Reservoir		1	LS	$160,000.00	$160,000.00
	2	Virden Creek Reservoir		1	LS	$40,000.00	$40,000.00
		Total Land cost					**$200,000.00**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
Henry Corretjer	Jeff Riley, P.E.	Henry Corretjer	Jeff Riley, P.E.
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
12/30/13	01/06/14	12/30/13	01/06/14

Bureau of Reclamation Proposal (alternatives)

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _1 _ OF _ 1_

FEATURE:

BOR Proposal Summary

PROJECT: **New Mexico-Arizona Water Settlement Act**

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Jun-14**

FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

Worksheet: Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	Conveyance	Diversion Dam	Storage Dam	AMOUNT	OM&R
		Spar	$76,250,000	$4,723,000	$80,610,000	$161,583,000	$987,298
		Winn	$16,410,000	$3,201,200	$63,680,000	$83,291,200	$778,666
		Garcia	$80,950,000	$4,723,000	$122,260,000	$207,933,000	$1,498,226
		Pope	$94,310,000	$3,201,200	$136,500,000	$234,011,200	$1,692,913
		Greenwood	$159,680,000	$3,201,200	$117,630,000	$280,511,200	$1,563,653
		Sycamore	$79,160,000	$3,201,200	$281,240,000	$363,601,200	$3,153,840
		Dam	$161,200,000	$4,723,000	$141,300,000	$307,223,000	$1,909,999
		Sycamore and Greenwood (65000)	$196,380,000	$3,201,200	$398,870,000	$598,451,200	$4,470,481
		Spar and Garcia (10000)	$86,780,000	$4,723,000	$202,870,000	$294,373,000	$2,525,699
		Mogollon and Winn (14000)	$83,900,000	$4,723,000	$218,680,000	$307,303,000	$2,683,799
		SUBTOTAL THIS SHEET					

QUANTITIES		**PRICES**	
BY	**CHECKED**	**BY**	**CHECKED**
Henry Corretjer	Jeffrey Riley	Henry Corretjer	Jeff Riley
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
03/01/14	03/04/14	03/01/14	03/04/14

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Conveyance Features
Sycamore Canyon
Conveyance Features
BOR Option

PROJECT:
New Mexico-Arizona Water Settlement Act

WOID: A252F
ESTIMATE LEVEL:
REGION: LC
UNIT PRICE LEVEL:
FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		constructing 350 cfs canal on west side of Gila river					
		(canal length = 118,950 lf)					
		excavation		540,000	cy	$6.60	$3,564,000.00
		embankments		540,000	cy	$6.90	$3,726,000.00
		compacting embankments		140,000	cy	$3.10	$434,000.00
		trimming		370,000	sy	$6.60	$2,442,000.00
		unreinf. concrete canal lining		32,000	cy	$320.00	$10,240,000.00
		joints in canal lining		490,000	lf	$1.85	$906,500.00
		siphon					
		concrete in transitions		200	cy	$1,050.00	$210,000.00
		(includes 20,000 lb reinforcement and 56 tons cement)					
		furnishing, laying steel pipe, 1.75" wall, cement		2,660	lf	$6,200.00	$16,492,000.00
		mortar lined and coated					
		road crossings (5 ea)					
		concrete		750	cy	$1,050.00	$787,500.00
		(includes 75,000 lb reinforcement and 200 tons cement)					
		culvert (20 ea)					
		concrete in transitions		110	cy	$1,050.00	$115,500.00
		(includes 20,000 lb reinforcement and 70 tons cement)					
		furnishing, laying symbol pipe - 36D25		1,650	lf	$145.00	$239,250.00
		SUBTOTAL THIS SHEET					**$39,156,750.00**

QUANTITIES		PRICES	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:
Conveyance Features Sycamore Canyon Conveyance Features BOR Option	New Mexico-Arizona Water Settlement Act
	WOID: / ESTIMATE LEVEL: APPRAISAL
	REGION: LC / UNIT PRICE LEVEL: Jan-14
	FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal Sheet 1=					$39,156,750.00
		Subtotal					**$39,160,000.00**
		Mobilization @ 5%			LS		$1,960,000.00
		Subtotal w/ Mobilization					**$41,120,000.00**
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$6,990,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$2,550,000.00
		Contract Cost					**$50,660,000.00**
		Construction Contingencies @ 25%			LS		$12,670,000.00
		Field Cost					**$63,330,000.00**
		Non- Contract Cost @ 25%			LS		$15,830,000.00
		Construction Cost (Unit Price Level June 2013)					**$79,160,000.00**

QUANTITIES		PRICES	
BY	CHECKED	BY	CHECKED
DATE PREPARED	PEER REVIEW / DATE	DATE PREPARED	PEER REVIEW / DATE

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Gila River Diversion
Sycamore Canyon
Diversion Features
BOR Proposal

PROJECT:
New Mexico-Arizona Water Settlement Act

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**

FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1
Worksheet: Sycamore 3

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	S011	diversion and care of stream	86-68140	1	ls	$390,000.00	$390,000.00
	S012	concrete in diversion dam	86-68140	910	cy	$820.00	$746,200.00
		(includes 200,000 lb reinforcement and 592 tons cement)					
	S013	galvanized steel sluice gate, 10' w x 8' h		2	ea	$150,000.00	$300,000.00
	S014	galvanized steel canal gate, 5' w x 6' h		4	ea	$37,000.00	$148,000.00
		Subtotal					$1,584,200.00
		Mobilization	5%	+/-	ls		$79,000.00
		Subtotal with Mobilization					$1,663,200.00
		Contract Cost Allowances (Sum of):	17%	+/-	ls		$283,000.00
		Design Contingencies, 17% (+/-)					
		APS, 0% (+/-). Type of procurement: Sealed bid, full and open competiton					
		Special Taxes (e.g., TERO, Triba, and/or Gross Receipts):					
		TERO Tax					
		New Mexico Gross Receipts Tax	6.2%				$103,000.00
		CONTRACT COST					$2,049,200.00
		Construction Contingencies	25%				$512,000.00
		FIELD COST					$2,561,200.00
		Non-Contract Costs (assumed value)	25%				$640,000.00
		CONSTRUCTION COST (Unit Price Level October 2013)					**$3,201,200.00**

QUANTITIES		PRICES	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:	
Gila River Diversion Sycamore Canyon Dam Embankment Dam APPRAISAL LEVEL	New Mexico-Arizona Water Settlement Act	
	WOID: A252F	ESTIMATE LEVEL: APPRAISAL
	REGION:	UNIT PRICE LEVEL: Oct-13
	FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1 Sycamore 4	

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Embankment:					
	S015	a. Excavation - Foundation	86-68313	833,400	yd^3	$7.30	$6,083,820.00
		(Assume 10% rock / 90% common)					
	S016	b. Excavation - Key Trench	86-68313	262,700	yd^3	$18.50	$4,859,950.00
		(Assume 25% rock / 75% common)					
	S017	c. Dewatering - Key Trench	86-68313	1	ls	$570,000.00	$570,000.00
		(5,000-ft line of well points)					
	S018	d. Zone 1 - Fine-grained impervious core	86-68313	1,914,700	yd^3	$7.10	$13,594,370.00
		(From silt/clay borrow on-site)					
	S019	e. Zone 2 - Sand Filter	86-68313	265,700	yd^3	$54.00	$14,347,800.00
		(From commercial source)					
	S020	f. Zone 3 - Gravel Drain	86-68313	133,400	yd^3	$61.00	$8,137,400.00
		(From commercial source)					
	S021	g. Zone 4 - Miscellaneous Shell Material	86-68313	4,280,500	yd^3	$6.50	$27,823,250.00
		(From excavation and borrow on-site)					
	S022	h. Riprap Bedding - Gravel and Cobbles	86-68313	66,000	yd^3	$57.00	$3,762,000.00
		(From commercial source)					
	S023	i. Riprap	86-68313	141,400	yd^3	$86.00	$12,160,400.00
		(From off-site quarry)					
	S024	j. Geocomposite	86-68313	470,900	ft^2	$1.10	$517,990.00
		(Plastic geodrain between two geotextiles, see Red Willow Dam mod)					
	S025	k. Shotcrete	86-68313	163,400	ft^2	$5.90	$964,060.00
		(Sprayed-applied, nonreinforced)					
		l. Blanket Grouting					
	S026	Drilling (10-ft-deep-holes)	86-68313	60,200	lin ft	$29.00	$1,745,800.00
	S027	Cement (Assume 2 sacks/ft of hole)	86-68313	120,400	sacks	$32.00	$3,852,800.00
		m. Curtain Grouting					
	S028	Drilling (70-ft-deep-holes)	86-68313	30,100	lin ft	$24.00	$722,400.00
	S029	Cement (Assume 2 sacks/ft of hole)	86-68313	60,200	sacks	$37.00	$2,227,400.00
	S030	n. Toe Drain	86-68313	3,032	lin ft	$145.00	$439,640.00
		(2-ft dia perforated SDR HDPE pipe)					
	S031	o. Inspection Wells	86-68313	5	ea	$16,500.00	$82,500.00
		(concrete, 6-ft dia., 15-ft deep, w/covers)					
		SUBTOTAL THIS SHEET					**$101,891,580.00**

QUANTITIES		PRICES	
BY Bob Dewey	**CHECKED** Chris Gemperline	**BY**	**CHECKED**
DATE PREPARED 06/27/14	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:
Gila River Diversion Sycamore Creek Dam Spillway and Outlet Works for Embankment APPRAISAL LEVEL	New Mexico-Arizona Water Settlement Act
	WOID: A252F — ESTIMATE LEVEL: APPRAISAL
	REGION: LC Region — UNIT PRICE LEVEL:
	FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Gated Spillway (100 ft wide, 2 gates):					
		a. Excavation	86-68130	270,000	CY	$28.00	$7,560,000.00
		(Assume 90% Rock / 10% Common)					
		b. Concrete	86-68130	19,000	CY	$730.00	$13,870,000.00
		(4,500 psi, includes approach channel,					
		gate house, chute, and stilling basin)					
		c. Reinforcement	86-68130	2,900,000	lbs	$1.45	$4,205,000.00
		(Assumed 150 lbs/cy)					
		d. Two - 50'x50' Fixed Wheel Gates	86-68130	1	LS	$8,800,000.00	$8,800,000.00
		(See Guernsey Dam N. Gated Spillway)					
		(Inc. all controls and metalwork)					
		e. Grout Curtain at Gate Structure	86-68130	500	LF	$70.00	$35,000.00
		(1 Row @ 10' Center @ 50' deep each)					
		(Assume 10 setups, 2" Dia holes, 1 sack/lf cement)					
		f. Rock Bolts - 60ksi, 1" Dia. 30' Long	86-68130	12,500	LF	$59.00	$737,500.00
		(Fully cement grout, 1 bolt per 200 sq ft))					
		(2" Dia. Holes, 1 sack/lf cement)					
		Outlet Works:					
		a. Concrete	86-68130	1,800	CY	$620.00	$1,116,000.00
		(4,500 psi, includes inlet structure, conduit,					
		gate house structure, and stilling basin)					
		b. Reinforcement	86-68130	270,000	lbs	$1.45	$391,500.00
		(Assumed 150 lbs/cy)					
		c. One - 5'x5' regulating gate	86-68130	1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
		d. One - 5'x5' emergency gate	86-68130	1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
		SUBTOTAL THIS SHEET					**$37,235,000.00**

QUANTITIES		PRICES	
BY Carly Stark	**CHECKED** Elisabeth Cohen	**BY**	**CHECKED**
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:			
Gila River Diversion Sycamore Canyon Dam Embankment Dam BOR Proposal	New Mexico-Arizona Water Settlement Act			
	WOID:	A252F	ESTIMATE LEVEL:	Appraisal
	REGION:	LC	UNIT PRICE LEVEL:	Oct-13
	FILE:	V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1 Worksheet: Sycamore 6		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal - Sheet 1					$101,891,580.00
		Subtotal - Sheet 2					$37,235,000.00
		Subtotal					**$139,130,000.00**
		Mobilization @ 5%			LS		$6,960,000.00
		Subtotal w/ Mobilization					**$146,090,000.00**
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$24,840,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$9,060,000.00
		Contract Cost					**$179,990,000.00**
		Construction Contingencies @ 25%			LS		$45,000,000.00
		Field Cost					**$224,990,000.00**
		Non- Contract Cost @ 25%			LS		$56,250,000.00
		Construction Cost (Unit Price Level June 2013)					**$281,240,000.00**

QUANTITIES		PRICES	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Conveyance Features
Dam Canyon
Conveyance Features
BOR Option

PROJECT: **New Mexico-Arizona Water Settlement Act**

WOID: **A252F** **ESTIMATE LEVEL:**

REGION: **LC** **UNIT PRICE LEVEL:**

FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		constructing 350 cfs canal on west side of Gila river					
		(canal length = 179,060 lf)					
		excavation		870,000	cy	$6.60	$5,742,000.00
		embankments		870,000	cy	$6.90	$6,003,000.00
		compacting embankments		230,000	cy	$3.10	$713,000.00
		trimming		590,000	sy	$6.60	$3,894,000.00
		unreinf. concrete canal lining		51,000	cy	$320.00	$16,320,000.00
		joints in canal lining		790,000	lf	$1.85	$1,461,500.00
		Specialized Canal		4,850	lf	$2,600.00	$12,610,000.00
		(Constructing canals on steep hillsides and rock)					
		siphon					
		concrete in transitions		400	cy	$1,050.00	$420,000.00
		(includes 20,000 lb reinforcement and 56 tons cement)					
		furnishing, laying steel pipe, 1.75" wall, cement		5,060	lf	$6,200.00	$31,372,000.00
		mortar lined and coated					
		road crossings (5 ea)					
		concrete		750	cy	$1,050.00	$787,500.00
		(includes 75,000 lb reinforcement and 200 tons cement)					
		culvert (24 ea)					
		concrete in transitions		130	cy	$1,050.00	$136,500.00
		(includes 20,000 lb reinforcement and 70 tons cement)					
		furnishing, laying symbol pipe - 36D25		2,000	lf	$145.00	$290,000.00
		SUBTOTAL THIS SHEET					**$79,749,500.00**

QUANTITIES		PRICES	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Conveyance Features
Dam Canyon
Conveyance Features
BOR Option

PROJECT:
New Mexico-Arizona Water Settlement Act

WOID:
ESTIMATE LEVEL: **APPRAISAL**
REGION: **LC**
UNIT PRICE LEVEL: **Jan-14**
FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal Sheet 1=					$79,749,500.00
		Subtotal					**$79,750,000.00**
		Mobilization @ 5%			LS		$3,990,000.00
		Subtotal w/ Mobilization					**$83,740,000.00**
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$14,240,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$5,190,000.00
		Contract Cost					**$103,170,000.00**
		Construction Contingencies @ 25%			LS		$25,790,000.00
		Field Cost					**$128,960,000.00**
		Non- Contract Cost @ 25%			LS		$32,240,000.00
		Construction Cost (Unit Price Level June 2013)					**$161,200,000.00**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Gila River Diversion
Dam Canyon
Diversion Features
BOR Proposal

PROJECT:

New Mexico-Arizona Water Settlement Act

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**

FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

Worksheet: Dam 3

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	D011	diversion and care of stream	86-68140	1	ls	$390,000.00	$390,000.00
	D012	concrete in diversion dam	86-68140	2,100	cy	$820.00	$1,722,000.00
		(includes 200,000 lb reinforcement and 592 tons cement)					
	D013	galvanized steel sluice gate, 10' w x 8' h		1	ea	$150,000.00	$150,000.00
	D014	galvanized steel canal gate, 5' w x 6' h		2	ea	$37,000.00	$74,000.00
		Subtotal					$2,336,000.00
		Mobilization	5%	+/-	ls		$117,000.00
		Subtotal with Mobilization					$2,453,000.00
		Contract Cost Allowances (Sum of):	17%	+/-	ls		$417,000.00
		Design Contingencies, 17% (+/-)					
		APS, 0% (+/-). Type of procurement: Sealed bid, full and open competiton					
		Special Taxes (e.g., TERO, Triba, and/or Gross Receipts):					
		TERO Tax					
		New Mexico Gross Receipts Tax	6.2%				$152,000.00
		CONTRACT COST					$3,022,000.00
		Construction Contingencies	25%				$756,000.00
		FIELD COST					$3,778,000.00
		Non-Contract Costs (assumed value)	25%				$945,000.00
		CONSTRUCTION COST (Unit Price Level October 2013)					$4,723,000.00

QUANTITIES		**PRICES**	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:	
Gila River Diversion Dam Canyon Dam Embankment Dam APPRAISAL LEVEL	New Mexico-Arizona Water Settlement Act	
	WOID: A252F	ESTIMATE LEVEL: APPRAISAL
	REGION:	UNIT PRICE LEVEL: Oct-13
	FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1 Dam 4	

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Embankment:					
	D015	a. Excavation - Foundation	86-68313	447,900	yd^3	$7.30	$3,269,670.00
		(Assume 10% rock / 90% common)					
	D016	b. Excavation - Key Trench	86-68313	225,500	yd^3	$18.50	$4,171,750.00
		(Assume 25% rock / 75% common)					
	D017	c. Dewatering - Key Trench	86-68313	1	ls	$570,000.00	$570,000.00
		(2,500-ft line of well points)					
	D018	d. Zone 1 - Fine-grained impervious core	86-68313	1,030,400	yd^3	$7.10	$7,315,840.00
		(From silt/clay borrow on-site)					
	D019	e. Zone 2 - Sand Filter	86-68313	134,700	yd^3	$54.00	$7,273,800.00
		(From commercial source)					
	D020	f. Zone 3 - Gravel Drain	86-68313	75,100	yd^3	$61.00	$4,581,100.00
		(From commercial source)					
	D021	g. Zone 4 - Miscellaneous Shell Material	86-68313	2,933,300	yd^3	$6.50	$19,066,450.00
		(From excavation and borrow on-site)					
	D022	h. Riprap Bedding - Gravel and Cobbles	86-68313	36,800	yd^3	$57.00	$2,097,600.00
		(From commercial source)					
	D023	i. Riprap	86-68313	74,800	yd^3	$86.00	$6,432,800.00
		(From off-site quarry)					
	D024	j. Geocomposite	86-68313	205,200	ft^2	$1.10	$225,720.00
		(Plastic geodrain between two geotextiles, see Red Willow Dam mod)					
	D025	k. Shotcrete	86-68313	64,600	ft^2	$5.90	$381,140.00
		(Sprayed-applied, nonreinforced)					
		l. Blanket Grouting					
	D026	Drilling (10-ft-deep-holes)	86-68313	23,800	lin ft	$29.00	$690,200.00
	D027	Cement (Assume 2 sacks/ft of hole)	86-68313	47,600	sacks	$32.00	$1,523,200.00
		m. Curtain Grouting					
	D028	Drilling (70-ft-deep-holes)	86-68313	11,900	lin ft	$24.00	$285,600.00
	D029	Cement (Assume 2 sacks/ft of hole)	86-68313	23,800	sacks	$37.00	$880,600.00
	D030	n. Toe Drain	86-68313	1,895	lin ft	$145.00	$274,775.00
		(2-ft dia perforated SDR HDPE pipe)					
	D031	o. Inspection Wells	86-68313	4	ea	$16,500.00	$66,000.00
		(concrete, 6-ft dia., 15-ft deep, w/covers)					
		SUBTOTAL THIS SHEET					**$59,106,245.00**

QUANTITIES		PRICES	
BY Bob Dewey	**CHECKED** Chris Gemperline	**BY**	**CHECKED**
DATE PREPARED 06/27/14	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:
Gila River Diversion Dam Canyon Dam Spillway and Outlet Works for Embankment APPRAISAL LEVEL	New Mexico-Arizona Water Settlement Act
	WOID: A252F — ESTIMATE LEVEL: APPRAISAL
	REGION: LC Region — UNIT PRICE LEVEL:
	FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Uncontrolled Spillway (135 feet wide):					
		a. Excavation	86-68130	64,000	CY	$28.00	$1,792,000.00
		(Assume 90% Rock / 10% Common)					
		b. Concrete	86-68130	6,700	CY	$730.00	$4,891,000.00
		(4,500 psi, includes approach channel,					
		gate house, chute, and stilling basin)					
		c. Reinforcement	86-68130	1,000,000	lbs	$1.45	$1,450,000.00
		(Assumed 150 lbs/cy)					
		d. Grout Curtain at Gate Structure	86-68130	700	LF	$70.00	$49,000.00
		(1 Row @ 10' Center @ 50' deep each)					
		(Assume 14 setups, 2" Dia holes, 1 sack/lf cement)					
		e. Rock Bolts - 60ksi, 1" Dia. 30' Long	86-68130	4,300	LF	$59.00	$253,700.00
		(Fully cement grout, 1 bolt per 200 sq ft))					
		(2" Dia. Holes, 1 sack/lf cement)					
		Outlet Works:					
		a. Concrete	86-68130	2,200	CY	$620.00	$1,364,000.00
		(4,500 psi, includes inlet structure, conduit,					
		gate house structure, and stilling basin)					
		b. Reinforcement	86-68130	330,000	lbs	$1.45	$478,500.00
		(Assumed 150 lbs/cy)					
		c. One - 5'x5' regulating gate	86-68130	1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
		d. One - 5'x5' emergency gate	86-68130	1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
		SUBTOTAL THIS SHEET					**$10,798,200.00**

QUANTITIES		PRICES	
BY Elisabeth Cohen	**CHECKED** Carly Stark	**BY**	**CHECKED**
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Gila River Diversion
Dam Canyon Dam
Embankment Dam
BOR Proposal

PROJECT:

New Mexico-Arizona Water Settlement Act

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**

FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

Worksheet: Dam 6

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal - Sheet 1					$59,106,245.00
		Subtotal - Sheet 2					$10,798,200.00
		Subtotal					**$69,900,000.00**
		Mobilization @ 5%			LS		$3,500,000.00
		Subtotal w/ Mobilization					**$73,400,000.00**
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$12,480,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$4,550,000.00
		Contract Cost					**$90,430,000.00**
		Construction Contingencies @ 25%			LS		$22,610,000.00
		Field Cost					**$113,040,000.00**
		Non- Contract Cost @ 25%			LS		$28,260,000.00
		Construction Cost (Unit Price Level June 2013)					**$141,300,000.00**

QUANTITIES		**PRICES**	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Conveyance Features
Greenwood Canyon
Conveyance Features
BOR Option

PROJECT:
New Mexico-Arizona Water Settlement Act

WOID: A252F **ESTIMATE LEVEL:**
REGION: LC **UNIT PRICE LEVEL:**
FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		constructing 350 cfs canal on east side of Gila river					
		(canal length = 136,600 lf)					
		excavation		660,000	cy	$6.60	$4,356,000.00
		embankments		660,000	cy	$6.90	$4,554,000.00
		compacting embankments		175,000	cy	$3.10	$542,500.00
		trimming		450,000	sy	$6.60	$2,970,000.00
		unreinf. concrete canal lining		39,000	cy	$320.00	$12,480,000.00
		joints in canal lining		600,000	lf	$1.85	$1,110,000.00
		siphon					
		concrete in transitions		200	cy	$1,050.00	$210,000.00
		(includes 20,000 lb reinforcement and 56 tons cement)					
		furnishing, laying steel pipe, 1.75" wall, cement		3,800	lf	$6,200.00	$23,560,000.00
		mortar lined and coated					
		road crossings (5 ea)					
		concrete		750	cy	$1,050.00	$787,500.00
		(includes 75,000 lb reinforcement and 200 tons cement)					
		culvert (24 ea)					
		concrete in transitions		130	cy	$1,050.00	$136,500.00
		(includes 20,000 lb reinforcement and 70 tons cement)					
		furnishing, laying symbol pipe - 36D25		2,000	lf	$145.00	$290,000.00
		SUBTOTAL THIS SHEET					**$50,996,500.00**

QUANTITIES		PRICES	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:
Conveyance Features Greenwood Canyon Conveyance Features BOR Option	New Mexico-Arizona Water Settlement Act
	WOID: / ESTIMATE LEVEL: APPRAISAL
	REGION: LC / UNIT PRICE LEVEL: Jan-14
	FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Relocate US 180 from Greenwood to Pope canyon					
		New interchange with NM 211		1	lf	$1,000,000.00	$1,000,000.00
		Construct new section of US 180		3	lf	$9,000,000.00	$27,000,000.00
		Subtotal Sheet 1=					$50,996,500.00
		Subtotal					**$79,000,000.00**
		Mobilization @ 5%			LS		$3,950,000.00
		Subtotal w/ Mobilization					**$82,950,000.00**
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$14,100,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$5,140,000.00
		Contract Cost					**$102,190,000.00**
		Construction Contingencies @ 25%			LS		$25,550,000.00
		Field Cost					**$127,740,000.00**
		Non- Contract Cost @ 25%			LS		$31,940,000.00
		Construction Cost (Unit Price Level June 2013)					**$159,680,000.00**

QUANTITIES		PRICES	
BY	CHECKED	BY	CHECKED
DATE PREPARED	PEER REVIEW / DATE	DATE PREPARED	PEER REVIEW / DATE

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Gila River Diversion
Greenwood Canyon
Diversion Features
BOR Proposal

PROJECT:

New Mexico-Arizona Water Settlement Act

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**

FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

Worksheet: Greenwood 3

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	G014	diversion and care of stream	86-68140	1	ls	$390,000.00	$390,000.00
	G015	concrete in diversion dam	86-68140	910	cy	$820.00	$746,200.00
		(includes 200,000 lb reinforcement and 592 tons cement)					
	G016	galvanized steel sluice gate, 10' w x 8' h		2	ea	$150,000.00	$300,000.00
	G017	galvanized steel canal gate, 5' w x 6' h		4	ea	$37,000.00	$148,000.00
		Subtotal					$1,584,200.00
		Mobilization	5%	+/-	ls		$79,000.00
		Subtotal with Mobilization					$1,663,200.00
		Contract Cost Allowances (Sum of):	17%	+/-	ls		$283,000.00
		Design Contingencies, 17% (+/-)					
		APS, 0% (+/-). Type of procurement: Sealed bid, full and open competiton					
		Special Taxes (e.g., TERO, Triba, and/or Gross Receipts):					
		TERO Tax					
		New Mexico Gross Receipts Tax	6.2%				$103,000.00
		CONTRACT COST					$2,049,200.00
		Construction Contingencies	25%				$512,000.00
		FIELD COST					$2,561,200.00
		Non-Contract Costs (assumed value)	25%				$640,000.00
		CONSTRUCTION COST (Unit Price Level October 2013)					**$3,201,200.00**

QUANTITIES		PRICES	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:	
Gila River Diversion Greenwood Canyon Dam Embankment Dam APPRAISAL LEVEL	New Mexico-Arizona Water Settlement Act	
	WOID: A252F	ESTIMATE LEVEL: APPRAISAL
	REGION:	UNIT PRICE LEVEL: Oct-13
	FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1 Greenwood 4	

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Embankment:					
	G018	a. Excavation - Foundation	86-68313	292,200	yd^3	$7.30	$2,133,060.00
		(Assume 10% rock / 90% common)					
	G019	b. Excavation - Key Trench	86-68313	76,300	yd^3	$18.50	$1,411,550.00
		(Assume 25% rock / 75% common)					
	G020	c. Dewatering - Key Trench	86-68313	1	ls	$570,000.00	$570,000.00
		(2,000-ft line of well points)					
	G021	d. Zone 1 - Fine-grained impervious core	86-68313	750,000	yd^3	$7.10	$5,325,000.00
		(From silt/clay borrow on-site)					
	G022	e. Zone 2 - Sand Filter	86-68313	94,700	yd^3	$54.00	$5,113,800.00
		(From commercial source)					
	G023	f. Zone 3 - Gravel Drain	86-68313	51,100	yd^3	$61.00	$3,117,100.00
		(From commercial source)					
	G024	g. Zone 4 - Miscellaneous Shell Material	86-68313	1,695,500	yd^3	$6.50	$11,020,750.00
		(From excavation and borrow on-site)					
	G025	h. Riprap Bedding - Gravel and Cobbles	86-68313	24,400	yd^3	$57.00	$1,390,800.00
		(From commercial source)					
	G026	i. Riprap	86-68313	50,000	yd^3	$86.00	$4,300,000.00
		(From off-site quarry)					
	G027	j. Geocomposite	86-68313	180,300	ft^2	$1.10	$198,330.00
		(Plastic geodrain between two geotextiles, see Red Willow Dam mod)					
	G028	k. Shotcrete	86-68313	53,200	ft^2	$5.90	$313,880.00
		(Sprayed-applied, nonreinforced)					
		l. Blanket Grouting					
	G029	Drilling (10-ft-deep-holes)	86-68313	19,600	lin ft	$29.00	$568,400.00
	G030	Cement (Assume 2 sacks/ft of hole)	86-68313	39,200	sacks	$32.00	$1,254,400.00
		m. Curtain Grouting					
	G031	Drilling (70-ft-deep-holes)	86-68313	9,800	lin ft	$24.00	$235,200.00
	G032	Cement (Assume 2 sacks/ft of hole)	86-68313	19,600	sacks	$37.00	$725,200.00
	G033	n. Toe Drain	86-68313	1,563	lin ft	$145.00	$226,635.00
		(2-ft dia perforated SDR HDPE pipe)					
	G034	o. Inspection Wells	86-68313	4	ea	$16,500.00	$66,000.00
		(concrete, 6-ft dia., 15-ft deep, w/covers)					
		SUBTOTAL THIS SHEET					**$37,970,105.00**

QUANTITIES		PRICES	
BY Bob Dewey	**CHECKED** Chris Gemperline	**BY**	**CHECKED**
DATE PREPARED 06/27/14	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:
Gila River Diversion Greenwood Canyon Spillway and Outlet Works for Embankment APPRAISAL LEVEL	New Mexico-Arizona Water Settlement Act
	WOID: A252F — ESTIMATE LEVEL: APPRAISAL
	REGION: LC Region — UNIT PRICE LEVEL:
	FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Gated Spillway (100 ft wide, 2 gates):					
		a. Excavation	86-68130	53,000	CY	$28.00	$1,484,000.00
		(Assume 90% Rock / 10% Common)					
		b. Concrete	86-68130	8,300	CY	$730.00	$6,059,000.00
		(4,500 psi, includes approach channel,					
		gate house, chute, and stilling basin)					
		c. Reinforcement	86-68130	1,250,000	lbs	$1.45	$1,812,500.00
		(Assumed 150 lbs/cy)					
		d. Two - 50'x50' Fixed Wheel Gates	86-68130	1	LS	$8,800,000.00	$8,800,000.00
		(See Guernsey Dam N. Gated Spillway)					
		(Inc. all controls and metalwork)					
		e. Grout Curtain at Gate Structure	86-68130	500	LF	$70.00	$35,000.00
		(1 Row @ 10' Center @ 50' deep each)					
		(Assume 10 setups, 2" Dia holes, 1 sack/lf cement)					
		f. Rock Bolts - 60ksi, 1" Dia. 30' Long	86-68130	3,600	LF	$59.00	$212,400.00
		(Fully cement grout, 1 bolt per 200 sq ft))					
		(2" Dia. Holes, 1 sack/lf cement)					
		Outlet Works:					
		a. Concrete	86-68130	1,550	CY	$620.00	$961,000.00
		(4,500 psi, includes inlet structure, conduit,					
		gate house structure, and stilling basin)					
		b. Reinforcement	86-68130	230,000	lbs	$1.45	$333,500.00
		(Assumed 150 lbs/cy)					
		c. One - 5'x5' regulating gate	86-68130	1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
		d. One - 5'x5' emergency gate	86-68130	1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
		SUBTOTAL THIS SHEET					**$20,217,400.00**

QUANTITIES		PRICES	
BY Carly Stark	**CHECKED** Elisabeth Cohen	**BY**	**CHECKED**
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Gila River Diversion
Greenwood Canyon Dam
Embankment Dam
BOR Proposal

PROJECT:

New Mexico-Arizona Water Settlement Act

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**

FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

Worksheet: Greenwood 6

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal - Sheet 1					$37,970,105.00
		Subtotal - Sheet 2					$20,217,400.00
		Subtotal					**$58,190,000.00**
		Mobilization @ 5%			LS		$2,910,000.00
		Subtotal w/ Mobilization					**$61,100,000.00**
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$10,390,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$3,790,000.00
		Contract Cost					**$75,280,000.00**
		Construction Contingencies @ 25%			LS		$18,820,000.00
		Field Cost					**$94,100,000.00**
		Non- Contract Cost @ 25%			LS		$23,530,000.00
		Construction Cost (Unit Price Level June 2013)					**$117,630,000.00**

QUANTITIES		PRICES	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:		
Gila River Diversion Garcia Canyon Conveyance Features BOR Proposal	New Mexico-Arizona Water Settlement Act		
	WOID: A252F	ESTIMATE LEVEL:	Appraisal
	REGION: LC	UNIT PRICE LEVEL:	Oct-13
	FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1 Worksheet: Garcia 1		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		constructing 350 cfs canal on east side of Gila river					
		(canal length = 87820 lf)					
	G001	excavation		440,000	cy	$6.60	$2,904,000.00
	G002	embankments		440,000	cy	$6.90	$3,036,000.00
	G003	compacting embankments		115,000	cy	$3.10	$356,500.00
	G004	trimming		300,000	sy	$6.60	$1,980,000.00
	G005	unreinf. concrete canal lining		26,000	cy	$320.00	$8,320,000.00
	G006	joints in canal lining		400,000	lf	$1.85	$740,000.00
		siphons (0 ea)					
		Specialized Canal		8,600	lf	$2,600.00	$22,360,000.00
		(Constructing canals on steep hillsides and rock)					
		road crossings (0 ea)					
		culvert (20 ea)					
	G007	concrete in transitions		110	cy	$1,050.00	$115,500.00
		(includes 8,800 lb reinforcement and 30 tons cement)					
	G008	furnishing, laying symbol pipe - 36D25		1,650	lf	$145.00	$239,250.00
		SUBTOTAL THIS SHEET					**$40,051,250.00**

QUANTITIES		PRICES	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Conveyance Features
Garcia Canyon
Conveyance Features
BOR Option

PROJECT:
New Mexico-Arizona Water Settlement Act

WOID:		**ESTIMATE LEVEL:**	**APPRAISAL**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**
FILE:			

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal Sheet 1=					$40,051,250.00
		Subtotal					**$40,050,000.00**
		Mobilization @ 5%			LS		$2,000,000.00
		Subtotal w/ Mobilization					**$42,050,000.00**
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$7,150,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$2,610,000.00
		Contract Cost					**$51,810,000.00**
		Construction Contingencies @ 25%			LS		$12,950,000.00
		Field Cost					**$64,760,000.00**
		Non- Contract Cost @ 25%			LS		$16,190,000.00
		Construction Cost (Unit Price Level June 2013)					**$80,950,000.00**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Gila River Diversion
Garcia Canyon
Diversion Features
BOR Proposal

PROJECT:

New Mexico-Arizona Water Settlement Act

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**

FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

Worksheet: Garcia 3

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	G009	diversion and care of stream	86-68140		ls	$390,000.00	$390,000.00
	G010	concrete in diversion dam	86-68140	2,100	cy	$820.00	$1,722,000.00
		(includes 200,000 lb reinforcement and 592 tons cement)					
	G011	galvanized steel sluice gate, 10' w x 8' h		1	ea	$150,000.00	$150,000.00
	G012	galvanized steel canal gate, 5' w x 6' h		2	ea	$37,000.00	$74,000.00
		Subtotal					$2,336,000.00
		Mobilization	5%	+/-	ls		$117,000.00
		Subtotal with Mobilization					$2,453,000.00
		Contract Cost Allowances (Sum of):	17%	+/-	ls		$417,000.00
		Design Contingencies, 17% (+/-)					
		APS, 0% (+/-). Type of procurement: Sealed bid, full and open competiton					
		Special Taxes (e.g., TERO, Triba, and/or Gross Receipts):					
		TERO Tax					
		New Mexico Gross Receipts Tax	6.2%				$152,000.00
		CONTRACT COST					$3,022,000.00
		Construction Contingencies	25%				$756,000.00
		FIELD COST					$3,778,000.00
		Non-Contract Costs (assumed value)	25%				$945,000.00
		CONSTRUCTION COST (Unit Price Level October 2013)					**$4,723,000.00**

QUANTITIES		PRICES	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:	
Gila River Diversion Garcia Canyon Dam Embankment Dam APPRAISAL LEVEL	New Mexico-Arizona Water Settlement Act	
	WOID: A252F	ESTIMATE LEVEL: APPRAISAL
	REGION:	UNIT PRICE LEVEL: Oct-13
	FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1 Garcia 4	

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Embankment:					
	G013	a. Excavation - Foundation	86-68313	365,300	yd^3	$7.30	$2,666,690.00
		(Assume 10% rock / 90% common)					
	G014	b. Excavation - Key Trench	86-68313	146,700	yd^3	$18.50	$2,713,950.00
		(Assume 25% rock / 75% common)					
	G015	c. Dewatering - Key Trench	86-68313	1	ls	$570,000.00	$570,000.00
		(4,000-ft line of well points)					
	G016	d. Zone 1 - Fine-grained impervious core	86-68313	686,400	yd^3	$7.10	$4,873,440.00
		(From silt/clay borrow on-site)					
	G017	e. Zone 2 - Sand Filter	86-68313	119,900	yd^3	$54.00	$6,474,600.00
		(From commercial source)					
	G018	f. Zone 3 - Gravel Drain	86-68313	64,400	yd^3	$61.00	$3,928,400.00
		(From commercial source)					
	G019	g. Zone 4 - Miscellaneous Shell Material	86-68313	1,161,500	yd^3	$6.50	$7,549,750.00
		(From excavation and borrow on-site)					
	G020	h. Riprap Bedding - Gravel and Cobbles	86-68313	28,700	yd^3	$57.00	$1,635,900.00
		(From commercial source)					
	G021	i. Riprap	86-68313	60,200	yd^3	$86.00	$5,177,200.00
		(From off-site quarry)					
	G022	j. Geocomposite	86-68313	210,900	ft^2	$1.10	$231,990.00
		(Plastic geodrain between two geotextiles, see Red Willow Dam mod)					
	G023	k. Shotcrete	86-68313	101,800	ft^2	$5.90	$600,620.00
		(Sprayed-applied, nonreinforced)					
		l. Blanket Grouting					
	G024	Drilling (10-ft-deep-holes)	86-68313	37,500	lin ft	$29.00	$1,087,500.00
	G025	Cement (Assume 2 sacks/ft of hole)	86-68313	75,000	sacks	$32.00	$2,400,000.00
		m. Curtain Grouting					
	G026	Drilling (70-ft-deep-holes)	86-68313	18,800	lin ft	$24.00	$451,200.00
	G027	Cement (Assume 2 sacks/ft of hole)	86-68313	37,600	sacks	$37.00	$1,391,200.00
	G028	n. Toe Drain	86-68313	2,441	lin ft	$145.00	$353,945.00
		(2-ft dia perforated SDR HDPE pipe)					
	G029	o. Inspection Wells	86-68313	4	ea	$16,500.00	$66,000.00
		(concrete, 6-ft dia., 15-ft deep, w/covers)					
		SUBTOTAL THIS SHEET					**$42,172,385.00**

QUANTITIES		PRICES	
BY Bob Dewey	**CHECKED** Chris Gemperline	**BY**	**CHECKED**
DATE PREPARED 06/27/14	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:
Gila River Diversion Garcia Canyon Spillway and Outlet Works for Embankment APPRAISAL LEVEL	New Mexico-Arizona Water Settlement Act
	WOID: A252F — ESTIMATE LEVEL: APPRAISAL
	REGION: LC Region — UNIT PRICE LEVEL:
	FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Uncontrolled Spillway (161 feet wide):					
		a. Excavation	86-68130	130,000	CY	$28.00	$3,640,000.00
		(Assume 90% Rock / 10% Common)					
		b. Concrete	86-68130	14,000	CY	$730.00	$10,220,000.00
		(4,500 psi, includes approach channel,					
		gate house, chute, and stilling basin)					
		c. Reinforcement	86-68130	2,100,000	lbs	$1.45	$3,045,000.00
		(Assumed 150 lbs/cy)					
		d. Grout Curtain at Gate Structure	86-68130	800	LF	$70.00	$56,000.00
		(1 Row @ 10' Center @ 50' deep each)					
		(Assume 16 setups, 2" Dia holes, 1 sack/lf cement)					
		e. Rock Bolts - 60ksi, 1" Dia. 30' Long	86-68130	240	LF	$59.00	$14,160.00
		(Fully cement grout, 1 bolt per 200 sq ft))					
		(2" Dia. Holes, 1 sack/lf cement)					
		Outlet Works:					
		a. Concrete	86-68130	980	CY	$620.00	$607,600.00
		(4,500 psi, includes inlet structure, conduit,					
		gate house structure, and stilling basin)					
		b. Reinforcement	86-68130	145,000	lbs	$1.45	$210,250.00
		(Assumed 150 lbs/cy)					
		c. One - 5'x5' regulating gate	86-68130	1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
		d. One - 5'x5' emergency gate	86-68130	1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
		SUBTOTAL THIS SHEET					**$18,313,010.00**

QUANTITIES		PRICES	
BY Carly Stark	**CHECKED** Elisabeth Cohen	**BY**	**CHECKED**
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Gila River Diversion
Garcia Canyon Dam
Embankment Dam
BOR Proposal

PROJECT:

New Mexico-Arizona Water Settlement Act

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**

FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

Worksheet: Garcia 6

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal - Sheet 1					$42,172,385.00
		Subtotal - Sheet 2					$18,313,010.00
		Subtotal					**$60,490,000.00**
		Mobilization @ 5%			LS		$3,020,000.00
		Subtotal w/ Mobilization					**$63,510,000.00**
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$10,800,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$3,940,000.00
		Contract Cost					**$78,250,000.00**
		Construction Contingencies @ 25%			LS		$19,560,000.00
		Field Cost					**$97,810,000.00**
		Non- Contract Cost @ 25%			LS		$24,450,000.00
		Construction Cost (Unit Price Level June 2013)					**$122,260,000.00**

QUANTITIES		**PRICES**	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Conveyance Features
Pope Canyon
Conveyance Features
BOR Option

PROJECT:
New Mexico-Arizona Water Settlement Act

WOID: A252F
ESTIMATE LEVEL:
REGION: LC
UNIT PRICE LEVEL:
FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		constructing 350 cfs canal on west side of Gila river					
		(canal length = 113,750 lf)					
		excavation		552,450	cy	$6.60	$3,646,170.00
		embankments		552,450	cy	$6.90	$3,811,905.00
		compacting embankments		146,050	cy	$3.10	$452,755.00
		trimming		374,650	sy	$6.60	$2,472,690.00
		unreinf. concrete canal lining		32,385	cy	$320.00	$10,363,200.00
		joints in canal lining		501,650	lf	$1.85	$928,052.50
		siphon					
		concrete in transitions		200	cy	$1,050.00	$210,000.00
		(includes 20,000 lb reinforcement and 56 tons cement)					
		furnishing, laying steel pipe, 1.75" wall, cement		3,800	lf	$6,200.00	$23,560,000.00
		mortar lined and coated					
		road crossings (5 ea)					
		concrete		750	cy	$1,050.00	$787,500.00
		(includes 75,000 lb reinforcement and 200 tons cement)					
		culvert (24 ea)					
		concrete in transitions		130	cy	$1,050.00	$136,500.00
		(includes 20,000 lb reinforcement and 70 tons cement)					
		furnishing, laying symbol pipe - 36D25		2,000	lf	$145.00	$290,000.00
		SUBTOTAL THIS SHEET					**$46,658,772.50**

QUANTITIES		PRICES	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Conveyance Features
Pope Canyon
Conveyance Features
BOR Option

PROJECT:
New Mexico-Arizona Water Settlement Act

WOID:
ESTIMATE LEVEL: **APPRAISAL**
REGION: **LC**
UNIT PRICE LEVEL: **Jan-14**
FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal Sheet 1=					$46,658,772.50
		Subtotal					**$46,660,000.00**
		Mobilization @ 5%			LS		$2,330,000.00
		Subtotal w/ Mobilization					**$48,990,000.00**
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$8,330,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$3,040,000.00
		Contract Cost					**$60,360,000.00**
		Construction Contingencies @ 25%			LS		$15,090,000.00
		Field Cost					**$75,450,000.00**
		Non- Contract Cost @ 25%			LS		$18,860,000.00
		Construction Cost (Unit Price Level June 2013)					**$94,310,000.00**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _1 _ OF _1 _

FEATURE:	PROJECT:			
Gila River Diversion Pope Canyon Diversion Features BOR Proposal	New Mexico-Arizona Water Settlement Act			
	WOID:	A252F	ESTIMATE LEVEL:	Appraisal
	REGION:	LC	UNIT PRICE LEVEL:	Oct-13
	FILE:	V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1 Worksheet: Pope 3		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		diversion and care of stream	86-68140	1	ls	$390,000.00	$390,000.00
		concrete in diversion dam	86-68140	910	cy	$820.00	$746,200.00
		(includes 200,000 lb reinforcement and 592 tons cement)					
		galvanized steel sluice gate, 10' w x 8' h		2	ea	$150,000.00	$300,000.00
		galvanized steel canal gate, 5' w x 6' h		4	ea	$37,000.00	$148,000.00
		Subtotal					$1,584,200.00
		Mobilization	5%	+/-	ls		$79,000.00
		Subtotal with Mobilization					$1,663,200.00
		Contract Cost Allowances (Sum of):	17%	+/-	ls		$283,000.00
		Design Contingencies, 17% (+/-)					
		APS, 0% (+/-). Type of procurement: Sealed bid, full and open competiton					
		Special Taxes (e.g., TERO, Triba, and/or Gross Receipts):					
		TERO Tax					
		New Mexico Gross Receipts Tax	6.2%				$103,000.00
		CONTRACT COST					$2,049,200.00
		Construction Contingencies	25%				$512,000.00
		FIELD COST					$2,561,200.00
		Non-Contract Costs (assumed value)	25%				$640,000.00
		CONSTRUCTION COST (Unit Price Level October 2013)					**$3,201,200.00**

QUANTITIES		PRICES	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:	
Gila River Diversion Pope Canyon Dam Embankment Dam BOR Proposal	New Mexico-Arizona Water Settlement Act	
	WOID: A252F	ESTIMATE LEVEL: APPRAISAL
	REGION:	UNIT PRICE LEVEL: Oct-13
	FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1 Pope 4	

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Embankment:					
P015		a. Excavation - Foundation	86-68313	428,700	yd^3	$7.30	$3,129,510.00
		(Assume 10% rock / 90% common)					
P016		b. Excavation - Key Trench	86-68313	206,500	yd^3	$18.50	$3,820,250.00
		(Assume 25% rock / 75% common)					
P017		c. Dewatering - Key Trench	86-68313	1	ls	$570,000.00	$570,000.00
		(2,000-ft line of well points)					
P017		d. Zone 1 - Fine-grained impervious core	86-68313	825,500	yd^3	$7.10	$5,861,050.00
		(From silt/clay borrow on-site)					
P018		e. Zone 2 - Sand Filter	86-68313	197,600	yd^3	$54.00	$10,670,400.00
		(From commercial source)					
P019		f. Zone 3 - Gravel Drain	86-68313	64,500	yd^3	$61.00	$3,934,500.00
		(From commercial source)					
P020		g. Zone 4 - Miscellaneous Shell Material	86-68313	1,240,600	yd^3	$6.50	$8,063,900.00
		(From excavation and borrow on-site)					
P021		h. Riprap Bedding - Gravel and Cobbles	86-68313	34,600	yd^3	$57.00	$1,972,200.00
		(From commercial source)					
P022		i. Riprap	86-68313	72,200	yd^3	$86.00	$6,209,200.00
		(From off-site quarry)					
P023		j. Geocomposite	86-68313	228,800	ft^2	$1.10	$251,680.00
		(Plastic geodrain between two geotextiles, see Red Willow Dam mod)					
P024		k. Shotcrete	86-68313	123,900	ft^2	$5.90	$731,010.00
		(Sprayed-applied, nonreinforced)					
		l. Blanket Grouting					
P025		Drilling (10-ft-deep-holes)	86-68313	45,600	lin ft	$29.00	$1,322,400.00
P026		Cement (Assume 2 sacks/ft of hole)	86-68313	91,200	sacks	$32.00	$2,918,400.00
		m. Curtain Grouting					
P027		Drilling (70-ft-deep-holes)	86-68313	22,800	lin ft	$24.00	$547,200.00
P028		Cement (Assume 2 sacks/ft of hole)	86-68313	45,600	sacks	$37.00	$1,687,200.00
P029		n. Toe Drain	86-68313	2,264	lin ft	$145.00	$328,280.00
		(2-ft dia perforated SDR HDPE pipe)					
P030		o. Inspection Wells	86-68313	4	ea	$16,500.00	$66,000.00
		(concrete, 6-ft dia., 15-ft deep, w/covers)					
		SUBTOTAL THIS SHEET					**$52,083,180.00**

QUANTITIES		PRICES	
BY Bob Dewey	**CHECKED** Chris Gemperline	**BY**	**CHECKED**
DATE PREPARED 06/27/14	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Gila River Diversion
Pope Canyon Dam
Spillway and Outlet Works for Embankment
APPRAISAL LEVEL

PROJECT: **New Mexico-Arizona Water Settlement Act**

WOID: A252F | **ESTIMATE LEVEL:** APPRAISAL
REGION: LC Region | **UNIT PRICE LEVEL:**
FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Uncontrolled Spillway (126 ft wide):					
		a. Excavation	86-68130	80,000	CY	$28.00	$2,240,000.00
		(Assume 90% Rock / 10% Common)					
		b. Concrete	86-68130	12,500	CY	$730.00	$9,125,000.00
		(4,500 psi, includes approach channel,					
		gate house, chute, and stilling basin)					
		c. Reinforcement	86-68130	1,900,000	lbs	$1.45	$2,755,000.00
		(Assumed 150 lbs/cy)					
		d. Grout Curtain at Gate Structure	86-68130	650	LF	$70.00	$45,500.00
		(1 Row @ 10' Center @ 50' deep each)					
		(Assume 13 setups, 2" Dia holes, 1 sack/lf cement)					
		Outlet Works:					
		a. Concrete	86-68130	910	CY	$620.00	$564,200.00
		(4,500 psi, includes inlet structure, conduit,					
		gate house structure, and stilling basin)					
		b. Reinforcement	86-68130	135,000	lbs	$1.45	$195,750.00
		(Assumed 150 lbs/cy)					
		c. One - 5'x5' regulating gate	86-68130	1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
		d. One - 5'x5' emergency gate	86-68130	1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
		SUBTOTAL THIS SHEET					**$15,445,450.00**

QUANTITIES		PRICES	
BY Carly Stark	**CHECKED** Elisabeth Cohen	**BY**	**CHECKED**
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Gila River Diversion
Pope Canyon Dam
Embankment Dam
BOR Proposal

PROJECT:

New Mexico-Arizona Water Settlement Act

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**

FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

Worksheet: Pope 6

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal - Sheet 1					$52,083,180.00
		Subtotal - Sheet 2					$15,445,450.00
		Subtotal					**$67,530,000.00**
		Mobilization @ 5%			LS		$3,380,000.00
		Subtotal w/ Mobilization					**$70,910,000.00**
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$12,050,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$4,400,000.00
		Contract Cost					**$87,360,000.00**
		Construction Contingencies @ 25%			LS		$21,840,000.00
		Field Cost					**$109,200,000.00**
		Non- Contract Cost @ 25%			LS		$27,300,000.00
		Construction Cost (Unit Price Level June 2013)					**$136,500,000.00**

QUANTITIES		**PRICES**	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Gila River Diversion
Spar Canyon
Conveyance Features
BOR Proposal

PROJECT:
New Mexico-Arizona Water Settlement Act

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**

FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1
Worksheet: Spar 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		constructing 350 cfs canal on east side of Gila river					
		(canal length = 56140 lf)					
	S001	excavation		280,000	cy	$6.60	$1,848,000.00
	S002	embankments		280,000	cy	$6.90	$1,932,000.00
	S003	compacting embankments		73,000	cy	$3.10	$226,300.00
	S004	trimming		190,000	sy	$6.60	$1,254,000.00
	S005	unreinf. concrete canal lining		16,500	cy	$320.00	$5,280,000.00
	S006	joints in canal lining		250,000	lf	$1.85	$462,500.00
		siphons (0 ea)					
		Specialized Canal		10,150	lf	$2,600.00	$26,390,000.00
		(Constructing canals on steep hillsides and rock)					
		road crossings (0 ea)					
		culvert (18 ea)					
	S007	concrete in transitions		100	cy	$1,050.00	$105,000.00
		(includes 8,000 lb reinforcement and 28 tons cement)					
	S008	furnishing, laying symbol pipe - 36D25		1,500	lf	$145.00	$217,500.00
		SUBTOTAL THIS SHEET					**$37,715,300.00**

QUANTITIES		**PRICES**	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:
Conveyance Features Spar Canyon Conveyance Features BOR Option	New Mexico-Arizona Water Settlement Act
	WOID: / ESTIMATE LEVEL: APPRAISAL
	REGION: LC / UNIT PRICE LEVEL: Oct-13
	FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal Sheet 1=					$37,715,300.00
		Subtotal					**$37,720,000.00**
		Mobilization @ 5%			LS		$1,890,000.00
		Subtotal w/ Mobilization					**$39,610,000.00**
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$6,730,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$2,460,000.00
		Contract Cost					**$48,800,000.00**
		Construction Contingencies @ 25%			LS		$12,200,000.00
		Field Cost					**$61,000,000.00**
		Non- Contract Cost @ 25%			LS		$15,250,000.00
		Construction Cost (Unit Price Level June 2013)					**$76,250,000.00**

QUANTITIES		PRICES	
BY	CHECKED	BY	CHECKED
DATE PREPARED	PEER REVIEW / DATE	DATE PREPARED	PEER REVIEW / DATE

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Gila River Diversion
Spar Canyon
Diversion Features
BOR Proposal

PROJECT:
New Mexico-Arizona Water Settlement Act

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**

FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1
Worksheet: Spar 3

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	S009	diversion and care of stream	86-68140	1	ls	$390,000.00	$390,000.00
	S010	concrete in diversion dam	86-68140	2,100	cy	$820.00	$1,722,000.00
		(includes 200,000 lb reinforcement and 592 tons cement)					
	S011	galvanized steel sluice gate, 10' w x 8' h		1	ea	$150,000.00	$150,000.00
	S012	galvanized steel canal gate, 5' w x 6' h		2	ea	$37,000.00	$74,000.00
		Subtotal					$2,336,000.00
		Mobilization	5%	+/-	ls		$117,000.00
		Subtotal with Mobilization					$2,453,000.00
		Contract Cost Allowances (Sum of):	17%	+/-	ls		$417,000.00
		Design Contingencies, 17% (+/-)					
		APS, 0% (+/-). Type of procurement: Sealed bid, full and open competiton					
		Special Taxes (e.g., TERO, Triba, and/or Gross Receipts):					
		TERO Tax					
		New Mexico Gross Receipts Tax	6.2%				$152,000.00
		CONTRACT COST					$3,022,000.00
		Construction Contingencies	25%				$756,000.00
		FIELD COST					$3,778,000.00
		Non-Contract Costs (assumed value)	25%				$945,000.00
		CONSTRUCTION COST (Unit Price Level October 2013)					$4,723,000.00

QUANTITIES		**PRICES**	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:	
Gila River Diversion Spar Canyon Dam Embankment Dam APPRAISAL LEVEL	New Mexico-Arizona Water Settlement Act	
	WOID: A252F	ESTIMATE LEVEL: APPRAISAL
	REGION:	UNIT PRICE LEVEL: Oct-13
	FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1 Spar 4	

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Embankment:					
	S013	a. Excavation - Foundation	86-68313	177,700	yd^3	$7.30	$1,297,210.00
		(Assume 10% rock / 90% common)					
	S014	b. Excavation - Key Trench	86-68313	64,200	yd^3	$18.50	$1,187,700.00
		(Assume 25% rock / 75% common)					
	S015	c. Dewatering - Key Trench	86-68313	1	ls	$570,000.00	$570,000.00
		(2,000-ft line of well points)					
	S016	d. Zone 1 - Fine-grained impervious core	86-68313	319,000	yd^3	$7.10	$2,264,900.00
		(From silt/clay borrow on-site)					
	S017	e. Zone 2 - Sand Filter	86-68313	51,500	yd^3	$54.00	$2,781,000.00
		(From commercial source)					
	S018	f. Zone 3 - Gravel Drain	86-68313	23,700	yd^3	$61.00	$1,445,700.00
		(From commercial source)					
	S019	g. Zone 4 - Miscellaneous Shell Material	86-68313	611,700	yd^3	$6.50	$3,976,050.00
		(From excavation and borrow on-site)					
	S020	h. Riprap Bedding - Gravel and Cobbles	86-68313	15,800	yd^3	$57.00	$900,600.00
		(From commercial source)					
	S021	i. Riprap	86-68313	32,500	yd^3	$86.00	$2,795,000.00
		(From off-site quarry)					
	S022	j. Geocomposite	86-68313	89,500	ft^2	$1.10	$98,450.00
		(Plastic geodrain between two geotextiles, see Red Willow Dam mod)					
	S023	k. Shotcrete	86-68313	43,100	ft^2	$5.90	$254,290.00
		(Sprayed-applied, nonreinforced)					
		l. Blanket Grouting					
	S024	Drilling (10-ft-deep-holes)	86-68313	15,900	lin ft	$29.00	$461,100.00
	S025	Cement (Assume 2 sacks/ft of hole)	86-68313	31,800	sacks	$32.00	$1,017,600.00
		m. Curtain Grouting					
	S026	Drilling (70-ft-deep-holes)	86-68313	7,900	lin ft	$24.00	$189,600.00
	S027	Cement (Assume 2 sacks/ft of hole)	86-68313	15,800	sacks	$37.00	$584,600.00
	S028	n. Toe Drain	86-68313	1,215	lin ft	$145.00	$176,175.00
		(2-ft dia perforated SDR HDPE pipe)					
	S029	o. Inspection Wells	86-68313	2	ea	$16,500.00	$33,000.00
		(concrete, 6-ft dia., 15-ft deep, w/covers)					
		SUBTOTAL THIS SHEET					**$20,032,975.00**

QUANTITIES		PRICES	
BY Bob Dewey	**CHECKED** Chris Gemperline	**BY**	**CHECKED**
DATE PREPARED 06/27/14	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Gila River Diversion
Spar Canyon Dam
Spillway and Outlet Works for Embankment
APPRAISAL LEVEL

PROJECT:
New Mexico-Arizona Water Settlement Act

WOID: A252F | **ESTIMATE LEVEL:** APPRAISAL
REGION: LC Region | **UNIT PRICE LEVEL:**
FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Uncontrolled Spillway (230 feet wide):					
		a. Excavation	86-68130	185,000	CY	$28.00	$5,180,000.00
		(Assume 90% Rock / 10% Common)					
		b. Concrete	86-68130	13,500	CY	$730.00	$9,855,000.00
		(4,500 psi, includes approach channel,					
		gate house, chute, and stilling basin)					
		c. Reinforcement	86-68130	2,000,000	lbs	$1.45	$2,900,000.00
		(Assumed 150 lbs/cy)					
		d. Grout Curtain at Gate Structure	86-68130	1,150	LF	$70.00	$80,500.00
		(1 Row @ 10' Center @ 50' deep each)					
		(Assume 23 setups, 2" Dia holes, 1 sack/lf cement)					
		e. Rock Bolts - 60ksi, 1" Dia. 30' Long	86-68130	6,600	LF	$59.00	$389,400.00
		(Fully cement grout, 1 bolt per 200 sq ft))					
		(2" Dia. Holes, 1 sack/lf cement)					
		Outlet Works:					
		a. Concrete	86-68130	1,100	CY	$620.00	$682,000.00
		(4,500 psi, includes inlet structure, conduit,					
		gate house structure, and stilling basin)					
		b. Reinforcement	86-68130	165,000	lbs	$1.45	$239,250.00
		(Assumed 150 lbs/cy)					
		c. One - 5'x5' regulating gate	86-68130	1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
		d. One - 5'x5' emergency gate	86-68130	1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
		SUBTOTAL THIS SHEET					**$19,846,150.00**

QUANTITIES		PRICES	
BY Elisabeth Cohen	**CHECKED** Carly Stark	**BY**	**CHECKED**
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Gila River Diversion
Spar Canyon Dam
Embankment Dam
BOR Proposal

PROJECT:

New Mexico-Arizona Water Settlement Act

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**

FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

Worksheet: Spar 6

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal - Sheet 1					$20,032,975.00
		Subtotal - Sheet 2					$19,846,150.00
		Subtotal					**$39,880,000.00**
		Mobilization @ 5%			LS		$1,990,000.00
		Subtotal w/ Mobilization					**$41,870,000.00**
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$7,120,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$2,600,000.00
		Contract Cost					**$51,590,000.00**
		Construction Contingencies @ 25%			LS		$12,900,000.00
		Field Cost					**$64,490,000.00**
		Non- Contract Cost @ 25%			LS		$16,120,000.00
		Construction Cost (Unit Price Level June 2013)					**$80,610,000.00**

QUANTITIES		**PRICES**	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Conveyance Features
Winn Canyon
Conveyance Features
BOR Option

PROJECT:
New Mexico-Arizona Water Settlement Act

WOID: A252F **ESTIMATE LEVEL:**
REGION: LC **UNIT PRICE LEVEL:**
FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		constructing 350 cfs canal on west side of Gila river					
		(canal length = 42,230 lf)					
		excavation		189,000	cy	$6.60	$1,247,400.00
		embankments		189,000	cy	$6.90	$1,304,100.00
		compacting embankments		49,000	cy	$3.10	$151,900.00
		trimming		129,500	sy	$6.60	$854,700.00
		unreinf. concrete canal lining		11,200	cy	$320.00	$3,584,000.00
		joints in canal lining		171,500	lf	$1.85	$317,275.00
		road crossings (3 ea)					
		concrete		450	cy	$1,050.00	$472,500.00
		(includes 75,000 lb reinforcement and 200 tons cement)					
		culvert (10 ea)					
		concrete in transitions		55	cy	$1,050.00	$57,750.00
		(includes 20,000 lb reinforcement and 70 tons cement)					
		furnishing, laying symbol pipe - 36D25		825	lf	$145.00	$119,625.00
		SUBTOTAL THIS SHEET					**$8,109,250.00**

QUANTITIES		PRICES	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:	
Conveyance Features Winn Canyon Conveyance Features BOR Option	New Mexico-Arizona Water Settlement Act	
	WOID:	ESTIMATE LEVEL: APPRAISAL
	REGION: LC	UNIT PRICE LEVEL: Jan-14
	FILE:	

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal Sheet 1=					$8,109,250.00
		Subtotal					**$8,110,000.00**
		Mobilization @ 5%			LS		$410,000.00
		Subtotal w/ Mobilization					**$8,520,000.00**
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$1,450,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$530,000.00
		Contract Cost					**$10,500,000.00**
		Construction Contingencies @ 25%			LS		$2,630,000.00
		Field Cost					**$13,130,000.00**
		Non- Contract Cost @ 25%			LS		$3,280,000.00
		Construction Cost (Unit Price Level June 2013)					**$16,410,000.00**

QUANTITIES		PRICES	
BY	CHECKED	BY	CHECKED
DATE PREPARED	PEER REVIEW / DATE	DATE PREPARED	PEER REVIEW / DATE

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Gila River Diversion
Winn Canyon
Diversion Features
BOR Proposal

PROJECT:
New Mexico-Arizona Water Settlement Act

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**

FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1
Worksheet: Winn 3

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	W012	diversion and care of stream	86-68140	1	ls	$390,000.00	$390,000.00
	W013	concrete in diversion dam	86-68140	910	cy	$820.00	$746,200.00
		(includes 200,000 lb reinforcement and 592 tons cement)					
	W014	galvanized steel sluice gate, 10' w x 8' h		2	ea	$150,000.00	$300,000.00
	W015	galvanized steel canal gate, 5' w x 6' h		4	ea	$37,000.00	$148,000.00
		Subtotal					$1,584,200.00
		Mobilization	5%	+/-	ls		$79,000.00
		Subtotal with Mobilization					$1,663,200.00
		Contract Cost Allowances (Sum of):	17%	+/-	ls		$283,000.00
		Design Contingencies, 17% (+/-)					
		APS, 0% (+/-). Type of procurement: Sealed bid, full and open competiton					
		Special Taxes (e.g., TERO, Triba, and/or Gross Receipts):					
		TERO Tax					
		New Mexico Gross Receipts Tax	6.2%				$103,000.00
		CONTRACT COST					$2,049,200.00
		Construction Contingencies	25%				$512,000.00
		FIELD COST					$2,561,200.00
		Non-Contract Costs (assumed value)	25%				$640,000.00
		CONSTRUCTION COST (Unit Price Level October 2013)					**$3,201,200.00**

QUANTITIES		**PRICES**	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:	
Gila River Diversion Winn Canyon Dam Embankment Dam BOR Proposal	New Mexico-Arizona Water Settlement Act	
	WOID: A252F	ESTIMATE LEVEL: APPRAISAL
	REGION:	UNIT PRICE LEVEL: Oct-13
	FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1 Winn 4	

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Embankment:					
	W016	a. Excavation - Foundation	86-68313	167,300	yd^3	$7.30	$1,221,290.00
		(Assume 10% rock / 90% common)					
	W017	b. Excavation - Key Trench	86-68313	87,100	yd^3	$18.50	$1,611,350.00
		(Assume 25% rock / 75% common)					
	W018	c. Dewatering - Key Trench	86-68313	1	ls	$570,000.00	$570,000.00
		(1,600-ft line of well points)					
	W019	d. Zone 1 - Fine-grained impervious core	86-68313	300,100	yd^3	$7.10	$2,130,710.00
		(From silt/clay borrow on-site)					
	W020	e. Zone 2 - Sand Filter	86-68313	51,500	yd^3	$54.00	$2,781,000.00
		(From commercial source)					
	W021	f. Zone 3 - Gravel Drain	86-68313	22,400	yd^3	$61.00	$1,366,400.00
		(From commercial source)					
	W022	g. Zone 4 - Miscellaneous Shell Material	86-68313	414,300	yd^3	$6.50	$2,692,950.00
		(From excavation and borrow on-site)					
	W023	h. Riprap Bedding - Gravel and Cobbles	86-68313	13,100	yd^3	$57.00	$746,700.00
		(From commercial source)					
	W024	i. Riprap	86-68313	27,500	yd^3	$86.00	$2,365,000.00
		(From off-site quarry)					
	W025	j. Geocomposite	86-68313	69,600	ft^2	$1.10	$76,560.00
		(Plastic geodrain between two geotextiles, see Red Willow Dam mod)					
	W026	k. Shotcrete	86-68313	47,500	ft^2	$5.90	$280,250.00
		(Sprayed-applied, nonreinforced)					
		l. Blanket Grouting					
	W027	Drilling (10-ft-deep-holes)	86-68313	17,500	lin ft	$29.00	$507,500.00
	W028	Cement (Assume 2 sacks/ft of hole)	86-68313	35,000	sacks	$32.00	$1,120,000.00
		m. Curtain Grouting					
	W029	Drilling (70-ft-deep-holes)	86-68313	8,800	lin ft	$24.00	$211,200.00
	W030	Cement (Assume 2 sacks/ft of hole)	86-68313	17,600	sacks	$37.00	$651,200.00
		n. Toe Drain	86-68313	1,182	lin ft	$145.00	$171,390.00
	W031	(2-ft dia perforated SDR HDPE pipe)					
	W031	o. Inspection Wells	86-68313	2	ea	$16,500.00	$33,000.00
		(concrete, 6-ft dia., 15-ft deep, w/covers)					
		SUBTOTAL THIS SHEET					**$18,536,500.00**

QUANTITIES		PRICES	
BY Bob Dewey	**CHECKED** Chris Gemperline	**BY**	**CHECKED**
DATE PREPARED 06/27/14	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:
Gila River Diversion Winn Canyon Dam Spillway and Outlet Works for Embankment APPRAISAL LEVEL	New Mexico-Arizona Water Settlement Act
	WOID: A252F — ESTIMATE LEVEL: APPRAISAL
	REGION: LC Region — UNIT PRICE LEVEL:
	FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Gated Spillway (50 ft wide, 1 gate)					
		a. Excavation	86-68130	53,000	CY	$28.00	$1,484,000.00
		(Assume 90% Rock / 10% Common)					
		b. Concrete	86-68130	6,000	CY	$730.00	$4,380,000.00
		(4,500 psi, includes approach channel,					
		gate house, chute, and stilling basin)					
		c. Reinforcement	86-68130	900,000	lbs	$1.45	$1,305,000.00
		(Assumed 150 lbs/cy)					
		d. One - 50'x50' Fixed Wheel Gate	86-68130	1	LS	$4,400,000.00	$4,400,000.00
		(See Guernsey Dam N. Gated Spillway)					
		(Inc. all controls and metalwork)					
		e. Grout Curtain at Gate Structure	86-68130	250	LF	$70.00	$17,500.00
		(1 Row @ 10' Center @ 50' deep each)					
		(Assume 5 setups, 2" Dia holes, 1 sack/lf cement)					
		f. Rock Bolts - 60ksi, 1" Dia. 30' Long	86-68130	3,800	LF	$59.00	$224,200.00
		(Fully cement grout, 1 bolt per 200 sq ft))					
		(2" Dia. Holes, 1 sack/lf cement)					
		g. spillway road crossing	86-68140	750	CY		
		Outlet Works:					
		a. Concrete	86-68130	750	CY	$620.00	$465,000.00
		(4,500 psi, includes inlet structure, conduit,					
		gate house structure, and stilling basin)					
		b. Reinforcement	86-68130	115,000	lbs	$1.45	$166,750.00
		(Assumed 150 lbs/cy)					
		c. One - 5'x5' regulating gate	86-68130	1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
		d. One - 5'x5' emergency gate	86-68130	1	LS	$260,000.00	$260,000.00
		(Inc. all controls and metalwork)					
		SUBTOTAL THIS SHEET					**$12,962,450.00**

QUANTITIES		PRICES	
BY Elisabeth Cohen	**CHECKED** Carly Stark	**BY**	**CHECKED**
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Gila River Diversion
Winn Canyon Dam
Embankment Dam
BOR Proposal

PROJECT:

New Mexico-Arizona Water Settlement Act

WOID:	**A252F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**LC**	**UNIT PRICE LEVEL:**	**Oct-13**

FILE: V:\SHARED\Henry Corretjer\Gila River\Excel\[BOR Proposal Cost Estimates.xlsx]Sycamore 1
Worksheet: Winn 6

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal - Sheet 1					$18,536,500.00
		Subtotal - Sheet 2					$12,962,450.00
		Subtotal					**$31,500,000.00**
		Mobilization @ 5%			LS		$1,580,000.00
		Subtotal w/ Mobilization					**$33,080,000.00**
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$5,620,000.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$2,050,000.00
		Contract Cost					**$40,750,000.00**
		Construction Contingencies @ 25%			LS		$10,190,000.00
		Field Cost					**$50,940,000.00**
		Non- Contract Cost @ 25%			LS		$12,740,000.00
		Construction Cost (Unit Price Level June 2013)					**$63,680,000.00**

QUANTITIES		**PRICES**	
BY Sayer	**CHECKED**	**BY**	**CHECKED**
DATE PREPARED Sept, 2013	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

Miscellaneous Cost Estimates

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:			
Standard Canal Unit Cost	New Mexico-Arizona Water Settlement Act			
	WOID:	A252F	ESTIMATE LEVEL:	14-Jun
	REGION:	LC	UNIT PRICE LEVEL:	Appraisal
	FILE:			

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		350 cfs canal					
		(canal length = 1 lf)					
		excavation		5	cy	$6.60	$33.00
		embankments		5	cy	$6.90	$34.50
		compacting embankments		1.3	cy	$3.10	$4.03
		trimming		3.39	sy	$6.60	$22.37
		unreinf. concrete canal lining		0.292	cy	$320.00	$93.44
		joints in canal lining		4	lf	$1.85	$7.40
		Subtotal					**$190.00**
		Mobilization @ 5%			LS		$10.00
		Subtotal w/ Mobilization					**$200.00**
		Contract Cost Allowances:					
		Design Contigencies @ 17%			LS		$30.00
		New Mexico Gross Receipts Tax @ 6.2%			LS		$10.00
		Contract Cost					**$240.00**
		Construction Contingencies @ 25%			LS		$60.00
		Field Cost					**$300.00**
		Non- Contract Cost @ 25%			LS		$80.00
		Construction Cost (Unit Price Level June 2013)					**$380.00**

QUANTITIES		PRICES	
BY Henry Corretjer	**CHECKED** Jeffrey P. Riley, P.E.	**BY** Henry Corretjer	**CHECKED** Jeffrey P. Riley, P.E.
DATE PREPARED 06/24/14	**PEER REVIEW / DATE** 06/24/14	**DATE PREPARED** 06/24/14	**PEER REVIEW / DATE** 06/24/14

Appendix – C – Upper Gila River Damsite Predicted Peak Discharge Estimates

Upper Gila River Damsites Peak Discharge Estimates

I. Introduction

This analysis was performed at the request of the Phoenix Area Office, Elizabeth Cohen (Waterways and Concrete Dams Group) and Kenneth Sayer (Water Conveyance Group). Peak discharge data was requested at 11 potential damsites along the Gila River in New Mexico in order to provide information for preliminary spillway design estimates. Figure 1 shows the location of the potential damsites.

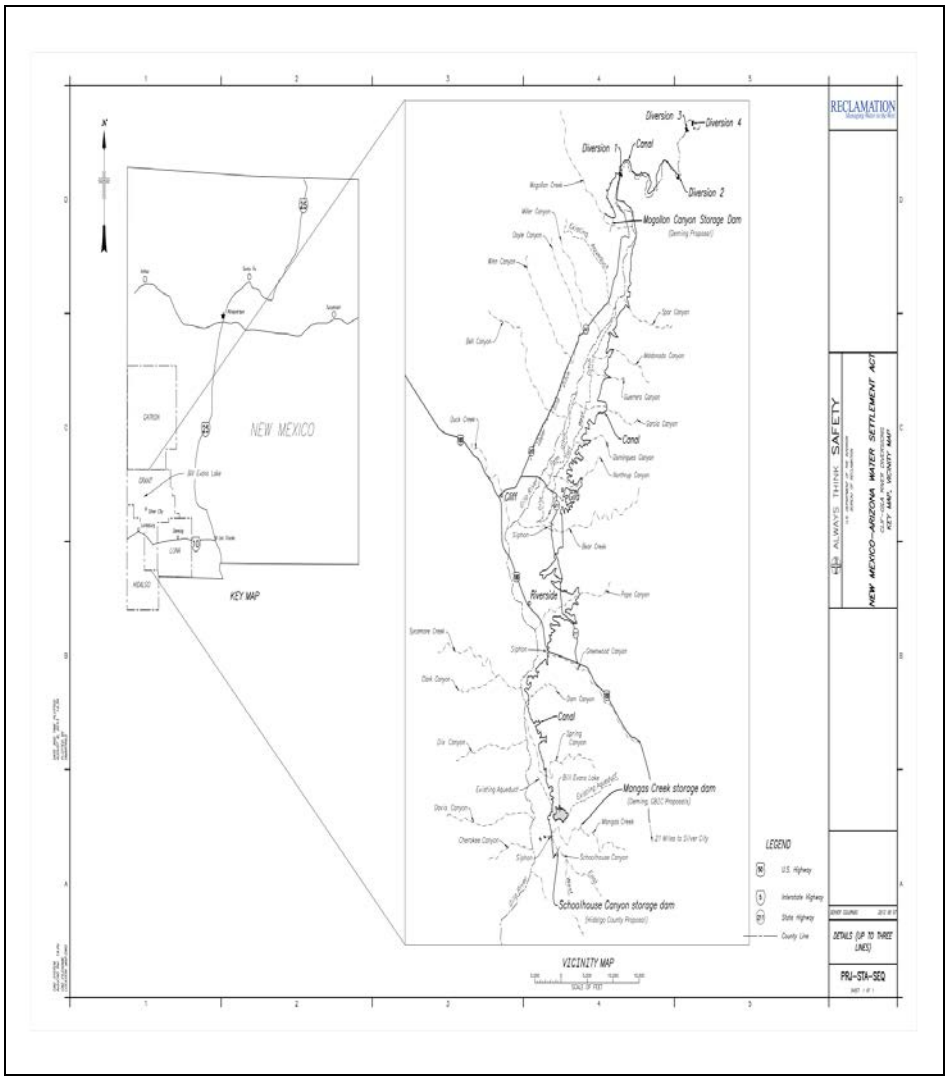

Figure 1.—Location Map, Upper Gila River Project Damsites

II. Calculations

Several existing Bureau of Indian Affairs (BIA) Dams are located within the area of interest. Existing Probable Maximum Flood (PMF) Studies for these dams were analyzed and determined to reasonably reflect the basin parameters of the 11 proposed damsites. The existing BIA dams, drainage areas and PMF peak discharge are listed in Table 1.

Table 1.--Existing Upper Gila River Dams

Dam	DA (mi^2)	PMF Peak Discharge (ft^3/s)		
		Local	Aug Gen	Max PMF
Dry Lake [1]	6.20	31,700	7,200	31,700
Upper Point of Pines [2]	10.50	45,700	12,000	45,700
Point of Pines [3]	13.10	48,700	14,900	48,700
Tufa Stone [4]	16.00	57,200	14,900	57,200

Elgo [5]	470.00	190,200	198,200	198,200
Coolidge [6]	12,870.00	N/A	800,000	800,000

The PMF peak discharges and their drainage areas were plotted. A linear regression was applied and it was determined that the R^2 value, a measure of goodness-of-fit, was quite high (R^2=0.9967) which indicated a very high correlation of the PMF peak discharge to drainage area for the existing Gila River dams. The linear regression equation is presented below:

$$\boldsymbol{PMF\ Peak\ Discharge\ Estimate} = 16{,}871 * Drainage\ Area^{0.407}$$

USGS streamflow gages in the area of study were located and their peak discharges were plotted versus the associated drainage areas. A plot of the linear regression and the envelope curve are presented in Figure 2. The resulting envelope curve closely follows the linear regression curve of the PMF peak discharges for the existing dams in the Upper Gila area. These USGS streamflow gages and the associated data are summarized in Appendix A.

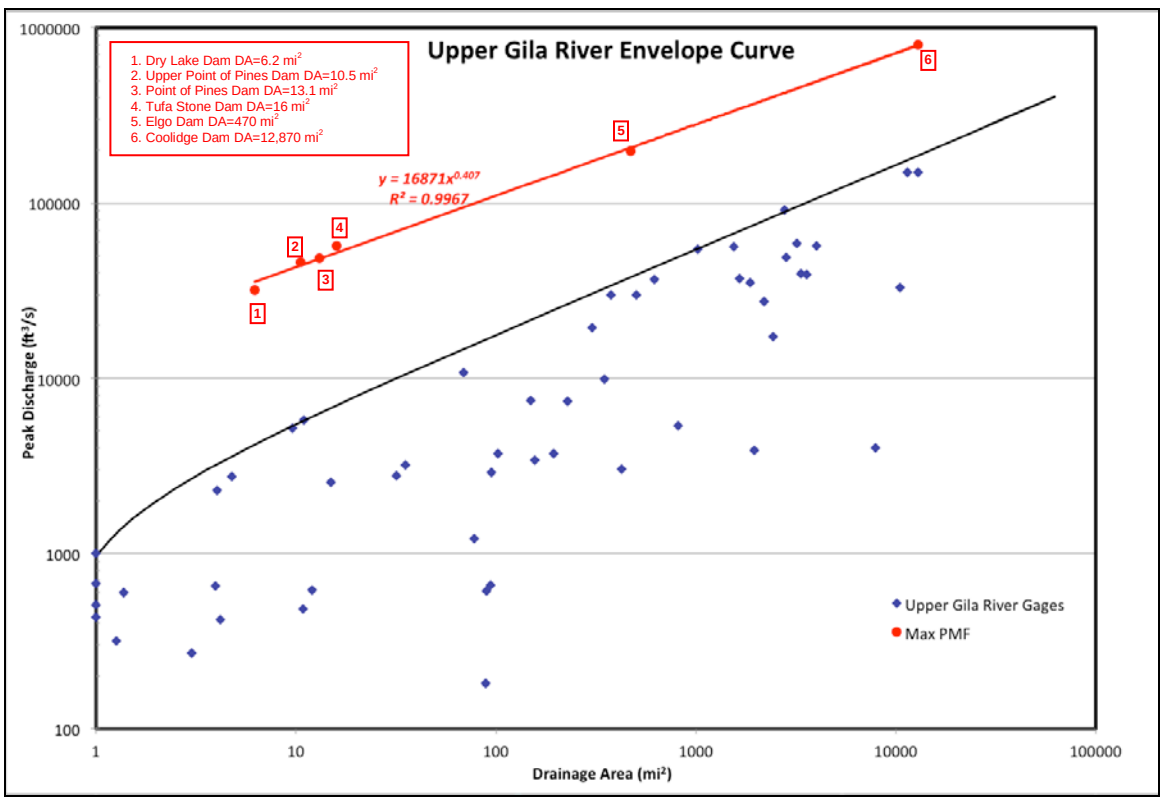

Figure 2.—Envelope Curve and Existing Dam PMFs, Upper Gila River Project

United States Geological Survey (USGS) Digital Elevation Model (DEM) data at a 1 meter resolution was downloaded for the study area. This data was used in ArcGIS, a Geographical Information System computer program used by Reclamation for spatial

analysis, to delineate each watershed. The watershed delineations were then used to calculate the watershed drainage area for each damsite.

The regression equation was used to estimate PMF peak discharges at the 11 damsites based on the drainage area for each damsite. Table 2 lists the damsites, their calculated drainage areas and the corresponding estimated PMF peak discharges.

Table 2.—Upper Gila River Project Damsites

Damsite	Drainage Area (mi^2)	PMF Peak Discharge (ft^3/s)
Mogollon Creek	124.00	120,000
Spar Canyon	4.08	29,900
Win Canyon	14.00	49,390
Garcia Canyon	2.06	22,640
Pope Canyon	1.13	17,730
Greenwood Canyon	27.60	65,100
Sycamore Creek	62.80	90,960
Dam Canyon	1.31	18,830
Upper Mangus Creek	194.00	143,970
Lower Mangus Creek	195.00	144,270
Schoolhouse Creek	9.14	41,520

III. Conclusions

Utilizing existing PMF studies at BIA dams in the vicinity of the proposed damsites, a linear regression equation was derived and PMF peak discharges at each proposed damsite was estimated based on the drainage areas calculated using ArcGIS. These damsites, with corresponding drainage areas and the estimated PMF peak discharges, are shown in Table 2. Existing PMF discharges and drainage areas at local BIA dams were plotted, compared with the regional envelope curve, and presented in Figure 2. The estimated PMF peak discharges for the 11 proposed damsites in the Upper Gila River study area can be used for preliminary spillway sizing only. Detailed PMF studies at each site are required for final design.

IV. Acknowledgements

This report was written by Colette Collins of the Flood Hydrology and Consequences Group and peer reviewed in accordance with Reclamation guidelines by Brenda Kinkel, PE, of the Flood Hydrology and Consequences Group. Please contact Colette Collins at 303-445-2540 with questions.

V. References

[1] "**Dry Lake Dam, Arizona, Probable Maximum Flood Study," *Memorandum from* xx, Bureau of Reclamation, Denver, Colorado, xx xx.

[3] "Probable Maximum Flood Study for Upper Point of Pines Dam, San Carlos Indian Reservation, Arizona," *Memorandum from* Floods Hydrology Group, Technical Service Center, Bureau of Reclamation, Denver, Colorado, February 1996.

[3] "Probable Maximum Flood Study for Point of Pines Dam, San Carlos Indian Reservation, Arizona," *Memorandum from* Floods Hydrology Group, Technical Service Center, Bureau of Reclamation, Denver, Colorado, March 1996.

[4] "Tufa Stone Dam Probable Maximum Flood Study (with Warning Time Temporal Arrangement), San Carlos Apache Indian Reservation, Arizona," *Memorandum from* Floods Section, Bureau of Reclamation, Denver, Colorado, December 1992.

[5] "Elgo Dam, Arizona, Probable Maximum Flood Study," *Memorandum from* Floods Section, Bureau of Reclamation, Denver, Colorado, June 1992.

[6] "Probable Maximum Flood Study for Coolidge Dam—San Carlos Irrigation Project, Arizona—Bureau of Indian Affairs," *Memorandum from* Chief, Division of Planning Technical Services, Bureau of Reclamation, Denver, Colorado, August 1994.

Prepared by Colette D. Collins, Civil Engineer (Hydrology) Flood Hydrology and Consequences Group (86-68250)	Date

Peer Review Certification

This section has been reviewed and is believed to be in accordance with the service agreement and standards of the profession.

Peer reviewed by Brenda K. Kinkel, P.E., Civil Engineer (Hydrology) Flood Hydrology and Consequences Group (86-68250)	Date

Appendix XX.--USGS Streamflow Gage Envelope Curve, Upper Gila River

ID	Gage Name	DA (mi^2)	Peak Date	Peak (ft^3/s)	Start	End	Records
9451800	TOLLGATE WASH TRIB NEAR CLIFTON AZ	0.12	10/19/1972	63	1963	1976	14
9444400	CHASE CREEK NEAR CLIFTON AZ	1.37	7/25/1964	600	1964	1979	14
9451900	AGRICUL RESRCH SERV SAFFORD WTRSHED W-I AZ	1.00	9/5/1944	434	1939	1969	31
9455800	STEINS CREEK AT STEINS NM	1.26	9/3/1965	317	1959	2012	52
9456680	AGRICUL RESRCH SERV SAFFORD WTRSHED W-V AZ	1.00	7/22/1955	671	1939	1969	30
9456820	AGRICUL RESCH SER SAFFORD WTRSHED W-IV AZ	1.00	8/16/1958	508	1939	1968	29
9462200	AGRICUL RESCH SER SAFFORD WTRSHD W-II AZ	1.00	9/28/1941	997	1939	1969	31
9468300	SEVENMILE WASH TRIB NEAR GLOBE AZ	0.83	12/18/1979	640	1933	1979	17
9443950	RED COLT CANYON AT PLEASANTON NM	3.00	8/28/2007	269	2006	2012	7
9430300	COPPERAS CANYON NR PINOS ALTOS NM	3.95	8/13/1980	650	1963	1993	31
9442630	MAIL HOLLOW NR LUNA NM	4.20	8/16/2003	420	1970	2012	40
9460150	FRYE CREEK NEAR THATCHER AZ	4.02	12/19/1979	2,300	1967	2012	34
9458200	DEADMAN CREEK NEAR SAFFORD AZ	4.78	12/18/1979	2,760	1967	1993	17
9442695	NEGRO CANYON AT ARAGON NM	9.62	7/28/1959	5,200	1958	1993	35
9442650	ROMERO CRK NR N.M.-ARIZ. ST. LINE NR LUNA NM	10.80	7/29/1967	480	1958	1976	19
9458050	MARIJILDA WASH NR SAFFORD AZ	10.90	12/18/1979	5,770	1972	1979	8
9444100	CAMPBELL BLUE CREEK NEAR ALPINE AZ	12.00	10/2/1984	619	1959	1989	31
9456400	GOLD GULCH NEAR BOWIE AZ	15.00	8/18/1971	2,550	1963	1976	14
9442660	TROUT CREEK AT LUNA NM	31.90	10/2/1984	2,790	1954	2011	54
9467120	SALT CREEK NEAR PERIDOT AZ	35.20	10/19/1973	3,200	1964	1979	13
9430600	MOGOLLON CREEK NEAR CLIFF NM	69.00	8/12/1967	10,800	1967	2012	46
9430150	SAPILLO CREEK BELOW LAKE ROBERTS NM	78.00	9/23/1964	1,210	1964	1971	8

Appendix XX.--USGS Streamflow Gage Envelope Curve, Upper Gila River

ID	Gage Name	DA (mi^2)	Peak Date	Peak (ft^3/s)	Start	End	Records
9442690	TULAROSA RIVER NEAR ARAGON NM	89.00	3/28/1966	181	1955	1967	13
9429900	SNOW CREEK NR. MOGOLLON NM	90.00	8/15/1964	608	1958	1967	9
9442692	TULAROSA RIVER ABOVE ARAGON NM	94.00	10/2/1984	660	1967	1996	30
9442700	APACHE CREEK NR. APACHE CREEK NM	94.60	8/11/1964	2,900	1957	1973	17
9445500	WILLOW C NR POINT OF PINES NR MORENCI AZ	102.00	12/30/1966	3,710	1945	1967	23
9446000	WILLOW C N DOUBLE CIRCLE RNCH N MORENCI AZ	149.00	12/30/1966	7,500	1944	1973	25
9438200	ANIMAS CREEK NR. CLOVERDALE NM	157.00	10/13/1975	3,400	1959	2011	49
9431130	MANGAS CREEK NEAR CLIFF, NM	194.00	9/22/1997	3,720	1988	2012	25
9430900	DUCK CREEK AT CLIFF NM	228.00	1/18/1993	7,400	1957	2012	56
9447800	BONITA CREEK NEAR MORENCI AZ	302.00	1/18/1993	19,500	1981	2012	32
9442680	SAN FRANCISCO RIVER NEAR RESERVE NM	350.00	10/1/1984	9,830	1959	2011	53
9446500	EAGLE C N DOUBLE CIRCLE RNCH N MORENCI AZ	377.00	10/20/1973	30,000	1944	1973	25
9442740	TULAROSA RIVER NEAR RESERVE NM	426.00	10/2/1984	3,020	1956	2012	48
9444200	BLUE RIVER NEAR CLIFTON AZ	506.00	10/20/1973	30,000	1966	2012	39
9447000	EAGLE CREEK ABOVE PUMPING PLANT NEAR MORENCI AZ	622.00	1/18/1993	36,800	1916	2012	71
9456000	SAN SIMON RIVER NEAR SAN SIMON AZ	814.00	7/21/2023	5,350	1923	1941	12
9468500	SAN CARLOS RIVER NEAR PERIDOT AZ	1026.00	1/8/1993	54,800	1916	2012	84
9443000	SAN FRANCISCO R NR ALMA NM	1546.00	10/2/1984	56,600	1964	1986	23
9444000	SAN FRANCISCO RIVER NEAR GLENWOODNM	1653.00	10/2/1983	37,100	1928	2012	85
9430500	GILA RIVER NEAR GILA NM	1864.00	12/28/1985	35,200	1928	2011	85
9456800	SAN SIMON RIVER NEAR TANQUE AZ	1953.00	10/2/1984	3,860	1982	1985	4
9457000	SAN SIMON RIVER NEAR SOLOMON AZ	2192.00	8/9/1931	27,500	1931	1984	53

Appendix XX.--USGS Streamflow Gage Envelope Curve, Upper Gila River

ID	Gage Name	DA (mi^2)	Peak Date	Peak (ft^3/s)	Start	End	Records
9431000	GILA RIVER NEAR CLIFF NM	2438.00	1/14/1949	17,200	1942	1970	29
9444500	SAN FRANCISCO RIVER AT CLIFTON AZ	2766.00	10/2/1984	90,900	1891	2012	106
9431500	GILA RIVER NEAR REDROCK NM	2829.00	12/19/1979	48,800	1906	2012	79
9432000	GILA RIVER BELOW BLUE CREEK NEAR VIRDEN NM	3203.00	12/19/1979	58,700	1927	2012	86
9438000	GILA RIVER AT N.MEX-ARIZ.ST.LINE NR VIRDEN NM	3360.00	9/29/1941	39,500	1939	1949	11
9439000	GILA RIVER AT DUNCAN AZ	3589.00	2/13/2005	38,900	2003	2012	10
9442000	GILA RIVER NEAR CLIFTON AZ	4010.00	12/19/1979	57,000	1911	2012	91
9448500	GILA RIVER AT HEAD OF SAFFORD VALLEY NR SOLOMON AZ	7896.00	10/2/1984	4,000	1914	2012	99
9458500	GILA RIVER AT SAFFORD AZ	10459.00	9/30/1941	33,000	1940	1965	23
9466500	GILA RIVER AT CALVA AZ	11470.00	10/3/1984	150,000	1916	2012	84
9469499	SAN CARLOS RESERVOIR INFLOW AT COOLIDGE DAM AZ	12900.00	10/3/1983	150,000	1906	1986	73

Appendix – D – Infiltration Storage GBIC Alternative

RECLAMATION

Managing Water in the West

Upper Gila River Appraisal Study – 2013
Aquifer Storage Alternative along the Gila River in Grant County between the Mogollon Creek and Bell Canyon Tributaries – Cliff-Gila Valley, New Mexico

Mission Statements

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

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

Upper Gila River Appraisal Study – 2013 Aquifer Storage Alternative along the Gila River in Grant County between the Mogollon Creek and Bell Canyon Tributaries – Cliff-Gila Valley, New Mexico

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Upper Gila River Appraisal Study – 2013
Aquifer Storage Alternative along the Gila River In Grant County between the Mogollon Creek and Bell Canyon Tributaries – Cliff-Gila Valley, New Mexico

1.0 Introduction

The Bureau of Reclamation's Phoenix Area Office (Reclamation) is investigating and assessing several Tier 2 Diversion and Non-Diversion Proposals at an appraisal level of study, as part of the 2004 Arizona Water Settlements Act (AWSA) Consumptive Use and Forebearance Agreement. Under the settlement, engineering analyses were undertaken in support of these assessments, including technical, environmental, economic, and cost considerations.

One such appraisal alternative concept involves the viability of capturing and diverting all or some portion of surplus river flow, such as flood peaks, and storing the water in the Gila River floodplain alluvial aquifer using an infiltration gallery type distribution and collection system, as well as using small on-farm storage ponds, stockponds, or reservoirs, or other less likely methods such as injection wells (Figure 2). The water could be stored during times of excess river flow and utilized for irrigation, stock use, and recovered during low-flow dry periods when demands are usually greater, and for recharging the aquifer.

Proponents and entities formulating this storage concept (Gila Basin Irrigation Commission (GBIC)) theorize that the areal extent, length, and depth of the Gila River alluvial aquifer is large enough to be able to store a significant volume of Gila River water, and that storage could be recovered when needed by recovery infrastructure like wells or galleries, to the point(s) of use.

1.1 Objective

Using publicly available literature and data, this appraisal report will assess the hypothesis that the floodplain alluvial aquifer has enough storage capacity and the requisite infiltration properties to warrant exploring this concept further as a viable diversion alternative (aquifer storage concept).

This report is included herein as an Appendix section to supplement Section 3.5 – Reclamation Engineering Options for Proposals.

1.2 Purpose, Problems, and Need

Preliminary data indicates that the depth to water adjacent to the study reach of the Gila River floodplain alluvium is shallow and thus there may be limited vadose zone capacity for storage. In addition, any infiltration system employed will require a low sediment (filtered) supply to minimize clogging and sealing off the infiltration interface. Supplying the water via unlined ditches may be problematic. Stilling basins may be required. Aquifer storage retention time will require an optimization analysis as the stored flood water will dissipate and seep back to the river

as return flow, and eventually return to pre-flood equilibrium conditions. These returns will enhance baseflow during dry periods.

By storing water in the alluvial aquifer and floodplain, the already shallow groundwater (even during seasonally low water table levels) will become even shallower, and possibly cause water logging problems for future agriculture.

1.3 Study Area

The study area falls within the Cliff Sub-basin of the New Mexico portion of the Upper Gila River Basin, in the northeastern half of the Cliff-Gila Valley of Grant County, New Mexico (Figure 1). The Cliff-Gila Valley is a northwest-southeast trending structural basin about 18 miles long and about 8 miles wide between the Mogollon Mountains to the north and Big Burro and Black Mountains to the south.

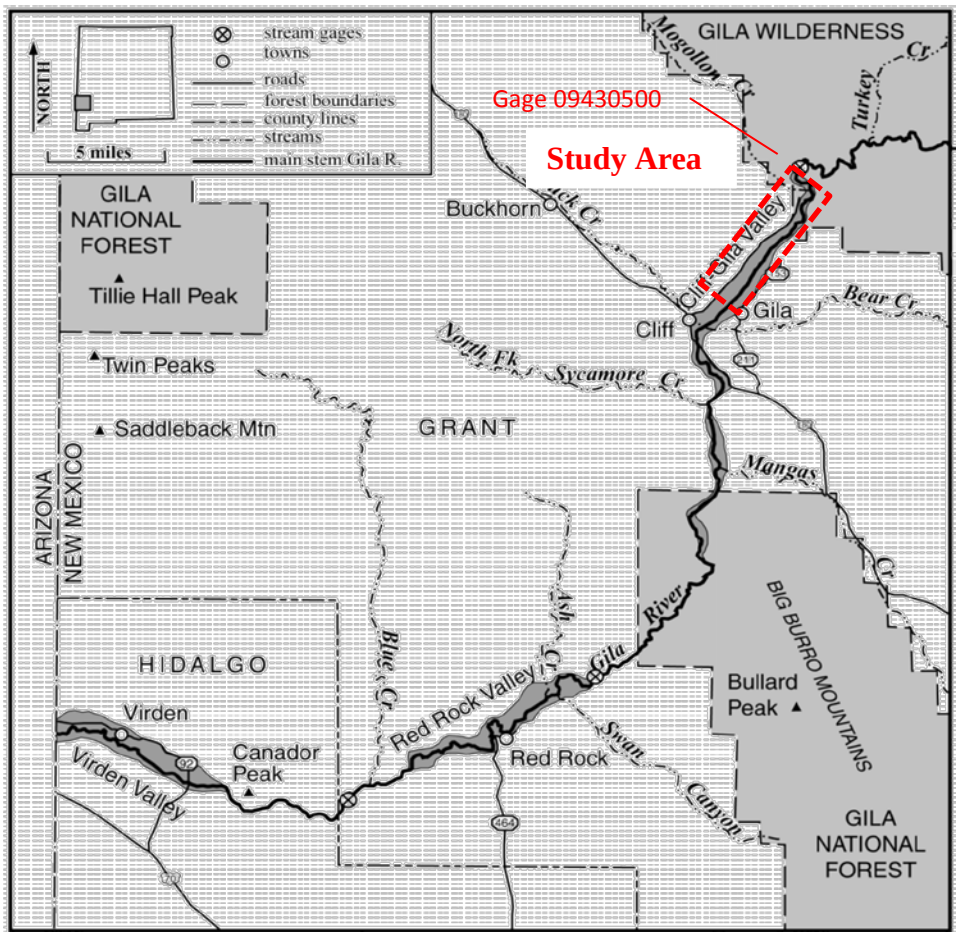

Figure 1. Southwestern New Mexico and Study Area (figure from USBR, 2004)

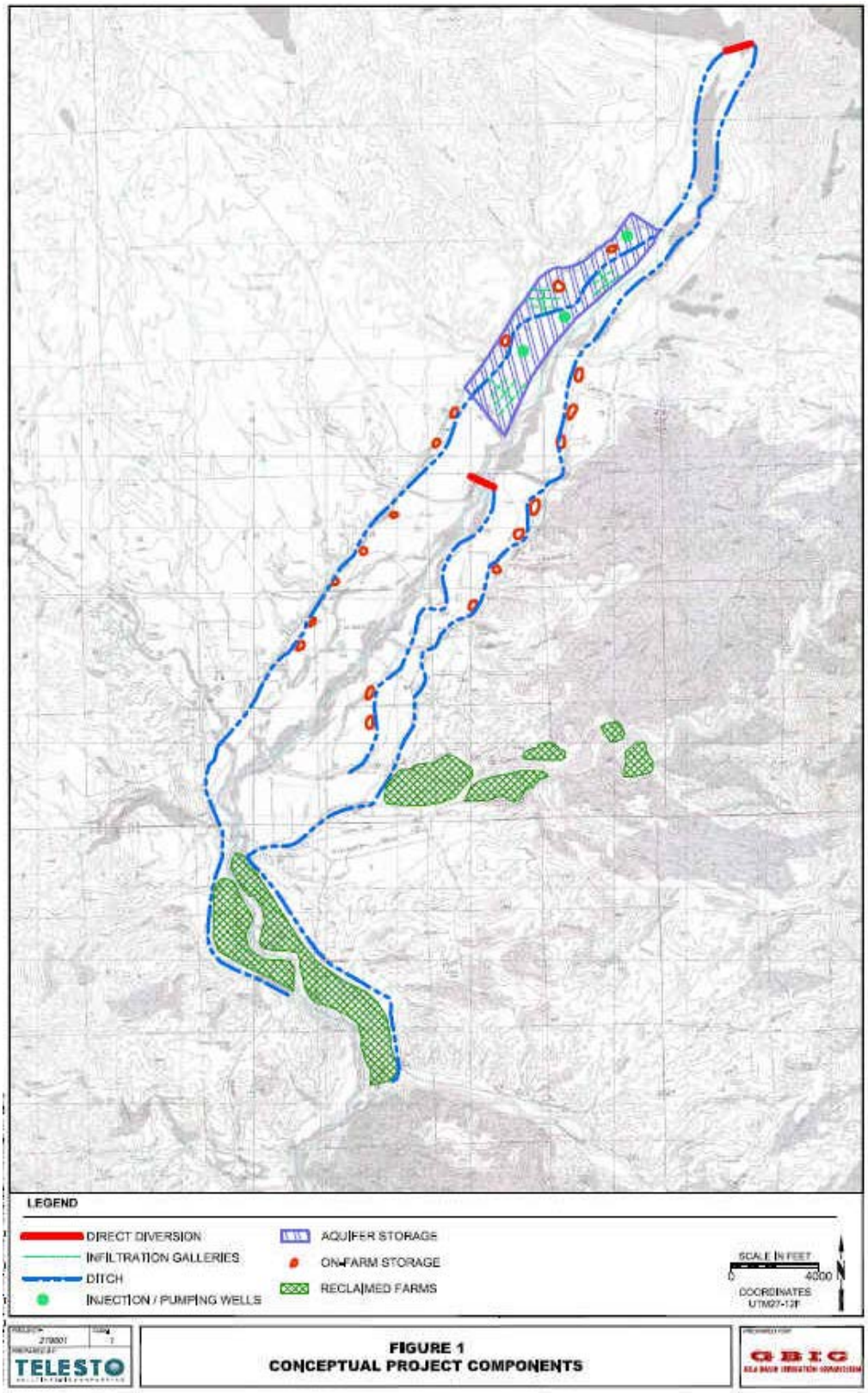

Figure 2. Conceptual Project Components (figure from TELESTO for GBIC)

The Gila River flows southwesterly across the valley from the Upper Gila Box to Cliff, New Mexico. The floodplain limits are generally defined by the Fort West Ditch and Turkey Creek Road along the east margin, and Upper Gila Ditch and Route 293 along the west margin. Specifically, the Area of Interest (AOI) falls within the Cliff Quadrangle Township 15 South, Range 17 West, Sections 1, 11-12, 14, and Section 23 (Figure 3).

1.4 Previous Investigations and Data Sources

For this study, the following investigations reports and data were those primarily utilized.

- Upper Gila River Fluvial Geomorphology Study Final Report, Recommendations for Demonstration Projects New Mexico - Geomorphic Map, New Mexico, Upper Gila River Fluvial Geomorphology Study, Bureau of Reclamation – Technical Service Center – Denver Federal Center, March 24, 2003

- Web Soil Survey, National Cooperative Soil Survey, United States Department of Agriculture, Natural Resources Conservation Service, Soil Map – Gila National Forest, New Mexico, Parts of Catron, Grant and Sierra Counties; and Grant County, New Mexico, Central and Southern Parts (NM_T15SR17WSec11121314_SoilMap)

- New Mexico Office of the State Engineer, Interstate Stream Commission (NMOSE/ISC), WATERS database

Other data sources:

- Geologic Map of the Cliff Quadrangle, Grant County, New Mexico, Department of the Interior, U.S. Geological Survey, Miscellaneous Investigations Series, Map I – 1768, Tommy L. Finnell, 1987

- Trauger, F., 1972. Water Resources and General Geology of Grant County, New Mexico. New Mexico State Bureau of Mines and Mineral Resources Hydrology Report 2.

- Geomorphology of the Upper Gila River Within the State of New Mexico, Mussetter Engineering, Inc., Submitted to New Mexico Interstate Stream Commission, 2006

- S.S. Papadopulos & Associates, Inc. (SSPA). Analysis of Surface Water – Groundwater Interactions along the Gila River, Gila-Cliff Basin. June 2010.

2.0 Geologic and Hydrologic Framework

The study area is in the Cliff Quadrangle and falls within T15S, R17W although the extreme upstream limits of the project area fall within T14S, R16W Section 31 where Mogollon Creek joins the main stem Gila River. The two ditches also begin at a diversion point at this tributary. The downstream limits of the project are considered to be at the Township boundary with T16S near Cliff, New Mexico and the Duck Creek and Bear Creek tributaries. The focused area of interest is defined as T15S, R17W Sections 1, 11-14, and Section 23 at the Bell Canyon tributary. This focused area is where any potential recharge project is anticipated.

Regional geology and tectonics, and physiography, will not be discussed herein. It has been discussed in detail in numerous studies and reports, some of which were listed above. General site geologic conditions will dictate the potential storage capacity, and if the site conditions are suitable, the type of infrastructure and recharge system to implement.

2.1 General Geology and Groundwater Conditions

The Cliff-Gila Valley generally coincides with the Cliff Sub-basin. This valley is a structural trough formed in the typical basin and range setting with northwest trending fault block mountain highlands and intervening valleys. The Cliff-Gila valley is filled with Tertiary basin fill/valley fill sediments and includes generally more consolidated older sediments of the Gila Group (Gila Conglomerate). Superimposed on that is the Quaternary alluvial deposits along the Gila River and its tributary drainages, as well as alluvial fan sediments and terrace deposits.

The Gila River is about 23 miles long in an approximately 18 mile long valley (sinuosity 1.29) and has an average gradient of 0.0028 (USBR, 2004). The largest flood channel width changes occurred between 1980 and 1996. The largest floods occur in the fall and winter months, with the largest instantaneous peak flows recorded in water years 1941, 1979 and 1985, of between 25,000 to 35,000 cfs (USBR, 2004).

For USGS Gage 09430500, Gila River near Gila, NM (the gage in the Upper Box about 1.6 miles upstream of Mogollon Creek at the old Hooker Damsite), the following graphic shows the mean monthly Gila River discharge in cubic feet per second (cfs) over the period of record 1927 to 2012, and for 2011-2012.

1927-2012 Mean Monthly Discharge (cfs)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
	176	242	305	215	134	57	64	149	149	115	100	160

Source: USGS NWIS

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2011 (cfs)	66.5	63.3	63.5	53.2	36.2	22.6	27.9	193.2	65.8	59.2	63.3	133.3
2012 (cfs)	144.3	95.4	115.2	106.6	52.0	25.1	61.4	73.2	57.3			

Source: USGS NWIS

Not surprisingly, this shows that historically through 2012, the largest Gila River flows entering the project study area occur in the wetter months of December through April (mean monthly range between 317 acre-feet/day to 605 acre-feet/day) and the low-flows in June and July (mean monthly flows of 113 acre-feet/day and 127 acre-feet/day). The 2011 and 2012 data show much lower flows than the long-term average (except August 2011), and may be more representative for infiltration gallery design purposes. Annual run-off over those 85 years is 112,700 acre-feet. The daily mean flow (some days estimated) from January 1, 1980 through year 2012 is 67 cfs.

The 2004 USBR study report concludes that in general, the Gila River geomorphic system through the Cliff-Gila Valley has been relatively stable (no net aggradation/degradation). Yet on more local scales, construction and failure during floods of levees has caused the most channel changes with diversions and other human-induced factors being secondary, and watershed and hydrology factors even less causative.

Medium scale mapping (1:50,000) of the Cliff Quadrangle by the USGS (Finnell, 1987) shows Quaternary Alluvium (Qa) as the surficial geologic unit along the Gila River and floodplain, and extending well into and filling the principal tributaries to the Gila River. West of the river, notable tributaries are Duck Creek, Bell Canyon, Winn Canyon, and the Mogollon Creek drainages, and to a lesser extent, the Doyle Canyon and Miller Canyon drainages. Tributaries east of the Gila River include Bear Creek, Northrup Canyon, Maldonado Canyon, Spar Canyon, and to a minor extent, Domingues and Guerrero Canyons.

The Quaternary Alluvium (Qa) along the Gila River and floodplain is composed of silt and clay, sand, gravel, and boulders and is reported to be up to or over 100 feet thick in some areas (USGS I-1768, NM WRRI, 1999). A Reclamation boring near Redrock from the floodplain, shows the alluvium as 101 feet thick (Trauger, 1972). This is outside the study area. Trauger (1972) mentions that the valley fill averages about 40 feet thick in other parts of the river valley, and that alluvial thicknesses in some principle tributaries to the Gila (and Mimbres) Rivers is generally thin – from 5 to 20 feet thick although locally (e.g., Mogollon Creek or Duck Creek), the alluvium could be and probably is thicker. Some dissected Quaternary Alluvial Fan (Qf) deposits of sand, gravel, and boulders up to about 40 feet in thickness overlie older fanglomerate/conglomerate pediments of the Gila Conglomerate, as mapped on the west side of the river between Duck and Mogollon Creeks (USGS I-1768). The Qf unit likely interfingers

with and should be gradational with the alluvial terraces (Qa) and related Gila Conglomerate unit (QTgo).

The Gila Conglomerate was described by Trauger (1972) as having upper and lower units with the upper younger unit unconsolidated to variably consolidated but in general more permeable, compared to the lower older unit being relatively much more consolidated and cemented, and of low permeability. The Gila is composed of Quaternary to Tertiary- aged light tan to pinkish gray clastics of silt, clay, sand, and gravel size where uncemented, to poorly sorted and poorly bedded cemented conglomerate and fanglomerate, conglomeritic sandstone and sandstone. Lacustrine deposits formed prior to through-flowing streams/ancestral Gila River are known to occur in the upper unit. Both units may have interbedded basalt flows and feeder dikes but volcanic interbeds are less common in the upper unit (Trauger, 1972).

Groundwater Conditions:

In the Cliff-Gila Valley, the generalized, basin-fill regional groundwater flow pattern is from upgradient areas southeast and northwest of the Gila River in the valley, towards the Gila River (USGS, HIA C-730). This pattern, like in many other alluvial basins in the southwest, has likely changed since pre-development equilibrium conditions, and has certainly changed locally over the decades in response to pumping, irrigation, and other human-caused perturbations. The Upper Gila River reach within the Cliff-Gila Valley, downstream of the Upper Box (USGS Gage 09430500, Gila River near Gila, NM), varies depending on season, from a gaining to losing condition as evidenced by water levels in the river alluvium and tributaries, as well as those outside the active floodplain, in wells screened in the Gila Conglomerate and associated deposits. During summer low flow periods when demands for irrigation, from evapotranspiration, and lack of tributary inflows are greatest, the diversions lead to downstream reaches of the Gila River going dry.

A consultant (SSPA, 2004) developed a groundwater level and river stage monitoring transect across the Gila River at The Nature Conservancy (TNC) site. This is about 2.25 miles downstream of the Mogollon Creek confluence. Here, another consultant (Tetra Tech) installed (on the right side (west) of the active river channel bank bearing west) a gage, and four 2-inch PVC observation wells, TNC-1S, TNC-1D, and TNC-2 and TNC-3. Another observation well, TNC-4, is not along the transect but located about 580 feet downstream of the transect line.

During installation, first encountered water (groundwater) was recorded on the boring logs (SSPA, 2004) as depths-to-water in either silty sand or gravel and cobbles, of only 3 feet in TNC-4, to 7.2 feet bgl in TNC-3. The other three wells showed first water near 6 feet bgl. Silty sand or sand or sandy silt occurs in the upper several feet of the channel floodplain with stratified layers of sands, silty sands, sandy gravels and silty gravels, and gravel and cobbles to the drilled depths of between 13 and 20 feet.

In a short water level monitoring program after piezometer installation by SSPA between May 5, 2010 and May 20, 2010 for the TNC site, the SSPA 2004 report includes a hydrograph (Figure 3.7 in their report) that shows the Gila River stage varying from about elevation 4580.5 starting on May 5, peaking to elevation 4580.7 on about May 10, and once again receding back to about 4580.5 on May 18. The observation well plots mimic the river elevation surface trend, but are slightly lower in elevation by several tenths of a foot to 0.5 feet in TNC-2. In the furthest transect well (TNC-3) from the river (about 390 feet west), the water level is about 1.5 feet lower in elevation and the May 10 peak slightly attenuated compared to the river. Although a short period of record of only 12 days was monitored in May 2010, this would indicate a uniform and fairly flat (0.0038) but declining hydraulic gradient away from the river and a slight losing stream condition in May, a normally drier quiescent period. TNC-1S and TNC-1D graphs show about a 0.1 foot lower level in the deeper observation well, even though TNC-1D is 6 feet upstream of the transect.

Two seepage measurement (velocity-area-depth) discharge events (Events 1 and 2) were undertaken by SSPA and ISC during May 10-12, 2010 and May 15-17, 2010 to attempt to quantify reaches where the river gained or lost water using a water balance (inflow-outflow) approach. Although the two events can't be directly compared spatially or temporally, the discharge reading sites between Winn Canyon and Mogollon Creek, generally near the Miller and Doyle Canyon tributaries, showed a flow gain, which is attributed to tributary inflows. Mogollon Creek to below the Upper Gila Ditch was a reach showing a net loss.

SSPA (2010) developed several transient riparian groundwater flow models along the Gila River through the Cliff-Gila Valley to investigate the surface water - groundwater interactions. In particular, their upper model (the Reach 1 Riparian Model) is useful for this appraisal study as the model domain extends from above the confluence of Mogollon Creek to below Duck and Bear Creek, covering the entire project study area. The time period was December 1, 2009 through May 20, 2010.

Locally, within the study area reach (Figure 1), the Gila River and its floodplain define a subflow zone of alluvium. The simulated water levels were about 4650 elevation at the Mogollon Creek confluence, dropping to about 4550 elevation at Winn Canyon, and 4510 elevation at the Route 211 bridge (SSPA, 2004, Figure 5.2a). This is about 25 feet groundwater elevation loss per mile of river.

SSPA state that groundwater levels along all transects are very shallow near the Gila River and that observation well water levels respond rapidly to changes in the river's stage, indicating a good hydraulic connection between surface flow and groundwater. The shallow groundwater levels in the project study area (focus area) of this document are further discussed in Section 2.1.1.

The Gila Conglomerate in Tyrone and Hurley, although located about 25 miles southeast of the project area, was aquifer tested by consultant DBSA (2007, unpublished). For Hurley in 46 tests, the hydraulic conductivity ranged from 0.03 to 800 ft/day (geometric mean = 13.9 ft/day), and the storage coefficient (specific yield) ranged from 0.10 to 0.15 (geometric mean = 0.012? likely 0.12). Their Tyrone tests (13 tests) showed hydraulic conductivity of 1.0 to 339.1 ft/day (geometric mean = 9.44 ft/day); the storativity was from 0.014 to 0.073 (geometric mean = 0.028). DBSA considered the Gila Conglomerate storage properties as low to very high, overall as modest.

In SSPA's (2004) Reach 1 riparian groundwater flow model (the model relevant to this study in the focus area), the initial hydraulic conductivity and specific yield values were 150 feet per day and 0.2 for Layer 1 alluvium and adjacent terrace or other deposits, and 25 feet per day and a specific storage of 1.0 x 10-5 for Layer 2, considered as the Gila Conglomerate aquifer. After calibration, layer 1 specific yield was reduced to 0.05.

SSPA also mentioned on-farm percolation used in their riparian models was at a recharge rate of 0.00415 feet per day for 241 days of a typical irrigation season, or 1-foot of water.

2.1.1 Wells and Water Levels from the NMOSE WATERS Database

The conceptual area selected by the GBIC for a water storage project (Figure 2), and where an infiltration gallery or other collection structure might be located, was determined to be in Township 15S, Range 17W, Sections 11-14, 22-23, and Section 27.

Using this area, a query from the New Mexico office of the State Engineer (NMOSE) WATERS database – Water Column/Average Depth to Water for wells in the GSR Sub-basin of Grant County returned 95 well records, of which 13 wells fall within the project focus area (Sections 11-14). The date of measurement is not given so it is assumed that these depth to water levels were at the time of well construction. This seems to be the case if the Point of Diversion (POD) Summary sheets for a particular well are downloaded.

The list gives the PLSS Cadastral location, UTM NAD 83 Zone 13 coordinates, and the recorded well depths, depths to water, and resulting water column thickness. Of the 95 wells, the minimum, maximum, and average depth to water was 3 feet, 200 feet, and 46 feet, respectively.

Of the 13 wells in the four section focus area, the average depth to water is about 18 feet if three null records populated as zero, are neglected. The range is 3 feet to 40 feet bgl neglecting the zero readings.

The TNC-1 through TNC-4 wells (GSF 04453 POD14, -POD16 through -19) have depth to water levels representative of the Gila River channel floodplain alluvium of only 3 to 7 feet bgl. The other eight wells in the focus area west of the river range in depth from 55 feet to 140 feet deep and have deeper water levels considered to be representative of the underlying alluvium/basin-fill units (wells GSF03957 and GSF03399) and sandstone/gravel/conglomerate interpreted from the drillers' logs to be the Gila Conglomerate (wells GSF01915, GSF00576, GSF04160, and well GSF 00503). These depth to water values range from 18 to 40 feet bgl, generally about 25 to 30 feet bgl.

These well coordinates were imported as a GIS layer, and the 13 wells are shown on Figure 4.

These depth to water readings crudely define the maximum fillable vadose zone capacity thickness depending on where surplus run-off winds up, and if the seasonal water level fluctuations are neglected. Estimates of the storage capacity are given in Sections 3.0 and 4.0.

2.2 Soils and Infiltration Potential along the Gila River and Floodplain

Soil characteristics are fundamental in determining the amount of water they can hold and release. The soils in this study are those deposited in the Gila River channel and floodplain, in terraces and tributary drainages and alluvial fans. Important characteristics include soil type and gradation, textures and structure, porosity and void space, degree and type of cementation, if any, permeability, available water capacity and transmitting capacity, and composition.

Other than the boring logs of wells, two sources of soil data were investigated for this study:

- Natural Resources Conservation Service (NRCS) Soil Survey data, and
- Soil data from Reclamation's Upper Gila River Fluvial Geomorphology Study (2002)

These data are discussed in the following sections.

2.2.2 NRCS Web Soil Survey

A soil map covering T15S, R17W Sections 11-14 (the focus area of interest is shown within the blue box on Figure 3) was downloaded from the NRCS National Cooperative Soil Survey Website (http://websoilsurvey.nrcs.usda.gov). The map is shown on Figure 3.

Figure 3 shows soil distribution polygons in orange with the number associated with the soil type, as mapped by the NRCS along both sides of the main stem Gila River. The soil polygons

on the west side of the river, and covering the farm fields, are of particular interest as those areas generally coincide with the extents of the conceptual aquifer storage area shown on Figure 2.

Several symbols are present on the map. From NRCS's Map Legend, the vegetation symbol (looks like ¼ of an asterisk) represents "wet spots" while the three circle pyramid symbol represents "gravelly spots" and the filled circles represent "Perrenial Water."

The map shows three tributary drainages on each side of the Gila River. From upstream (top of map) going downstream on the east side (right side of figure), they are Spar Canyon (sections 6-8), Maldonado Canyon (sections 12-13, 7, and 18), and Garvin Canyon (14, 23-24). From upstream to downstream on the west side of the river, they are Doyle Canyon (sections 1-2, 12), Winn Canyon (sections 3, 10-11), and Bell Canyon (sections 15, 22-23).

The entire area of interest (blue box extents) encompasses 3933 acres. For the purposes of this appraisal study, soil survey areas or map units Nos. 43, 32, 33, 44, and 69 are those of greatest interest and relevance of a total 15 mapped areas, on the west side of the river in the general areas in which the aquifer storage was conceptualized (Figure 1 and Table 1). These six areas are not all the largest in the AOI in terms of acreage.

Table 1 Soil Characteristics and Depth to Water for Storage Concept, summarizes the soil unit names corresponding to the map unit numbers, percent of acres within the AOI for each unit, and the soil stratigraphy, and water storage and transmitting properties for each soil type, from the USDA soil taxonomy perspective. These are often qualitative, but very helpful in assessing the near surface soil profiles/areas as to their potential capacity for water storage and/or any impeding layers. This information is really only applicable in the upper 5 to 6 feet where manual excavation was possible. The "DTRL" column field means "Depth to Restricting Layer."

Of the six soil areas the five soil areas of most importance, covering most of the area shown as farm fields where land use would most permit storing water, having relatively large areas, and more favorable water holding and transmitting/drainage properties and flatter slopes are: 1) #43 Paymaster-Ellicot Complex, 2) #32 Manzano Loam, 3) #33 Manzano Loam (1-3 percent slopes). 4) #44 Paymaster-Ellicot Complex (1-3 percent slopes), and 5) Tesajo-Manzano Complex (1-3 percent slopes).

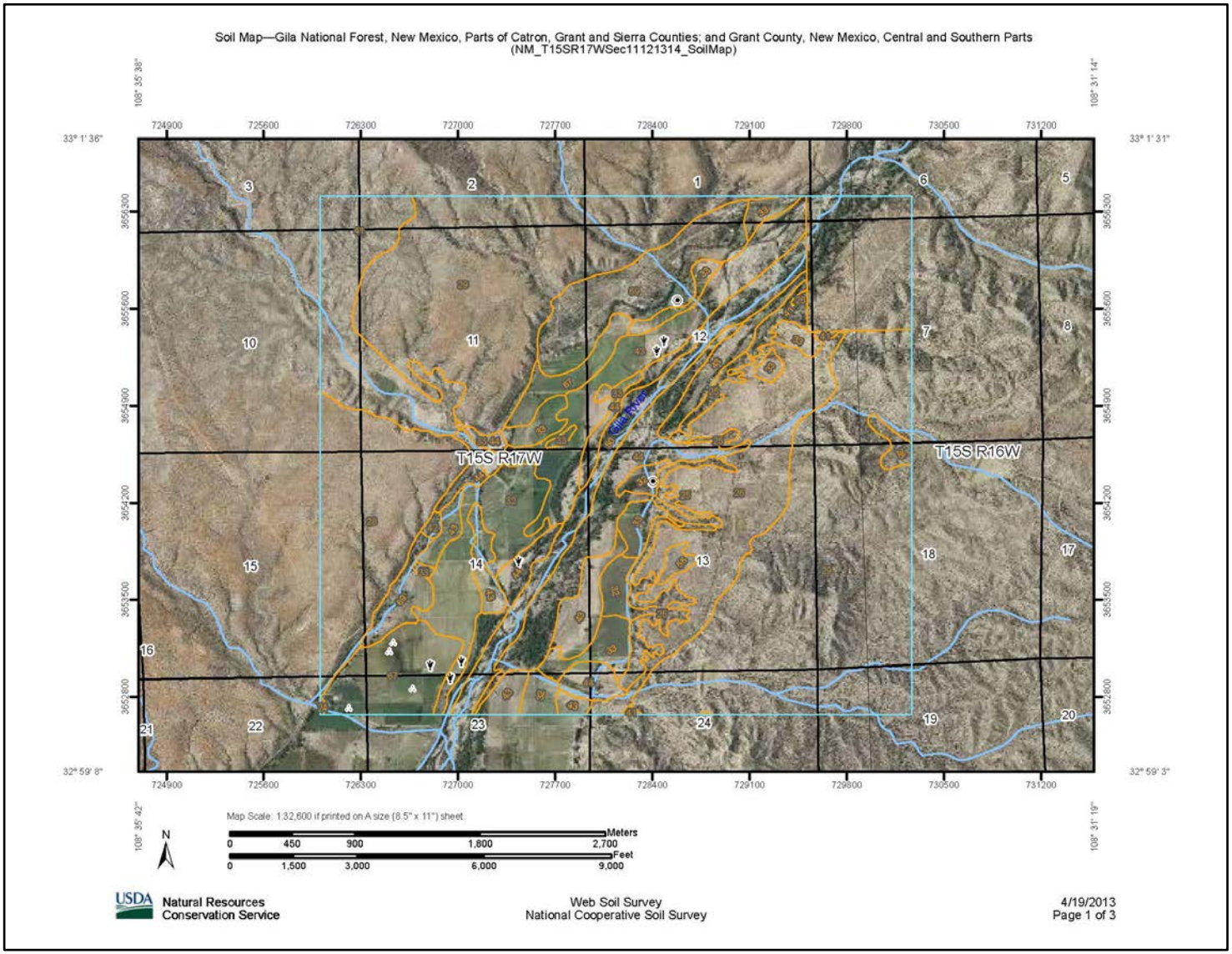

Figure 3. NRCS National Cooperative Soil Survey Web Soil Map for Focus Study Area

Table 1. Soil Characteristics and Depth to Water for Storage Concept - Township 15S, Range 17W, Sections 11-14; 22-23; 27 Cliff and Canteen Canyon Quadrangles - Grant Co., New Mexico

Map Unit Symbol	Map Unit Name: Unit Name	Map Unit Name: Primary %	Map Unit Name: Secondary %	Area of Interest (AOI) # Acres % AOI	Landform	Source and Soil Stratigraphy	Drainage Class	Transmitting Capacity of Most Limiting Layer (Ksat)	DTW (in.) DTRL (in.)	Available Water Capacity (in.)
43	Paymaster-Ellicott Complex 0 to 1 percent slopes	Paymaster 60 %	-	330.6 8.4	Alluvial Fan Floodplain	Mixed Alluvium Sandstone & Shale 0-14 in. Sandy Loam	Well Drained	High 2.0 to 6.0 in/hr	> 80 in > 80 in	Moderate ~ 7.8
43		-	Ellicott 20 %	-	Alluvial Fan Terraces	0 – 8 in. Gravelly Sand 8 -60 in. Strat. Coarse Sand to Sandy Loam	Somewhat Excessively Drained	High to Very High 6.0 to 20.0 in/hr	> 80 in > 80 in	Low ~ 4.0
32	Manzano Loam 0 to 1 percent slopes	-	-	192.5 4.9	Drainageways, intermittent Streams, valley floors	Mixed Alluvium Sandstone & Shale 0 -3 in. Loam 3 – 60 in. Clay Loam	Well Drained	Moderately High 0.2 to 0.6 in/hr	> 80 in > 80 in	High ~11.3
67	Stirk Variant Silty Clay Loam 0 to 1 percent slopes	-	-	156.6 4.0	Drainageways, intermittent Streams, valley floors	Mixed Alluvium Sandstone & Shale 0-2 in. Silty Clay Loam 2-60 in. Clay	Moderately Well Drained	Very Low to Moderately Low 0.0 to 0.06 in/hr	> 80 in > 80 in	Moderate ~6.1
33	Manzano Loam 1 to 3 percent slopes	-	-	153.9 3.9	Drainageways, intermittent Streams, valley floors	Mixed Alluvium Sandstone & Shale 0-3 in. Loam 3-60 in. Clay Loam	Well Drained	Moderately High 0.2 to 0.6 in/hr	> 80 in > 80 in	High ~11.3
44	Paymaster-Ellicott Complex 1 to 3 percent slopes	Paymaster 50 %	-	275.8 7.0	Alluvial Fan Floodplain	Mixed Alluvium Sandstone & Shale 0-10 in. Fine, Sandy Loam 10-35 in. Sandy Loam 35-60 in. Extremely Gravelly Loamy Sand	Well Drained	High 2.0 to 6.0 in/hr	> 80 in > 80 in	Moderate ~7.0
44		-	Ellicott 35 %	-	Alluvial Fan Terraces	Mixed Alluvium Igneous & Sedimentary 0-6 in. Gravelly sand 6-60 in. Coarse sand, Sandy Loam	Somewhat Excessively Drained	High to Very High 6.0 to 20.0 in/hr	> 80 in > 80 in	Low ~ 4.1

Table 1. Soil Characteristics and Depth to Water for Storage Concept - Township 15S, Range 17W, Sections 11-14; 22-23; 27 Cliff and Canteen Canyon Quadrangles - Grant Co. New Mexico

Map Unit Symbol	Map Unit Name: Unit Name	Map Unit Name: Primary %	Map Unit Name: Secondary %	Area of Interest (AOI) # Acres % AOI	Landform	Source and Stratigraphy	Drainage Class	Transmitting Capacity of Most Limiting Layer (Ksat)	DTW (in.) DTRL (in.)	Available Water Capacity (in.)
69	Tesajo-Manzano Complex 1 to 3 percent slopes	Tesajo 55 %	-	206.9 5.3	Drainageways, intermittent Streams, valley Floors	Mixed Alluvium Sandstone & Shale 0-9 in. Gravelly Sandy Loam 9-60 in. Very Gravelly loam	Well Drained	Moderately High to High 0.6 to 2.0 in/hr	> 80 in > 80 in	Low ~4.6
69		-	Manzano 15 %	-	Drainageways, intermittent Streams, valley floors	Mixed Alluvium Sandstone & Shale 0-11 in. Gravelly Sandy Clay Loam 11-60 in. Clay Loam	Well Drained	Moderately High 0.2 to 0.6 in/hr	> 80 in > 80 in	High ~10.6

Source: NRCS Web Soil Survey – National Cooperative Soil Survey

Table 2. Acreage of Six Soil Groups West of the River in the Focus Study Area & Within the Storage Area – Figure 4

Soil Group #	# Soil Polygons West of the Gila River	Individual Acres of each Soil Group Polygon West of The River (Includes 345 Acre Storage Area (Total Acres)	Individual Acres of each Soil Group Polygon Within the 345 Acre Storage Area (Percent of Storage Area)
43	3	17, 25, 175 (217)	131 Acres (38 %)
32	1	139 (139)	81 Acres (23 %)
33	7	7, 21, 3, 10, 3, 14, 17 (75)	54 Acres (16 %)
44	4	26, 8, 11, 42 (87)	12 Acres (3 %)
67	1	40 (40)	40 Acres (12 %)
69	2	40, 167 (207)	24 Acres (7 %)

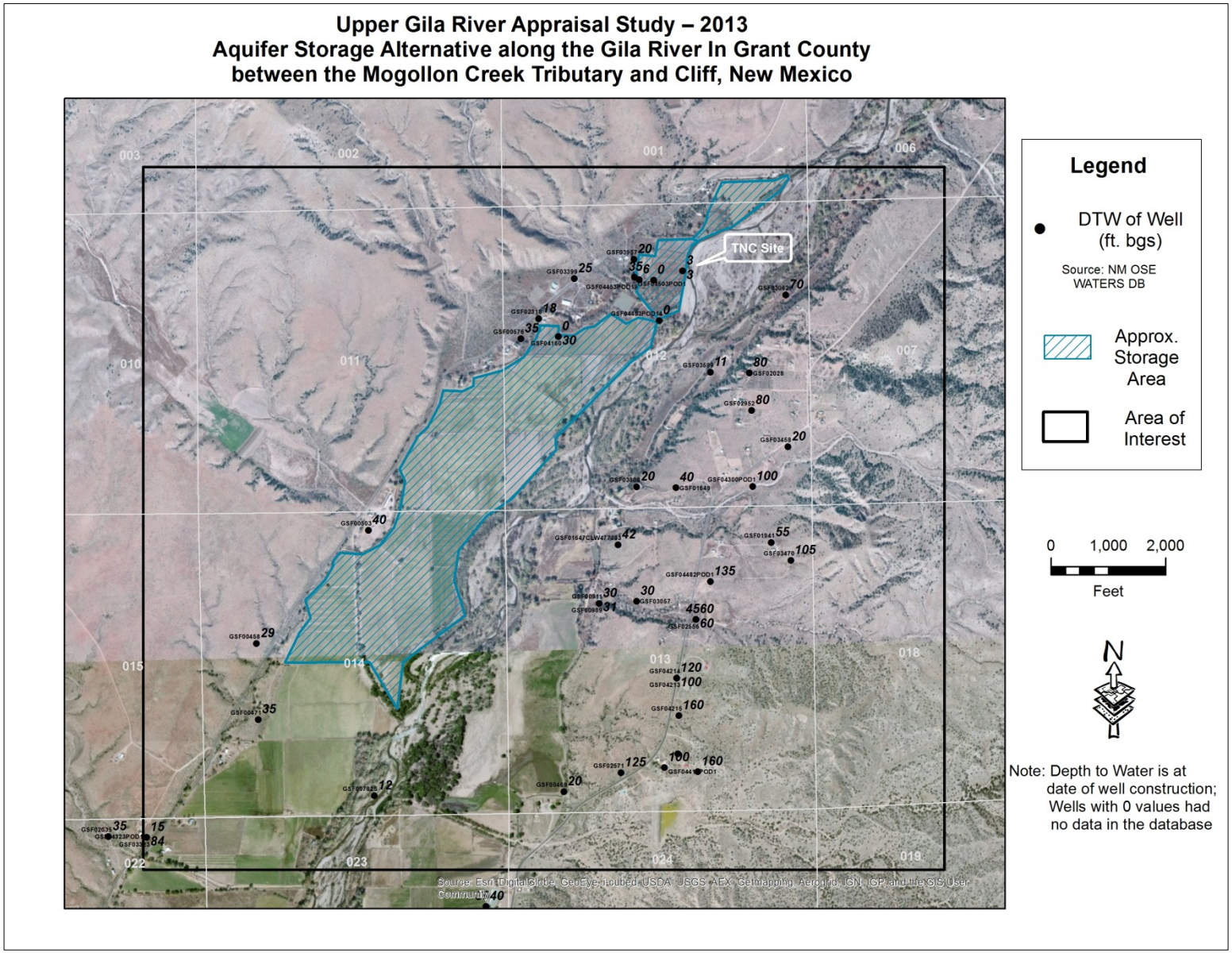

Figure 4. Study Area showing Wells and Recharge Area used in Analysis

Note that wet spots are mapped in soil areas #32, #43, #44, and #67 and gravelly spots in #67. This would be consistent with the shallow groundwater levels noted in SSPA's TNC transect and possibly clayey fines wicking capillary water to the surface.

Paymaster-Ellicot #43 has a maximum calcium carbonate content (cementitious property) of up to 2 percent, the Manzano Loam (#33), and Tesajo-Manzano Complex (#69) up to 4 percent, and the Manzano Loam (#32) and Stirk Variant (#67) soils up to 7 percent calcium carbonate. The Manzano Loams (#32-33) can also have up to 3 percent gypsum, a potentially soluble mineral, but a soil with anything less than about 10 percent is not considered susceptible to solution and collapse (NSSH, Title 430, Part 618). Therefore, the soils should not have particularly problematic impeding potential for water infiltration or mounding.

All soil groups except for the Stirk Variant (#67) are either well drained, or somewhat excessively drained where the secondary (less prominent) Ellicot soil predominates the Paymaster-Ellicot Complex (#43-44). The Stirk Variant (#67) is moderately well drained meaning there is a slowly permeable layer in or just below the active soil horizon, so it could be slow to percolate. Somewhat excessively drained soils are very permeable without mottling. This soil would be good for rapid infiltration of floodwaters for storage yet be able to hold water well. The degree of drainage reflects the natural condition of the soil when saturated.

The available water capacity is the capacity of the soils to hold water available to plants, in inches of water per inch of soil. It is also relevant when designing drainage or infiltration features. In irrigation and agricultural contexts, it is the difference between the amount of soil pore-water at field capacity and the amount of soil-pore water at a plant's wilting point. Field capacity is akin to the moisture content after 2 to 3 days since the soil was saturated.

All soil units except Paymaster-Ellicot Complex (#44) and Stirk Variant (#67) are in Hydrologic Soil Unit Group B. The other two are in Groups A and D, respectively (NRCS Part 630).

Soil Group B has a moderately low runoff potential when wet and an unimpeded water transmission through the soil; it has typically 10 to 20 percent clay and 50 to 90 percent sand with sandy loam or loamy sand textures. Soils having loam, silt loam, silt, or sandy clay loam textures can be Group B if they are of low bulk density, contain greater than 35 percent rock fragments, or well aggregated. The saturated hydraulic conductivity (Ksat) between the ground surface and 20 inches depth for the least transmissive (most limiting) soil horizon typically ranges from 1.42 inches/hour to 5.67 inches/hour. The specific soil Ksat is listed on Table 1.

Soil Group A soil Paymaster-Ellicot Complex (#44) has low wet runoff potential and water freely percolates through it (free draining) especially as it has less than 10 percent clay and much sand and gravel. The Stirk Variant (#67) is a Group D soil. As such, it has a high runoff potential, and tends to be restrictive or very restrictive (not free draining) with typically greater than 40 percent clay and less than 50 percent sand – a clay.

2.2.3 Upper Gila River Fluvial Geomorphology Study Soil Stratigraphy Sites

In 2002-2003 the Bureau of Reclamation's Technical Service Center – Denver Federal Center conducted geomorphology fieldwork along the Gila River in two separate reaches, one from the Arizona – New Mexico border to just downstream of the Highway 92 bridge in Hidalgo County, and the other reach in Grant County starting from T17 S, Range 17W north along the river through the project area. The second reach of investigation ended at the upstream diversion point in T15 S, Range 16W above Doyle and Miller Canyons. In all, 10 orthophoto image maps were generated with Maps 8-10 being of primary interest as they occur in the project focus area. Maps 8-10 were created using 40 meter DEM's and 1:10,000 scale aerials flown on March 2001.

Annotated are the limits of their geomorphic study with eroded banks and levee locations and river bank locations as of 1980. In addition, the three maps (not included) show four Soil Stratigraphy Description Sites or GNM# and the associated Geomorphic Analysis (GA#) locations. These are:

- GNM#4 located just upstream of the Highway 211 Bridge; GA#7-#8 on map 8
- GNM#5 located just downstream of the Highway 211 Bridge; GA#9-#10 on map 8
- GNM#13 located about one mile upstream of the GNM#4 site or 1.5 miles upstream of the Highway 211 Bridge near the lower diversion, and Bell Canyon; GA#5-#6 on map 9
- GNM#12 located just below Winn Canyon near the downstream end of the conceptual aquifer storage polygon shown on Figure 1; GA#1-#2 on map 10 and GA#3-#4 on map 9

These GNM data were not found by Reclamation's Denver Office.

Figure 5 is a gradation plot of 16 soil samples collected from eroded Gila River bank locations by the Bureau of Reclamation (USBR, 2004) in their *Analysis Reach* between the USGS Gage 09430500 and Ira Canyon. Ira Canyon is a left tributary just downstream of Mangus Creek. It is unknown which of the sample numbers 51-66 occur within the project focus area but the curves show all the soil sites to be similar along the Gila River through the Cliff-Gila Valley.

The curves show the soils to be clean gravels and sands with some small cobbles. The D_{50} size particle (USCS System) ranges from about 6.0 to 30.0 mm or fine gravel size while the D_{10} particle size (the particle size corresponding to the sieve size that allows 10 percent by weight of material to pass through) is from 0.25 to 1.0 mm, a fine to medium sand size. From 10 to 25 percent of the grains are finer than 1.0 mm. The maximum size clast is about 4 inches. Any fines once present, were likely washed out from the banks.

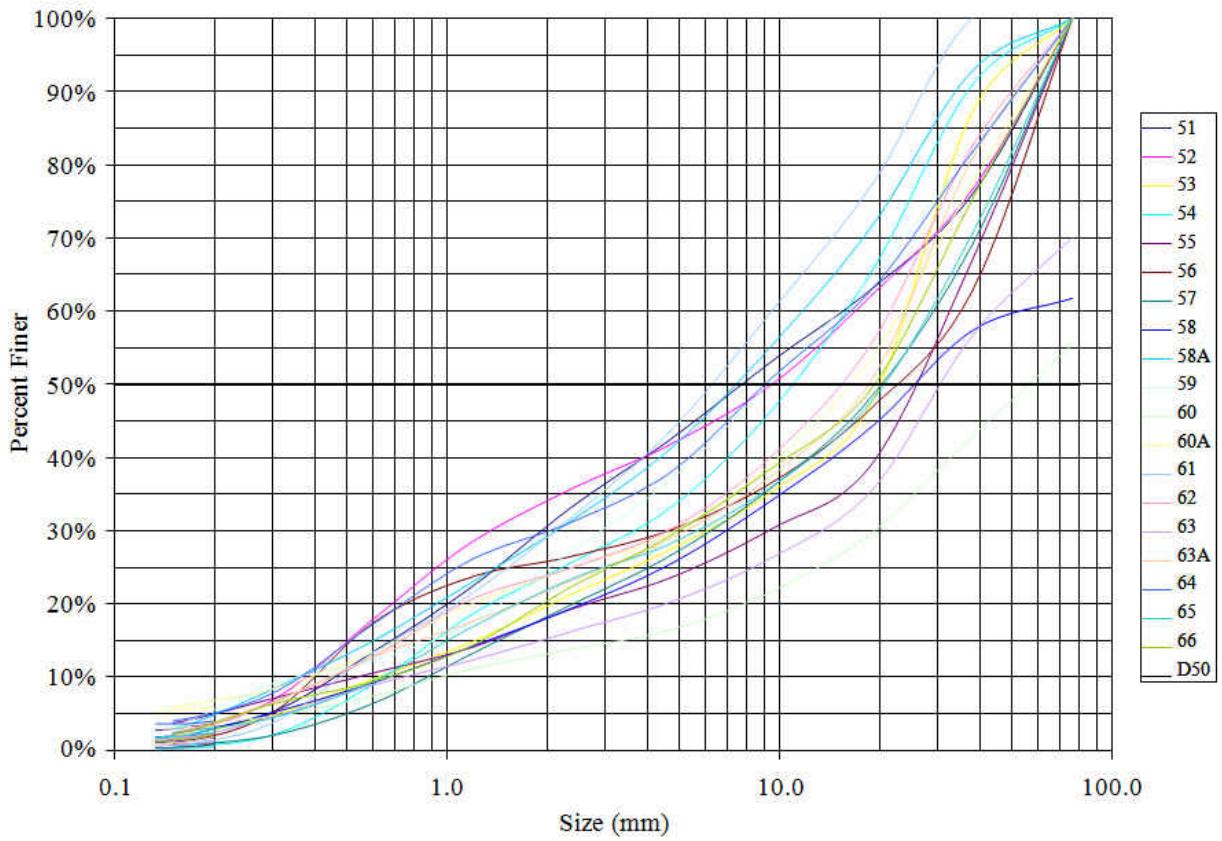

Figure 5. Gradation Plot for Bank Samples between Gage 09430500 and Ira Canyon (after USBR, 2004, Figure 13)

3.0 Storage of Gila River Water

Estimates of the aquifer storage capacity in this project consist of determining the fillable capacity of the vadose zone, or the partially saturated to unsaturated zone above the water table. The fillable capacity of the vadose zone is dependent on the thickness of this zone, which is defined by the depth to water both spatially and temporally, the lateral area of the storage zone in question, and on the material characteristics of the vadose soil zone. The material characteristics include the estimated specific yield, specific retention, in-place density and cementation of the soil matrix, and in-situ saturation from previous percolation events.

A number of simplifying assumptions are made to derive an initial estimate of the volume of water which could be stored neglecting time dependent recharge and discharge. It is assumed 1.) that certain land use restrictions, such as waterlogged areas, or areas having cultural features, are not factored into these estimates; 2.) that with the exception of some thin but unconsolidated surface or near-surface silt layers, there are no obvious clay layers or caliche seams (aquitards or impeding layers in the soil profile) from an inspection of fifteen NMOSE WATERS Drillers' Logs or S.S. Papadopulus & Associates, Inc. surface water-groundwater interaction piezometer boring logs; 3.) that the saturated zone in the alluvial aquifer is hydraulically connected to and continuous with depth into the full saturated thickness of the underlying Gila Conglomerate; 4.) that the average depth to water for the alluvial aquifer over the project focus area throughout the year is 18 feet bgl (from the 13 wells of the NMOSE WATERS database); 5.) and a range of specific yield is used to calculate the range of potential alluvial storage capacity (Table 3). It is also assumed there will be no additional storage in the Gila Conglomerate. The 345 acre storage area (shown on Figure 4) is assumed as a unit block of alluvial aquifer without considering that lateral storage increases elsewhere (e.g., under residences, roads, etc.) would in reality increase any potential estimates of storage volumes.

The storage capacity of the unconfined alluvial aquifer system (water table aquifer) is dependent on the specific yield. Specific yield is the physical drainage or dewatering (or filling of) of the water in the pore spaces by gravity in the alluvial matrix. Not all of the water filling the pore spaces can be drained or recovered due to some retention of water in the pores – specific retention. Specific yield plus specific retention of a porous medium equals the porosity.

The specific yield is defined as the ratio of the volume of soil voids that can be drained by gravity to the total volume of the saturated soil, or:

$$S_y = V_D/V_T$$

where:

V_D = volume of water drained by gravity, and

V_T = volume of saturated soil

The instantaneous storage capacity volume is then the product of specific yield, aquifer area, and addition in vadose zone head (ft.) in the fillable zone as water is recharged. or:

$$\Delta V = S_y A \Delta h$$

Specific yield is considered to be the storage coefficient for an unconfined (water table) aquifer. The storage coefficient is defined as the volume of water that comes out of (or goes into) aquifer storage per unit area of the aquifer, per unit decline (or rise) of hydraulic head. Quantitatively, the expression can be written as:

$$S = \Delta V / A \Delta h$$

where:

ΔV = the volume of water coming into or going out of storage, and

A = the cross-sectional (per unit) area of unconfined aquifer, and

Δh = the change in hydraulic head

The conceptual polygon shown on Figure 2 is about 560 acres but not all of that area is useable. Five NRCS soil groups shown on Figure 3 (#43, #32, #33, #44, and #69), located west of the river in the focus area of study, primarily sections 11-14, have the most favorable infiltration and storage properties from Table 1. Of the proposed 345 acre storage area (Figure 4 and Table 2), the acreage for each soil group is 131 (38%), 81 (23%), 54 (16%), 12 (3%), and 69 (7%) acres, respectively.

For instance, soil group #67 accounts for 40 acres but it is a silty clay loam and would not be expected to be a favorable soil for infiltration. The other five soil groups (#43, #32, #33, #44, and #69) have more favorable infiltration and storage properties. Table 1 in Appendix D summarizes the soil characteristics and estimated infiltration properties.

Figure 4 shows three polygons defining the extents of the farm/open fields where infiltration gallery/collection infrastructure could be buried below the fields. These areas are estimated in

GIS at 18 acres, 22 acres, and 305 acres. This gives approximately 345 acres available for infiltration recharge of surplus water. Using a typical range of specific yield values, the following appraisal level estimated storage volumes are presented in Table 3. The 0.05 specific yield is based on S.S. Papadopulos & Associates, Inc. (SSPA) calibrated Reach 1 riparian model value for the layer 1 channel alluvium. A typical sandy, gravely, cobbly alluvium with some silty fines should have a specific yield of 0.2, or 20 percent. The following appraisal level estimated storage volumes are presented in Table 3.

Table 3. Estimated Vadose Zone Storage under Farm/Open Fields West of the River in the Potential Storage Area Using a Range of Specific Yield and Average Annual Depth-to-Water of 18 feet bgl.

Specific Yield	Acre-feet of Potential Storage (based on 345 acres)
0.05	315
0.10	630
0.20	1260

SSPA (2004) used an on-farm percolation rate in their riparian models of a recharge rate of 0.00415 feet per day over a 241 day typical irrigation season. At such a constant infiltration rate, and assuming all the soil groups have similar percolation rates to the farm fields, applying that rate to 350 acres would equate to a recharge rate of about 1.45 acre-feet per day or 350 acre-feet per 241 day irrigation cycle. Annually this would equate to about 1-foot of applied water.

The range of expected aquifer storage might then be roughly 315 to 1260 acre-feet at any given snapshot of time. Note that due to the low precision of the available field data and recharge storage area that would actually be utilized, a round qualitative range of roughly 350 to 1000 acre-feet would serve as a good appraisal level planning range.

These estimates don’t factor in transient (time-dependant) seepage outflows or other inflows into the 350 acre unit block of aquifer. Static water levels within the proposed approximately 350 acre groundwater storage area (the cross-hatched region shown on Figure 4), fluctuate seasonally in response to natural and artificial recharge (flood/storm water, agricultural return flows, stock tank seepage, river losses, etc.) and any diversions, pumping, or evapo-transpiration taking water out of groundwater storage.

This fluctuation in groundwater levels translate into corresponding changes in the available, seasonal vadose zone thickness available for storage of Gila River flood waters. The soil moisture content within the vadose zone will also vary, which also affects the amount and the

rate at which the diverted flood waters can be recharged in the 345 acre farm field area. These hydrologic processes are dynamic and the groundwater flow system (and thus potential aquifer storage capacity) is constantly in motion, moving from areas of recharge to areas of discharge. This is true whether some portion of Gila River flood flow is being diverted and recharged under the farm fields, or not. Additional flood flow recharge will cause static water levels to rise and a groundwater mound to form, which will increase hydraulic heads, changing groundwater gradients and increasing the rate at which groundwater will flow and migrate down-gradient, and laterally as baseflow discharge to the river, from the storage area. Thus, the potential aquifer storage volume will not be constant over a given year and the rate at which the aquifer storage area can accept recharge will vary throughout the year based on both natural and anthropogenic factors.

The aquifer and aquifer storage area is not analogous to a bathtub. Short of constructing a positive cut-off engineered barrier such as a slurry cut-off wall, secant pile or sheet-pile type cellular barrier wall around the 345 acre farm fields to a lower permeability formation (such as the underlying Gila Conglomerate, or deeper volcanic rocks), or by using hydrodynamic controls (pumping/injection wells), there is no practicable way to isolate the aquifer storage area as would occur if one could construct an underground storage tank.

3.1 Infiltration Collection Systems

Several different water collection system designs may be feasible for this project. Several types are:

- Infiltration Gallery
- Infiltration Trench
- Ranney Collector Well
- Horizontal Collector Well
- River Intake

Infiltration Gallery. An infiltration gallery is essentially a horizontal well or subsurface drain that intercepts underflow in permeable materials or infiltration of surface water. Infiltration galleries are usually constructed to discharge water into a pumped sump. The gallery can be placed below or adjacent to the river. The collector pipelines should always be enveloped with gravel. An infiltration gallery site requires permeable soils.

Infiltration galleries come in two basic configurations – bed-mounted galleries and on-shore galleries. In a bed-mounted gallery, the intake screens are buried beneath the water body in a constructed trench that is backfilled with a suitably sized filter pack material. In an on-shore gallery, the intake screen is buried in a trench constructed parallel to the water body shoreline, and is also backfilled with a suitable filter pack material.

Bed-mounted gallery – burial depths greater than 6 to 10 feet are generally not necessary: the

total amount of screen can be installed in a variety of lengths, from 5 feet to over 30 feet: the major controlling factor is the conductivity of the filter pack material, which can be engineered to exceed the native materials. Disadvantages include a large disturbed area, the water body must be diverted or otherwise prevented from flooding the excavation area; repair or replacement is difficult, shifts in the location of the water body (river migration, river stage changes, etc.) can affect the system's efficiency and yields.

The bed mounted infiltration gallery is not suitable for this project.

On-Shore gallery – all factors being equal, this type generally requires more screen than bed-mounted galleries. Burial depths of 6 to 10 feet are generally adequate. It does not require the diversion or damming off of the water body. Repair and replacement is easier. It does require a large disturbed area but maintenance costs are generally lower than bed-mounted systems. The controlling factor is the conductivity of the native aquifer materials as opposed to the filter pack materials. Also important in this project, shifts in the water body (river) will not make a major impact.

Since the primary controlling factors in any infiltration gallery design are the conductivity and the thickness of the alluvial/aquifer materials – it is critical that these factors be determined at the proposed site in order to arrive at any reasonable estimates of gallery designs, or even if a gallery system is practical or feasible. Figure 6 depicts the on-shore concept.

Following are the advantages and disadvantages of an Infiltration Gallery.

Advantages:

- Intake facility would be buried.
- No sediment disposal required.
- Could be installed outside of the river bed.
- Does not require diversion or damming off of the water body.
- Works with large river elevation fluctuations or minor lateral migration.
- Can install perforated pipe "backwash" systems to maintain hydraulic efficiency.

Disadvantages:

- Sands and gravels of sufficient stability to prevent movement of fines may be lacking.
- May have to construct a gallery with three times capacity to provide the required reliability.
- Readily allows surface contaminants migration into the subflow zone.

Infiltration Trench. Infiltration trenches are subsurface backhoe or hydraulic excavator trenches backfilled with various combinations of graded sands and gravels as engineered filters, and with or without filter fabric/geomembranes, designed to infiltrate and screen storm water. The filter gradation design is based on the gradation and physical characteristics of the native alluvial materials.

As with the infiltration gallery excavation, the trench concept in this project configuration may require some diversion or dewatering to allow trench walls to remain open for excavation and backfilling under shallow groundwater conditions, or a biopolymer slurry to hold the trench open while sands and gravels are placed through the water slurry. Further from the Gila River, the current depth to groundwater may be below the trench invert facilitating construction in the dry. Trench laterals could be placed and designed to convey filtered surface water to bleed back into the river at various points under low flow conditions.

Following are the advantages and disadvantages of Infiltration Trenches.

Advantages:

- Intake facility would be buried.
- No sediment disposal required.
- Works with large river elevation fluctuations or minor lateral migration.
- Can install perforated pipe “backwash” systems to maintain hydraulic efficiency.

Disadvantages:

- Sands and gravels of sufficient stability to prevent movement of fines may be lacking.
- Need to construct trenches outside the active river channel.
- Readily allows surface contaminants migration into the subflow zone

Ranney Collector Well. Another collector type is often referred to as a Ranney Collector Well. The Ranney system can be thought of as a hybrid between the bed-mounted and on-shore infiltration galleries. In a Ranney system, a vertical caisson shaft is installed at some distance from the water body and one or many radiating intake screens are pushed out from inside the caisson into the aquifer materials. The screen can be pushed out underneath the water body, parallel to the water body, or any angle in-between.

Following are the advantages and disadvantages of Ranney Collector Wells.

Advantages:

- Intake facility would be buried.
- No sediment disposal required.

- Works with large river elevation fluctuations or minor lateral migration.

Disadvantages:

- Sands and gravels of sufficient stability to prevent movement of fines may be lacking.
- Suitable alluvial materials with the required hydraulic characteristics.
- Can be expensive.
- Cobbles and boulders can hinder or stop advancement of screens.
- Generally not economically feasible for systems of 1.5 MGD (2.3 cfs) or less.
- Requires a sufficient thickness of saturated alluvium, generally at least 20 to 30 feet.

Horizontal Collector Well. A horizontal collector well is usually one or more long perforated pipes that lie transverse or normal to the river, and some distance below the river bed thalweg, usually below the scour depth. They can be either installed in trenches where the stream has been temporarily diverted, or dewatered, or using a horizontal directional drilling (HDD) operation.

Following are the advantages and disadvantages of Horizontal Collector Wells.

Advantages:

- Intake facility would be buried.
- Should install below the river scour depth.
- No sediment disposal required.
- Works with large river elevation fluctuations.

Disadvantages:

- Sands and gravels of sufficient stability to prevent movement of fines may be lacking.
- Suitable alluvial materials with the required hydraulic characteristics.
- Can be expensive when using horizontal directional drilling (HDD) methods.

Filtered River Intake. A river intake would consist of a pipeline that extends into the river and has a screening system at the end. The water would then be pumped into a settling basin or clarifier. The screens would be exposed to the elements in the river.

Following are the advantages and disadvantages for a river intake system.

Advantages:

- Can be installed in rocky areas.

- Works with large fluctuations in river elevation.
- Intake facility would be buried or below water line in river.
- Less sediment to dispose of than with a canal diversion.

Disadvantages:

- Intake is exposed in the river.
- Requires sediment trap.
- Settling basin or clarifier is exposed.

Each type or configuration has some common requirements as well as its individual advantages and disadvantages. Two of the basic requirements for all configurations of infiltration collection systems are the need for a suitable thickness of alluvial or aquifer material for the design of the gallery, and an alluvial or aquifer material with a sufficiently high hydraulic conductivity to permit the design of a reasonably sized system. Appendix A contains a detailed discussion of the infiltration gallery, along with the controlling equations and representative graphs of screen length versus hydraulic conductivity.

For the infiltration gallery, Ranney collector, and horizontal well types, in general, the deeper the screen is buried, and the higher the conductivity of the controlling materials, the shorter the total amount of screen that is required. In the case of the on-shore gallery, another controlling factor is the distance from the centerline of the trench to the water body – the closer the trench is to the water body, the shorter the total amount of screen that is required.

Any of the collector systems presented above would ultimately connect to the Upper Gila Ditch for conveyance to various terminal locations.

3.2 On Farm Storage Ponds

Several conceptual on-farm storage pond locations are shown on Figure 2 within the proposed aquifer storage area (Figure 4). Although these ponds are envisioned as only 1 to 5 acres in size, unlined ponds could store and recharge by bleeding off significant volumes of water to the alluvial aquifer, depending on the soil type(s) they would be excavated in, their infiltration characteristics, and how far they are from the river channel.

They would be excavated approximately 5 to10 feet into the floodplain alluvium and/or alluvial terraces along the west margin of the floodplain/alluvial fans and west of the Upper Gila Ditch where the water table is known to be deeper (e.g., 20 to 40-foot depth to water as shown on Figure 4). Ponds located too close to the river would have little to no storage capacity or would encounter water as the saturated zone is only several feet below ground as evidenced by wet spots (Figure 3) and the TNC Site borings (Figure 4). The elevation of the basin floors would be optimized to take advantage of gravity flow from Upper Gila Ditch

turnouts, or if necessary, placed to minimize the lifts if centrifugal pumps were utilized. Limited soil data exists and ring infiltrometer/percolation test data is unavailable to help estimate recharge infiltration rate. However, the NRCS Soil Survey Map could be helpful to site ponds having more favorable infiltration characteristics. As described under Section 2.2.2 and Table 1, Soil Map Units No. 43, 44, and 69 are classified as well drained, have high to moderately high transmitting capacity (0.6 to 6.0 inches/hour), are located in the western floodplain area, and consist of sandy, gravelly loams. Again, these attributes are applicable in the upper 6 feet of soil horizon. Digging deeper may intercept more pervious alluvium.

SSPA (2004) in their Reach 1 riparian flow model stated the on-farm percolation rate was 0.00415 feet/day during the irrigation cycle. This would be 1.5 to 7 acre-feet per year of recharge at a constant inflow. Recharge basins in Arizona show 1 to 2 feet/day. A clogging layer would develop but the basins could be ripped/scarified to maintain percolation rates.

3.3 Injection Wells

Injection wells are not suitable for this project due to the shallow groundwater conditions and the necessity for clean source water for injection.

3.4 Recovery Wellfield Simulations

As an alternative to constructing an infiltration gallery collection system in the alluvial aquifer to recover stored water, the viability of using shallow recovery wells was considered using a brief analytic groundwater flow model drawdown analysis. A numerical groundwater flow model analysis was beyond the scope of this appraisal study.

The objective was to see how many wells could be placed within the modeled domain assuming each pumps the same rate at the same time, in order to estimate the cumulative drawdown that might occur over selected pumping periods, using reasonable aquifer parameter values, idealized aquifer geometry, and an estimate of a practical but sustainable pump rate, all based on the limited alluvial aquifer data described and developed in this report.

Each well is assumed to pump at the same rate which was selected to be 300 gallons per minute, based on the lithologic descriptions from the Tetra Tech boring logs, from the drillers' logs of the NMOSE WATERS database, and riparian modeling discussed previously. This pump rate estimate was tested in the analytical model by seeing what the drawdown might be for a single well located in the middle of the model domain at two time periods – 30 days and 90 days pumping. This "unit" well showed a maximum drawdown next to the well of 17 feet and 18.5 feet, respectively, almost half of the estimated saturated thickness. The 1-foot drawdown contours are at 1000-foot and 2000-foot radii from the pump well, at those times. An observation well located 10 feet away from the pump well after 90 days showed 10 feet of drawdown.

The analytical model code used was THWELLS, which uses the Theis non-equilibrium well equation and principle of superposition to calculate drawdown (or buildup mounding) in an idealized confined, leaky confined, or unconfined aquifer with uniform regional flow or flat potentiometric surface using any number of production or injection wells. As the aquifer system is unconfined in this project, a Jacob's water table correction is applied in the equation. A flat water table (relative) superposition approach is utilized for these drawdown estimates.

The aquifer parameters used in the model have hydraulic conductivity set at 150 feet/day, the aquifer saturated thickness set at a constant 40 feet, and the storage coefficient, in this case, the specific yield, set at 0.1. The transmissivity was specified at 44,880 gallons per day per foot (gpd/ft). The aquifer thickness was assumed to be 50 to 60 feet. Lateral aquifer boundaries and initial conditions are not explicitly defined in this analytical model unlike in a numerical flow model. Image wells were not used to simulate recharge and barrier boundary effects, with the assumption that in the short 90 day time frame, idealized aquifer extents still hold. Adding image wells could be a future phase although it is expected numerical modeling would be undertaken anyways.

To see what the drawdown interference might be based on various well spacings, two unit wells pumping 300 gpm each were modeled spaced apart at 500 and 1000 feet. The 90-day maximum drawdown between them was about 25 feet for the 500-foot spacing, and 22.5 feet drawdown for the two wells spaced 1000 feet apart. In this 1000-foot apart scenario, the 1-foot drawdown contour was at about 2500 feet away from the wells. Adding two more wells for four total (a small wellfield), and pumping 90 days began showing the effects of well interference. A maximum 40 feet of drawdown is calculated at each well in this configuration although most of the region of the overlapping cones of depression showed about 18 feet of drawdown in an observation well located in the middle of the four well parallelogram.

Finally, a unit well pumping 500 gpm for 90 days showed 40 feet of drawdown. This rate was considered too high for the limited areal and vertical extents of the Gila River alluvium.

Using the unit well conditions of 300 gpm and a reasonable pumping duration of 90 days (to emulate a summer irrigation schedule), a staggered wellfield configuration of wells was laid out on the west side of the Gila River in the proposed 350 acre aquifer storage area (Figure 4). A rectangular analytical model domain was overlain on the storage area with dimensions of 12,000 feet by 2000 feet. The domain width of 2000 feet includes the Gila River channel and floodplain, and lower terrace sediments. Using well spacings of 1000 feet and 500 feet within this domain, conceptual staggered wellfields of 17 and 34 wells, respectively, was specified within this footprint.

For the 17 well wellfield with 1000-foot well spacing, drawdowns in the model extent ranged from 5 to 40 feet or more maximum at the wells, with an average drawdown of about 16 feet, and a 75%-tile of 19.6 feet. The 34 well wellfield spaced 500 feet apart, showed a minimum drawdown of 10 feet and maximum of 40 feet or more at the wells, with an average drawdown of about 37 feet, and the 25 through100%-tiles at 40 feet. Most of the analytical model grid was dewatered except for about 1000 feet of aquifer at the ends of the model grid.

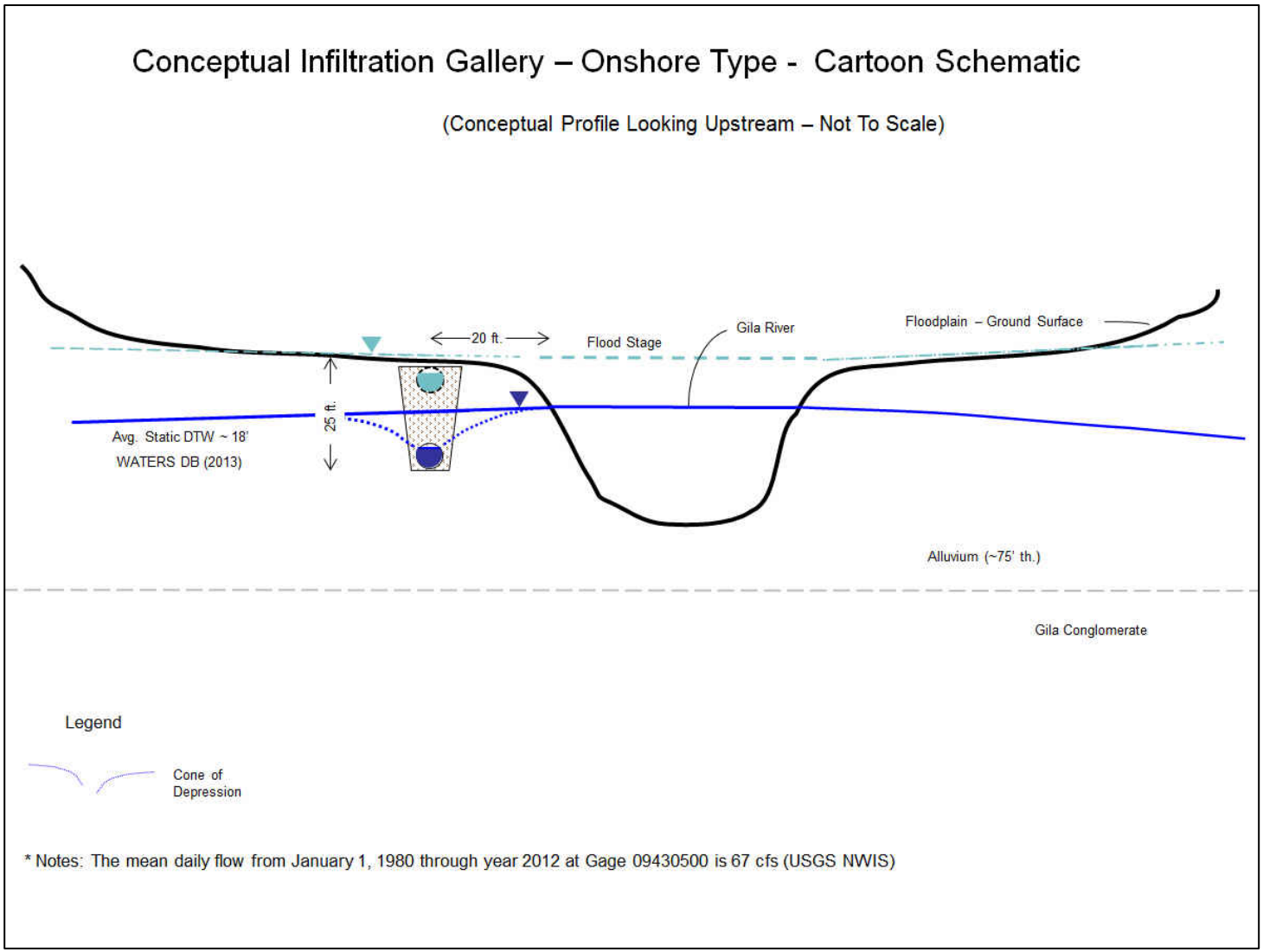

Figure 6. Conceptual Infiltration Gallery – Onshore Type

4.0 Conclusions

A limited volume of Gila River floodwater can be stored within the floodplain alluvium on the west side of the river channel in the area delineated by the GBIC, between the Mogollon Creek and Bell Canyon tributaries in the Cliff-Gila Valley. The available area in which to construct percolation pipe/collection infrastructure is only about 350 acres, if it is assumed that only existing open fields and fallowed farm land can be disturbed by construction.

The estimated appraisal level volume of stored water ranges between about 315 and 1260 acre-feet of water; however, these numbers imply more precision than warranted based on limited soil and water level field data, and necessary assumptions regarding available land use areas, soil storage capacities and uncertainties regarding lateral aquifer boundaries. A round planning level recharge range may be about 350 to 1000 acre-feet of surplus Gila River flood water at any given time, using a reasonable range of specific yield soil values (0.05, 0.10, and 0.20).

Note that the potential aquifer storage volume and retention/rate of outflow will not be constant over time. Local and regional water levels fluctuate due to natural hydrologic factors like recharge, soil-moisture changes, seepage return flow and evapotranspiration discharges, as well as anthropogenic factors such as diversions and pumping. This storage estimate does not factor in transient storage change. The alluvial groundwater storage is not analogous to a bathtub – it is not a closed system. A calibrated numerical groundwater flow model would be required to track the storage and disposition of recharged water.

There is some information on the soil types and estimated infiltration/storage properties of the alluvial materials comprising the Gila River alluvial aquifer, mostly from the NRCS Web Soil Service Data site, as well as limited soil boring data collected by several different consultants for the Nature Conservancy study, and for a riparian groundwater model study. Sixteen soil samples (collected by Reclamation from eroded banks along the river for gradation analysis), showed the soils were clean to silty sands and sandy to silty gravels with some small cobbles.

Although the alluvial soils are generally considered to be suitable for infiltration, and have typical storage capacity properties (specific yields), their limited lateral and vertical thickness along with a perennially shallow water table leaves little vadose zone capacity available for additional storage.

Water level information is sparse. The NMOSE WATERS database does list some depth to water information on shallow wells within the storage study area. However, these were taken at the time of well construction and many are out of date. The database shows that of 13 wells falling within the three sections west of the river (T15S, R17W, Sections 11, 12, -14), the average depth to water (potential vadose storage zone) is only 18 feet below ground level (bgl). TNC monitor wells show water levels near the river as only 3 to 6 feet bgl, with the water table hydraulic gradient sloping away from the river (losing condition) to only 20 to 40-foot depth below ground at maximum, at the western margins of the floodplain. NRCS soil maps show some wet spots and seeps which corroborates that groundwater is shallow and that waterlogging could be possible.

Any actual production wells in the alluvial aquifer should not be spaced any closer than about 1000 feet, and number less than 20 wells each at 300 gpm or less, from this preliminary analytical modeling work. The alluvial aquifer between the Mogollon Creek and Bell Canyon Tributaries (the aquifer storage area described in this report) have similar lithologic and hydraulic characteristics to the alluvial aquifer further downstream between Sycamore and Mangas Creeks. The simulation results are for the analytical model domain (GBIC Concept) described in this report, but similar drawdown trends for a 300 gpm unit "well" would be expected in the alluvial aquifer below Sycamore Creek. The one caveat is that the lower aquifer may have more areal length in which to place wells. Therefore, drawdown effects may be less severe given the same 17 well wellfield configuration at 1000-foot spacing; provided, not too many additional wells are added.

5.0 References

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APPENDIX A

Infiltration Gallery Collection Systems

General

Horizontal collector intake systems, which are essentially just horizontal wells, are of two general types – bed-mounted and on-shore systems. There are several parameters, as in more traditional vertical wells, that concern flow velocities within the pipes and screens that are also important to horizontal collector systems. These parameters are inflow velocity through the screen slots and the flow (axial) velocity through the screens themselves.

The inflow velocity through the screen slots should be limited to 0.1 ft/sec or less. Inflow velocities greater than 0.1 ft/sec can damage the screen and shorten the life of the well. Inflow velocities can be controlled by proper selection of screen slot sizes, diameter of the screen, length of screen, percent of open space per foot of screen (design of the slots), and filter pack material.

The axial velocity inside the screen should be 3 ft/sec or less so that the head loss between the well and the surrounding matrix is 1 ft or less. This can also be controlled by proper selection of screen diameter, length of screen, burial depth below static water level, and the production rate, Q, of the system.

There are a number of factors to be considered when deciding between a bed-mounted or on-shore infiltration gallery. They are:

1. Yield requirements: galleries placed under a water body initially produce about twice the yield of galleries place adjacent to the water body. As the disturbed lake or river bed assumes its normal sedimentation regime, the transmissivity values will fall as finer grained particles infiltrate the filter pack material surrounding the screens. This reduction in transmissivity values can be somewhat offset by use of backwash systems (discussed below).

2. Water quality requirements: galleries located adjacent to a water body usually receive water that has lower turbidity and fewer bacteria than bed-mounted galleries because the water has been filtered more extensively.

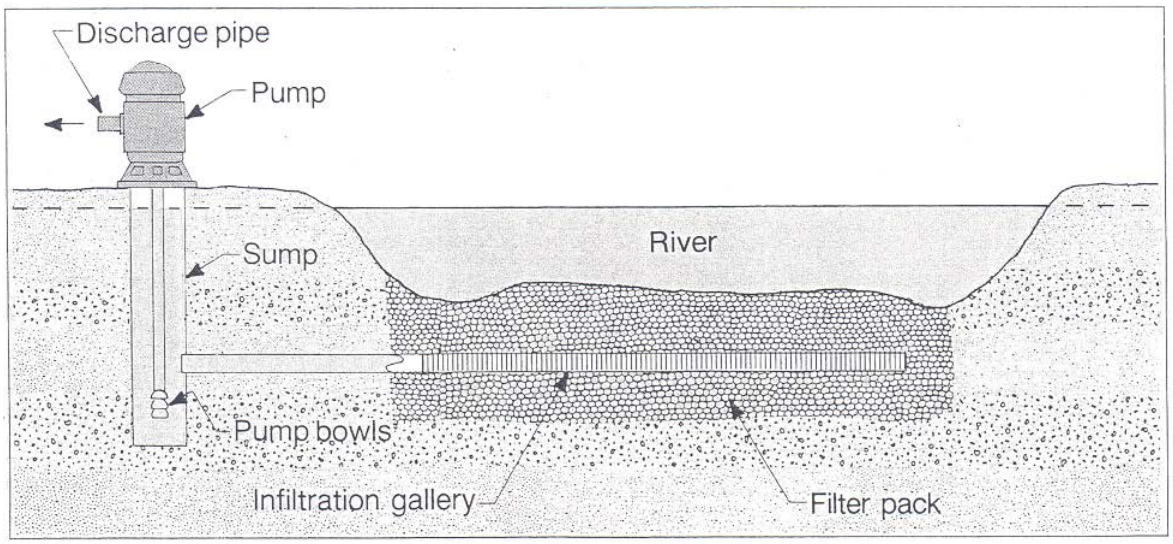
3. Construction difficulties: it is generally more difficult to install a gallery beneath a stream or lake bed.

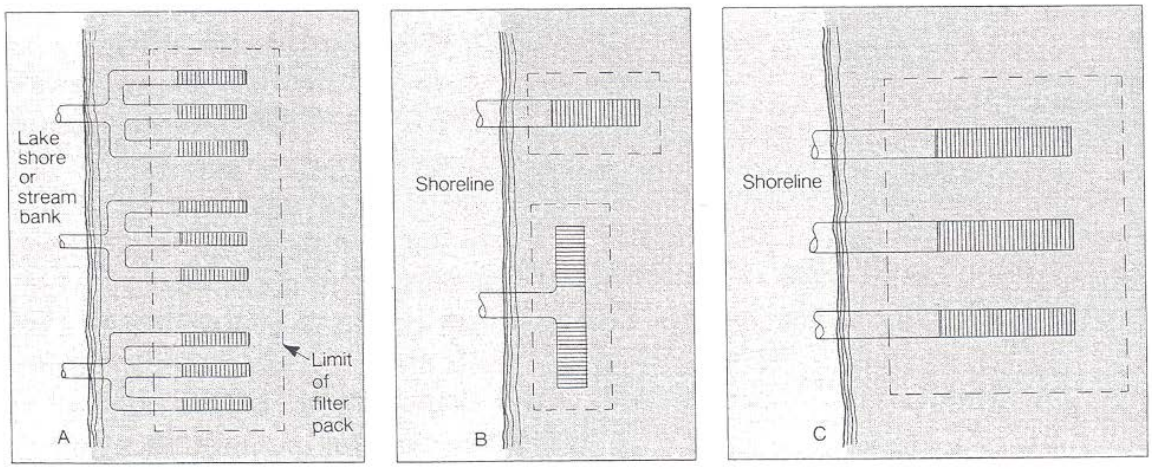
4. Maintenance considerations: maintenance and repairs are easier to perform on galleries installed adjacent to a water body. In general, more maintenance is required for bed-mounted galleries because fine material is continually added to the top of the filter pack by stream current.

5. Stability of the river course or lake level: rivers may meander great distances over relatively short periods, and either carry away a gallery placed on the river bank or cover completely a bed-mounted gallery with less permeable material. Changes in the elevation of a water body can also affect where the gallery is placed.

Bed-Mounted Infiltration Galleries

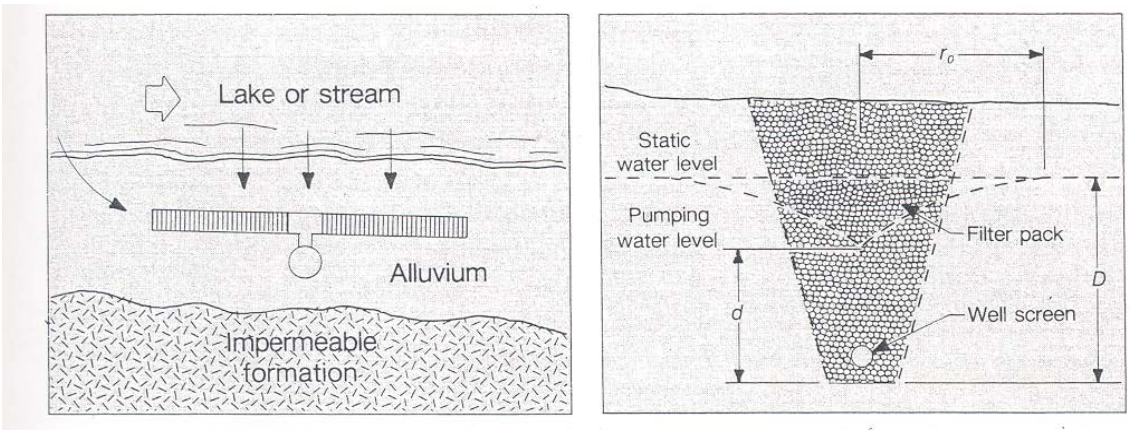
Bed-mounted infiltration galleries are systems where the screened intervals of the horizontal wells are beneath a water body such as a lake or river. The following figures (Driscoll, 1986, "Groundwater and Wells") show a typical cross-section of a bed-mounted gallery and plan view of some different configurations of screen arrangements for bed-mounted galleries.





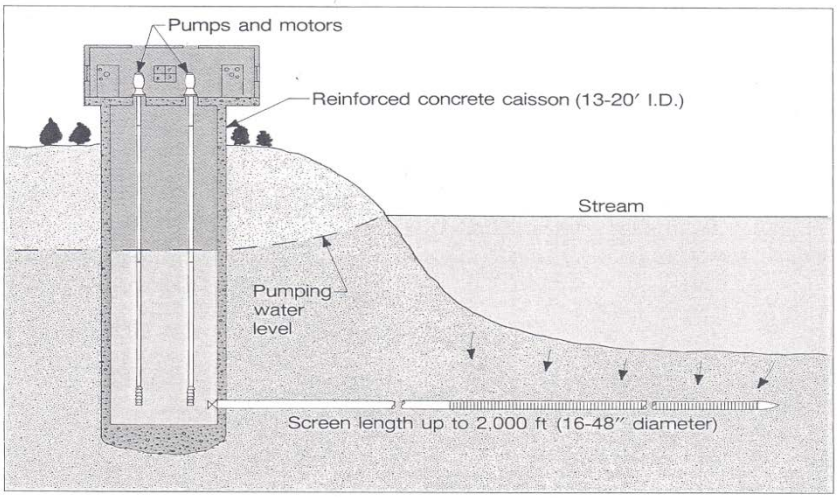
On-shore Infiltration Galleries

On-shore infiltration galleries are usually placed adjacent to a stream or river, less often adjacent to a lake. A single screen is run parallel to the bank or shore. Burial depths should be at least 4 feet, but because of limits on depths of trench excavations, they are generally not more than 25 feet deep. The following figures (Driscoll, 1986) show a typical cross-section and plan view of an on-shore infiltration gallery.



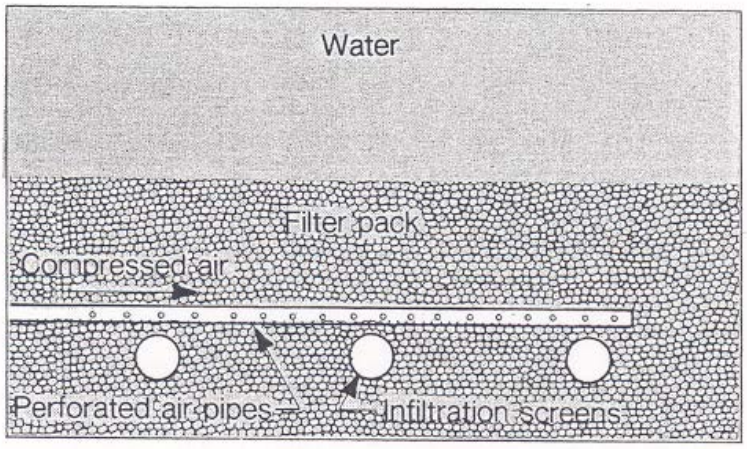
Collector Wells

A collector well is a special adaptation of infiltration galleries. Commonly called a 'Ranney Well' after the Ranney Corporation which first developed this type of system, it consists of a series of screens (called laterals) extending radially outward from a large central vertical caisson constructed adjacent to a stream, river, or lake. This system combines the features of bed-mounted and on-shore infiltration galleries because some of the laterals may extend beneath the water body while other laterals may be parallel to the bank or shoreline. The following figure (Driscoll, 1986) shows a typical cross-section of a Ranney Collector Well.



Backwash System

A backwash system can be installed with any infiltration gallery, although it is more difficult to install in a Ranney Collector Well than in systems installed by excavation or trenching. The system consists of perforated pipes permanently installed in the filter pack material or native materials above the screens. Compressed air can be forced through the perforated pipe to inject air into the filter pack. This has the effect of agitating the finer grained materials that tend to infiltrate into the filter pack over time. The agitation has the effect of loosening the finer grained materials and mobilizing it so that it moves out of the filter pack and into the water body where it is dispersed or removed by the natural water currents. Chemicals can also be injected into the backwash pipes, or the screens, for treatment of iron bacteria, organic encrustations, and inorganic incrustations. The following figure (Driscoll, 1986) shows a typical configuration for a backwash system. Although the figure shows the backwash system emplaced perpendicular to the intake screens, the backwash pipes can also be placed parallel and above the intake screens.



Flow Design

Driscoll (1983) provides a discussion of equations for computing the production rates (Q) of various designs and the length of screen necessary to obtain a desired Q. A report by International Water Consultants, Inc. for the City of Bismarck includes an equation for calculating the drawdown in the caisson for a Ranney Collector Well. These equations can be used to calculate the production rate of a single lateral or the entire collector well, or to compute the required length of screen for a given production rate.

These equations, both from Driscoll and from the International Water Consultants, Inc., were used to calculate the required length of screens for bed-mounted infiltration galleries, on-shore infiltration galleries, and Ranney Collector Wells. The results of these calculations are

discussed below, and are based on common values of permeability, conductivity, and porosity. The values used are for conceptual computational purposes only and are not meant to indicate or predict actual conditions along the Gila River – as the values for these parameters have not been established or determined accurately enough in this appraisal study for design. In the calculations, all parameters are held constant with the exception of screen lengths, diameters, and burial depths.

Results:
Inherent in all the designs is the necessity for the proper amount of Gila River alluvium to be used as the aquifer. This means that there needs to be material of appropriate hydrologic properties in sufficient thickness and lateral extent to accommodate the different design requirements for each type of system.

The results presented in Figures 1 through 3 are based on some assumptions of the conditions in the Gila River sediments. These assumptions are that:

1. The hydraulic conductivity of the alluvium ranges from 1600 to 5000 gpd/ft^2 [typical range of values for materials ranging from clean sands and gravels to silty sands and gravels with cobbles];

2. Gila River is about 1.5 to 2 feet deep on average;

3. That the alluvial materials are at least 50 feet thick in the case of the Ranney Collector Well system, and at least 15 feet thick for the bed-mounted and on-land infiltration gallery designs; and

4. That there is sufficient lateral extent of the alluvial materials present to accommodate the lengths of laterals and screen required.

The equations for the length of screen for bed-mounted infiltration gallery and the on-shore infiltration gallery are:

Bed-Mounted

$$L = \frac{528\ Q \log(1.1d/r)}{0.25\ K\ H}$$

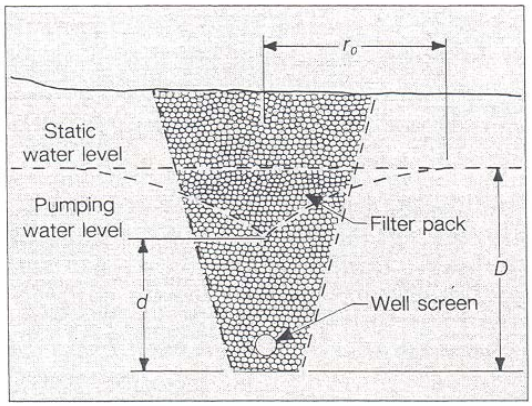
On-Shore

$$L = \frac{2880\ r_o\ Q}{K\ (D^2 - d^2)}$$

where:
L = length of screen required, in feet
Q = yield of the system, in gpm
K = hydraulic conductivity of filter pack, in gpd/ft^2 [bed-mounted]
K = hydraulic conductivity of the bank sediments, in gpd/ft^2 [on-shore]
H = head (distance from stream surface to center of the pipe, in feet

r = radius of the screen, in feet
r_o = radius of influence [On-Shore only]
d = burial depth (distance from channel bottom to screen center), in feet [bed-mounted]
d = saturated thickness of filter pack while operational, in feet [On-shore]
D = depth of the ditch/trench below static water level, in feet [On-shore]

The following figure is shown again to illustrate most of the variables.



So, for bed-mounted systems, the length of screen required is reduced when the radius of the screen is increased, the hydraulic conductivity of the filter pack is increased, the yield (Q) is reduced, and/or the head between the stream surface and the center line of the screen (a function of the depth of water in the stream and the burial depth) is increased.

Similarly, for on-shore systems, the length of screen required is reduced when the hydraulic conductivity of the sediments is large, the burial depth is increased, and the drawdown in the pipe trench is increased. Increasing the drawdown in the pipe trench will be somewhat offset by the increased radius of influence of the drawdown.

All factors being equal, the bed-mounted systems generally require less screen lengths then do the on-shore systems but construction is more difficult, and the river regime more altered.

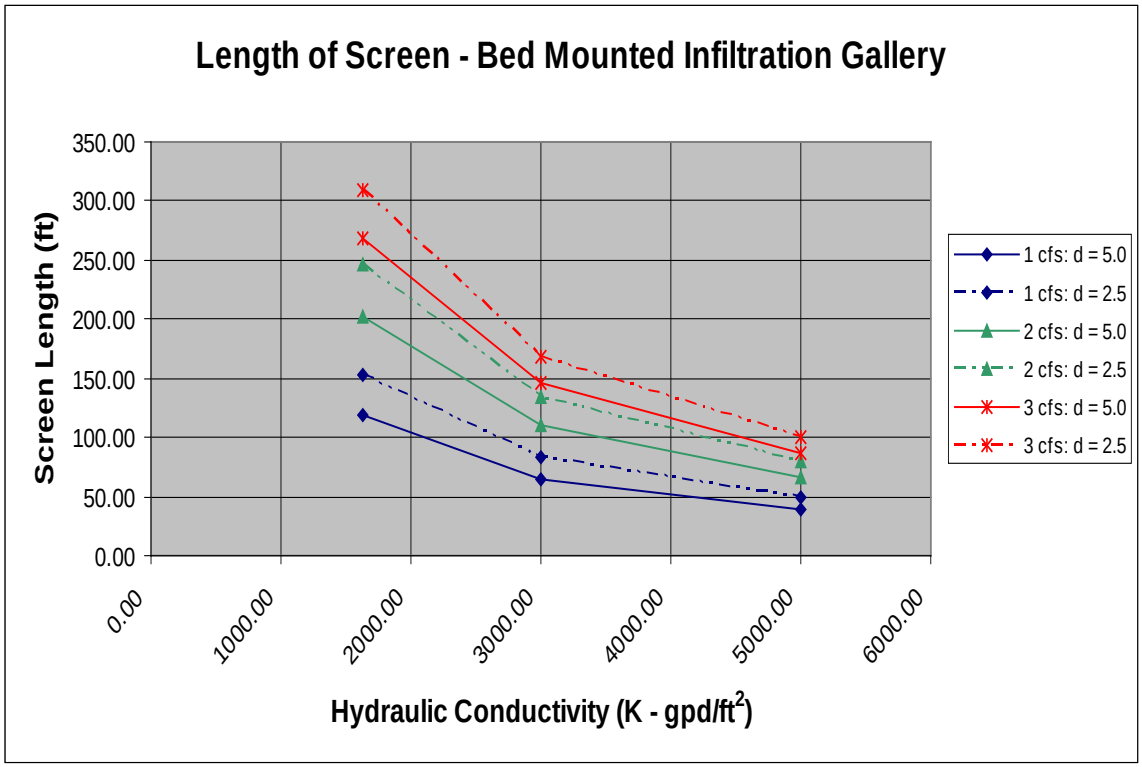
Since one of the design limitations is the axial velocity in the screens (ideally 3 ft/s or less), the first step is to compute the minimum radius of the intakes screen. The following equation (Driscoll, 1983) can be rearranged to solve for r, the minimum radii.

$$V = \frac{2.228E\text{-}3\ (Q)}{\pi\ (r^2)} \qquad r = \sqrt{\frac{2.228E\text{-}3\ (Q)}{\pi V}}$$

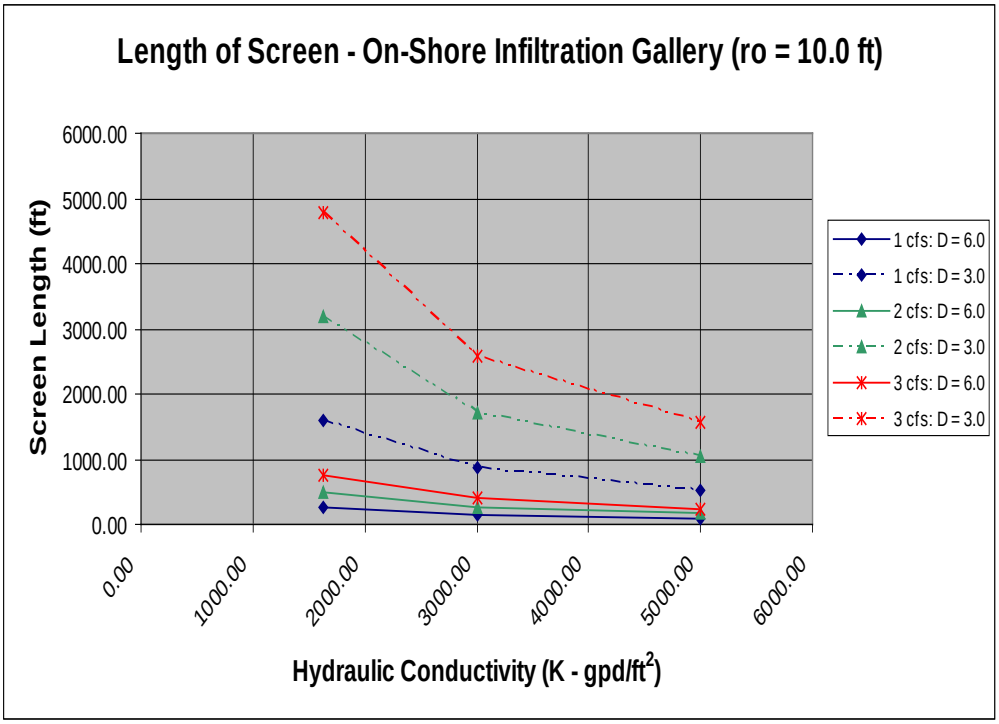
Q (gpm)	449.00	898.00	1347.00
Q (cfs)	1.00	2.00	3.00
Vp = Axial Pipe Velocity (ft/sec)	2.92	2.55	2.19
Pipe Radius (ft)*	0.33	0.50	0.66

* = Pipe radii have been adjusted to standard pipe sizes.

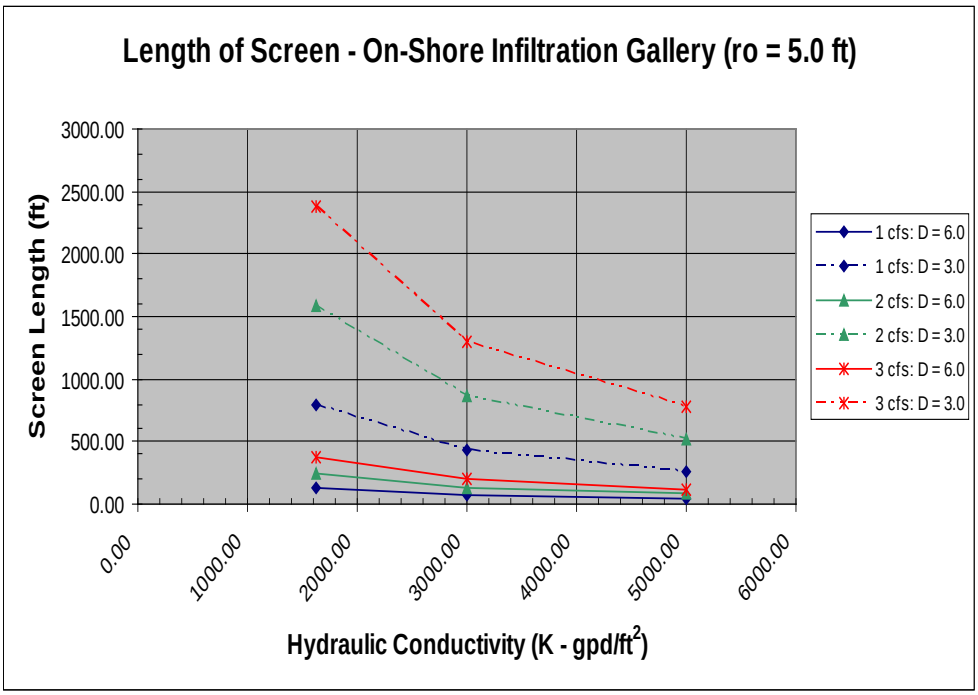
Using these pipe sizes, and solving the equations, the following graphs were produced for a range of Q's, burial depths, and material conductivities.



Graph 1. Bed-mounted infiltration gallery. The 'd' value represents the burial depth of the screen below the channel bottom.



Graph 2. On-shore infiltration gallery 10 ft from shore-line. The 'D' represents the depth of the trench below static water level.



Graph 3. On-shore infiltration gallery 5 ft from shore-line. The 'D' represents the depth of the trench below static water level.

As can be seen from Graph 1, the deeper the screen is buried, and the higher the conductivity of the filter pack, the less the amount of screen that is needed.

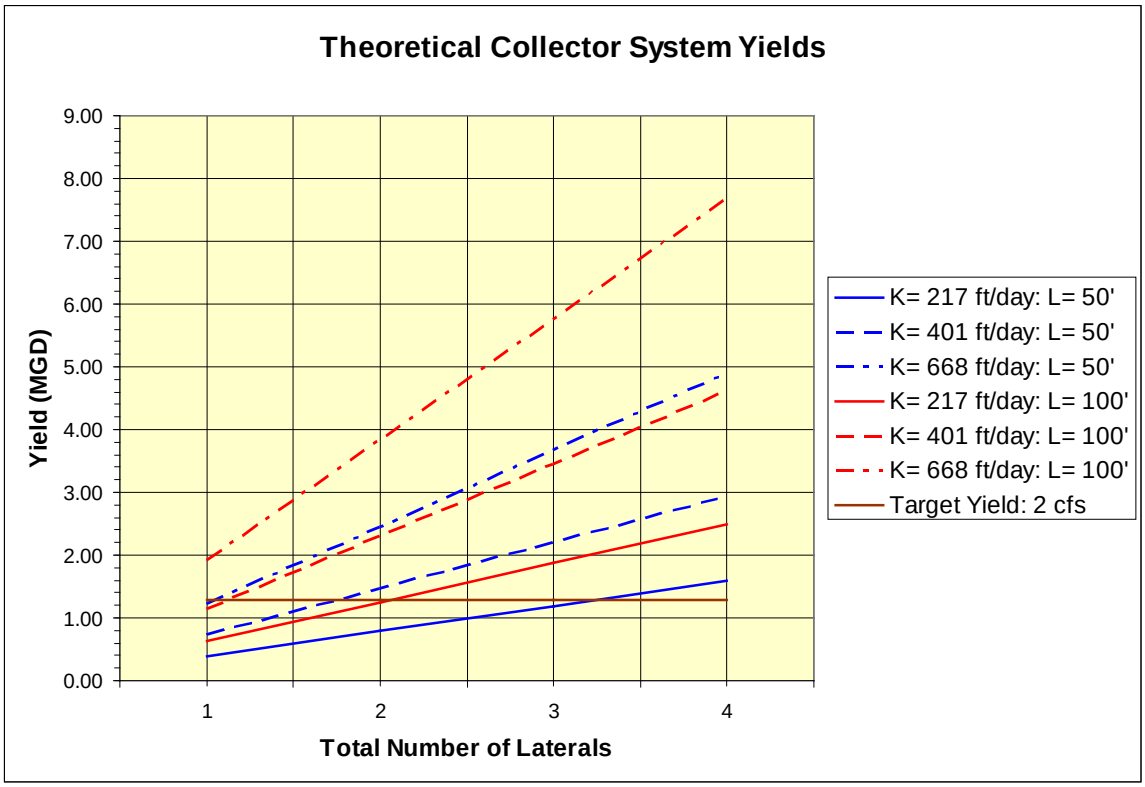
From Graphs 2 & 3, the deeper the screen is buried, the higher the conductivity of the native materials, and the closer the trench is to the shore-line, the less the amount of screen that is needed.

Another controlling factor in the design of wells is the intake velocity – or the velocity of the fluid as it flows through the screen. This velocity is simply calculated using the equation:

V = Q A where V = velocity in ft/s; Q = yield in ft^3/s; and A = area of openings per foot of screen in ft^2.

Solving for A, and converting ft^2 to $inch^2$, the amount of open area per foot of screen for the bed-mounted system (for the 2cfs case) ranges from 12 $inch^2$ to 44 $inch^2$, and for the on-shore system (at 2cfs) it ranges from 6 $inch^2$ to 36 $inch^2$. PVC screens have open areas in these ranges in slot sizes down to about 0.05 inches (coarse sand sized slot openings) while stainless steel screens have open areas exceeding these ranges in slot sizes down to 0.01 inches (fine sand sized slot openings). Using stainless steel screen with more open area per foot of screen than the minimum needed will result in an intake velocity less than 0.1 ft/s.

The following graph is the calculated yields per number of laterals in a Ranney Collector System. The graph assumes that the caisson is 100 ft from Gila River, that there is 20 ft of saturated alluvial/aquifer materials, and that the laterals radiating out from the caisson are all 1 ft diameter (for an axial velocity of 3 ft/s or less) and are 15 ft below the static water levels.



Graph 4. Theoretical Collector System yields.

The blue lines represent 50 ft long laterals and are at the same three K values that were used for the bed-mounted and on-shore graphs, namely 1626, 3000, and 5000 gpd/ft^2. The red lines represent 100 ft long laterals at the same three K values. The brown line represents the target yield of 2 cfs (1.292 MGD).

As can be seen from Graph 4, lower conductivity materials require more laterals. Since the conductivity of the materials is the major controlling factor, increasing the size of the laterals only has minimal effect on the yields, whereas increasing the length of the laterals (the red lines in Graph 4) has a significant impact on the yields – fewer laterals for a given yield, or more yield for a given number of laterals.

Ranney systems generally tend to be the most efficient – but 2 cfs (1.292 MGD) is getting near the lower end of economically feasible systems. This is primarily due to the initial capital cost of the caisson which is the same regardless of the size of the yield.

Appendix – E – Geophysics Testing

The work was done to determine depth of alluvium over bedrock at possible dam sites. The data provided a better understanding of what type of dam foundation work would be required and allows for more accurate excavation quantity calculations for cost estimates.

RECLAMATION

Managing Water in the West

Technical Memorandum 85-833000-2014-38

Seismic Refraction Surveys Gila River Diversion Project Gila, New Mexico

U.S. Department of the Interior
Bureau of Reclamation

July 2014

Mission Statements

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

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

Technical memorandum
TM-85-833000-2014-38

Seismic Refraction Surveys
Gila River Diversion Project
Gila, New Mexico

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7/25/14
Date

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7/11/14
Date

of the
Reclamation Technical Service Center
Seismotectonics & Geophysics Group
Denver, Colorado

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1.0 Summary

Seismic refraction surveys have been performed at five valley sites near Gila, NM. The purpose is to map the subsurface velocity structure with respect to flood plain sediments, underlying partially cemented alluvium, and underlying bedrock. Bedrock types include both sandy conglomerates and volcanic andesite depending on the site. Most sites are believed to have an overlying layer of consolidated alluvium on top of the bedrock. Top of bedrock velocity ranges from approximately 7,000 ft/sec to 9,000 ft/sec. Most locations are 9,000 ft/sec. Top of consolidated alluvium is believed to range from 6,500 ft/sec to 7,000 ft/sec.

2.0 Background

The five sites surveyed include Diversion Site #1, Mogollon Creek, Winn Site, School House Site, and Mangas Creek. Bedrock geology at Mogollon Creek has been identified as a sandy conglomerate. Bedrock geology at School House Site and Mangas creek has been identified as andesite.

Two seismic lines were surveyed at Diversion Site #1. The creek bottom was too narrow between the canyon walls for a cross-canyon survey, so the lines were oriented parallel to the creek alignment (low channels to the north, high channels to the south). Two seismic lines were surveyed at the Mogollon Creek site both running perpendicular to the creek orientation. The creek split the extents of the two survey lines (both lines had low channels to the north, high channels to the south). One seismic line was surveyed at the Winn Site (low channels to the north, high channels to the south) running perpendicular to the direction of the valley. Two seismic lines were surveyed at the School house site, which overlapped by 50%, both running perpendicular to the creek alignment (low channels to the north, high channels to the south). Two seismic lines were surveyed at the Mangas Creek site, however Line #2 provided faulty data so just Line #1 was processed at that site on the northeast side of the creek (low channels to the southeast, high channels to the northwest).

3.0 Field Coordinates & Acquisition

Figure 1 shows the area map of the 5 seismic survey locations. Figures 2 through 11 provide the map views and topographic perspective views of each of the five sites and each line surveyed at those sites. Overhead maps of each site label the lines surveyed and their orientation with respect to low end channels and high end channels. When comparing these maps to the processed velocity tomograms in Appendix A, "low end" of the lines correspond to the distance (x axis) "0 feet" on the tomograms and "high end" of the lines correspond to the greatest distance (x axis) on the tomograms. Combined tomograms are provided for each the Mogollon Creek site and the School House site, and they can be found in Appendix A.

Table 1 provides the GPS coordinates of the beginning and end of each seismic refraction line. Note that School House site is composed of two separate lines which overlap by 50% however GPS points are only provided at the outer extents of the combined line because the surveys were combined into one tomogram.

Line/Location	Longitude	Latitude
Diversion Site #1 Line 1 Low End	-108.538034°	33.061380°
Diversion Site #1 Line 1 High End	-108.538607°	33.060613°
Diversion Site #1 Line 2 Low End	-108.537591°	33.061853°
Diversion Site #1 Line 2 High End	-108.538001°	33.061174°
Mogollon Creek Line 1 Low End	-108.542599°	33.048444°
Mogollon Creek Line 1 High End	-108.543065°	33.047392°
Mogollon Creek Line 2 Low End	-108.543198°	33.047096°
Mogollon Creek Line 2 High End	-108.543383°	33.046115°
Winn Site Low End	-108.569824°	33.008092°
Winn Site High End	-108.570534°	33.007175°
School House Low End	-108.576667°	32.856305°
School House High End	-108.577634°	32.855120°
Mangas Creek Line 1 Low End	-108.570905°	32.857325°
Mangas Creek Line 1 High End	-108.571666°	32.857840°

Table 1 – GPS Coordinates of Seismic Lines

Figure 1 – Large Map of all 5 Sites

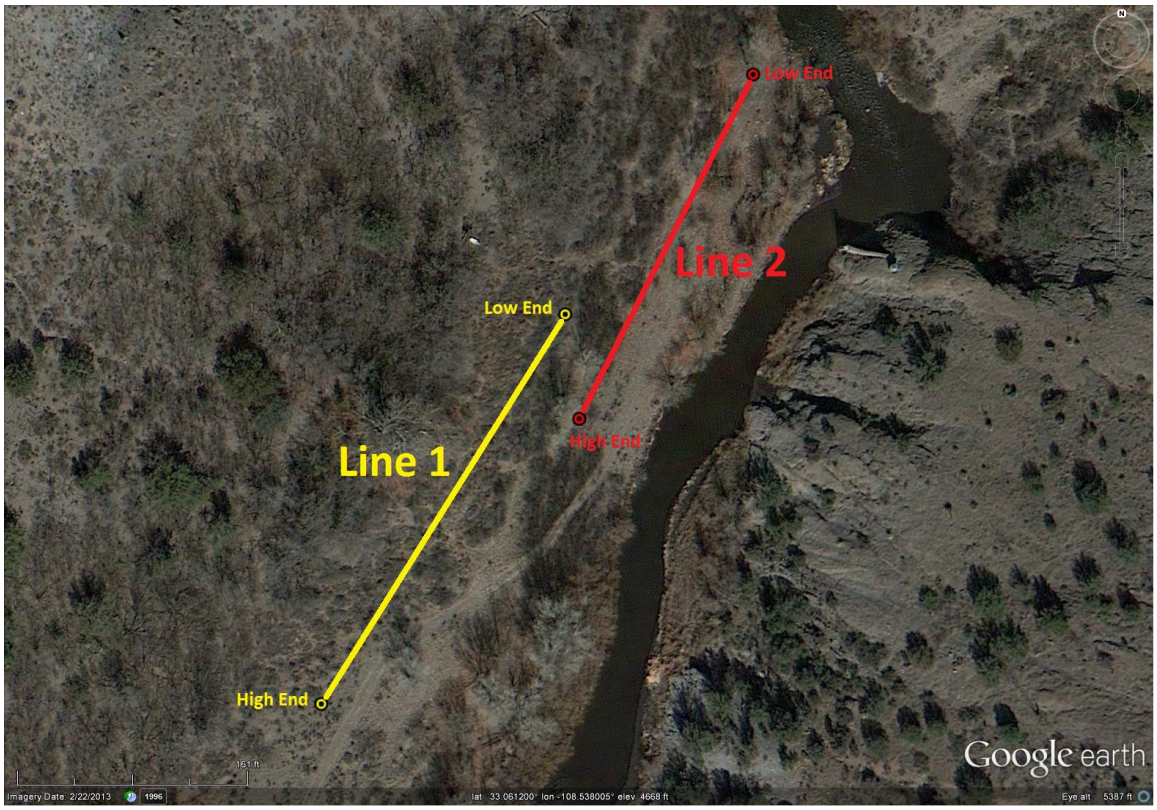


Figure 2 – Diversion Site #1 Map

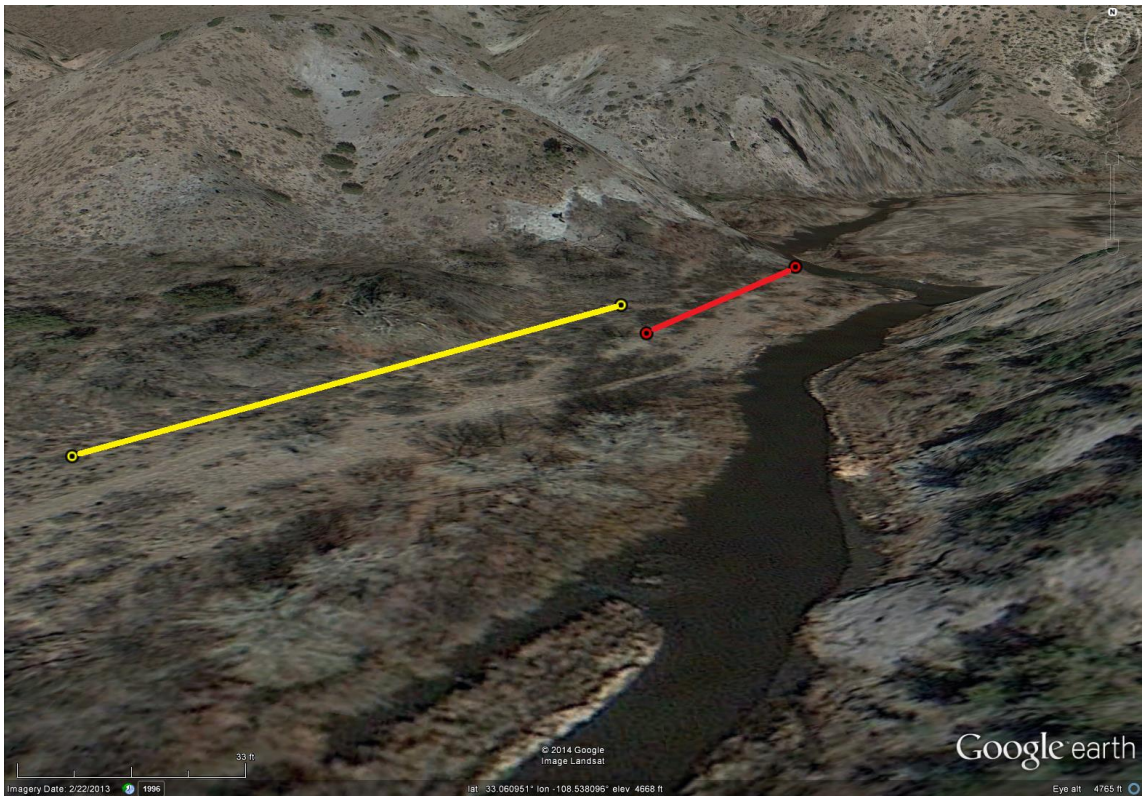


Figure 3 – Diversion Site #1 View Towards North

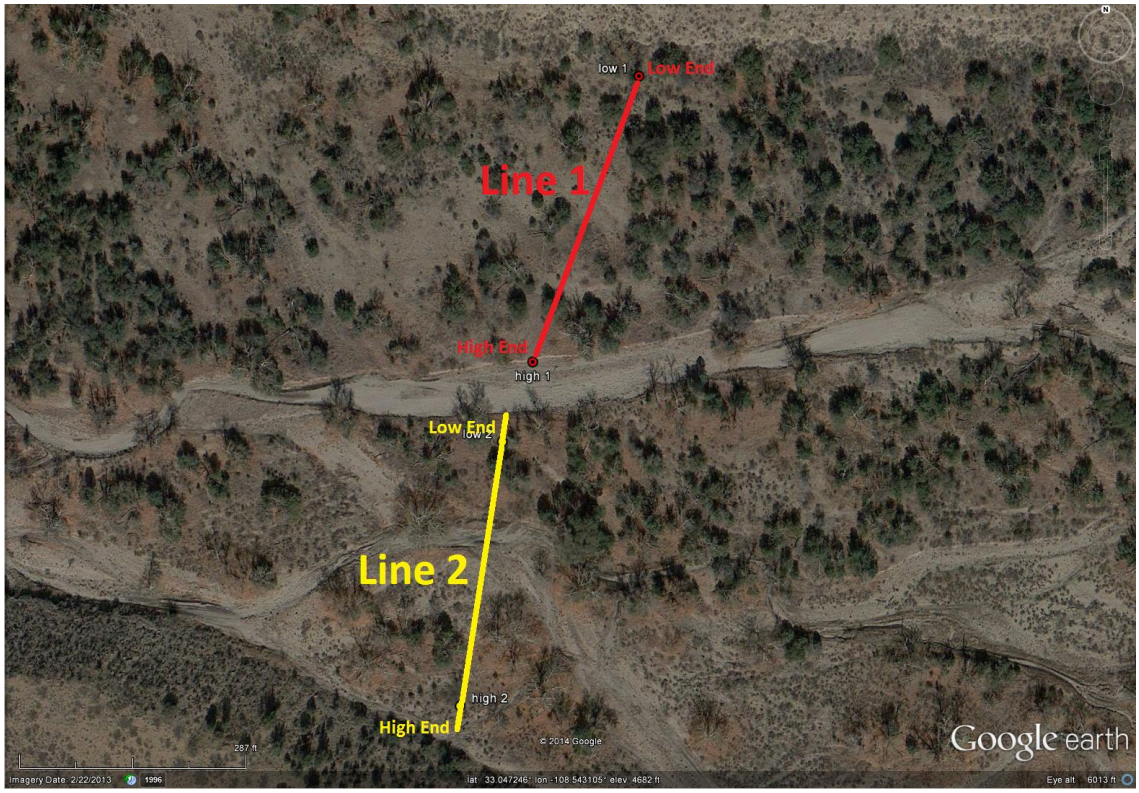


Figure 4 – Mogollon Creek Map

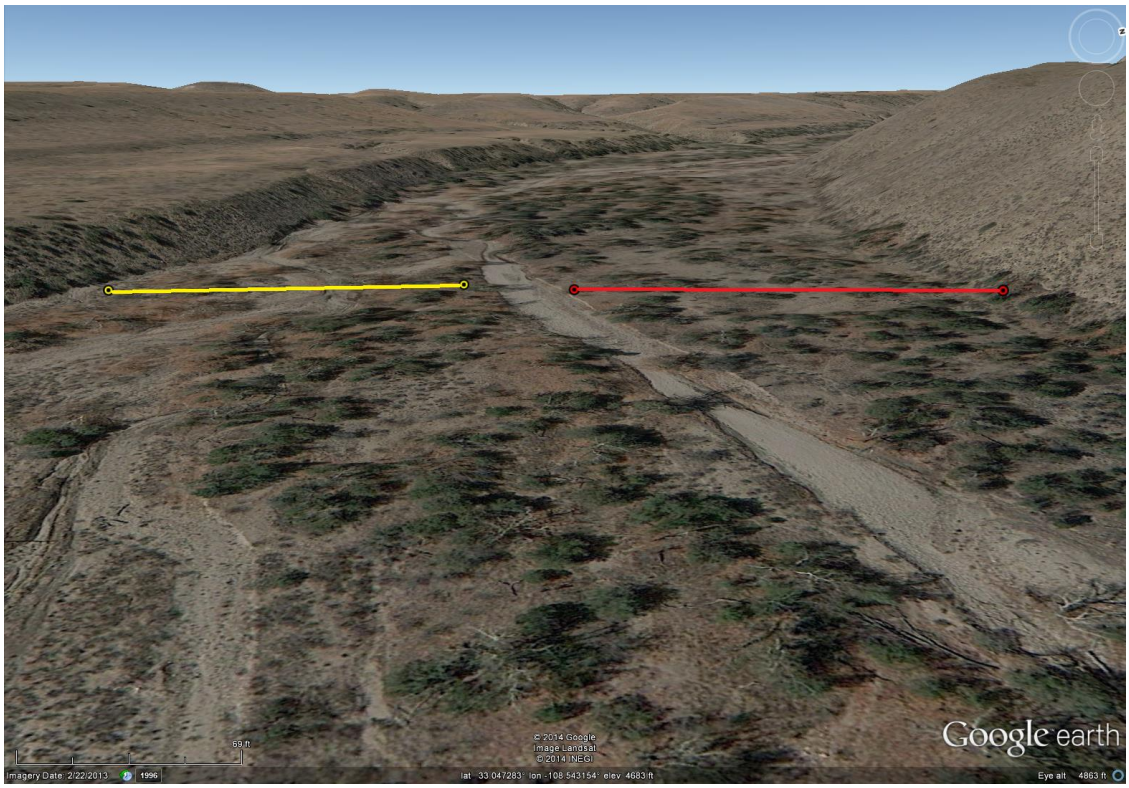


Figure 5 – Mogollon Creek View Towards West

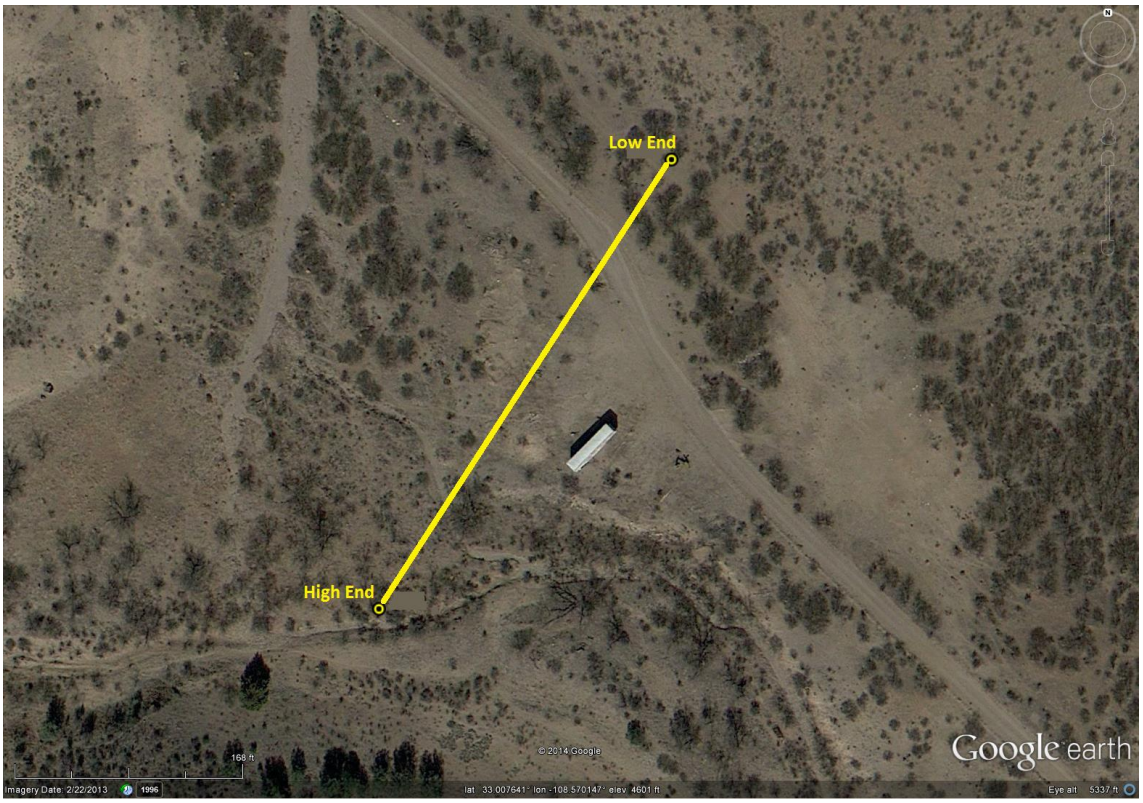


Figure 6 – Winn Site Map

Figure 7 – Winn Site View Towards North West

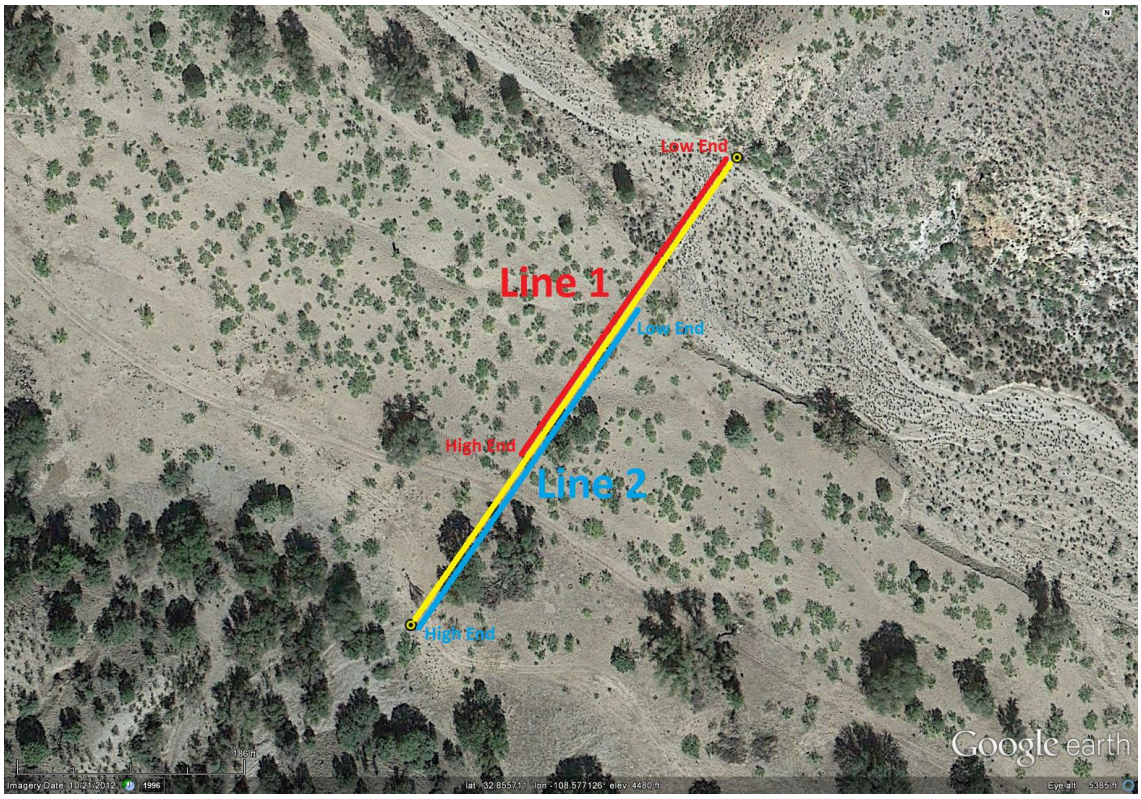


Figure 8 – School House Site Map

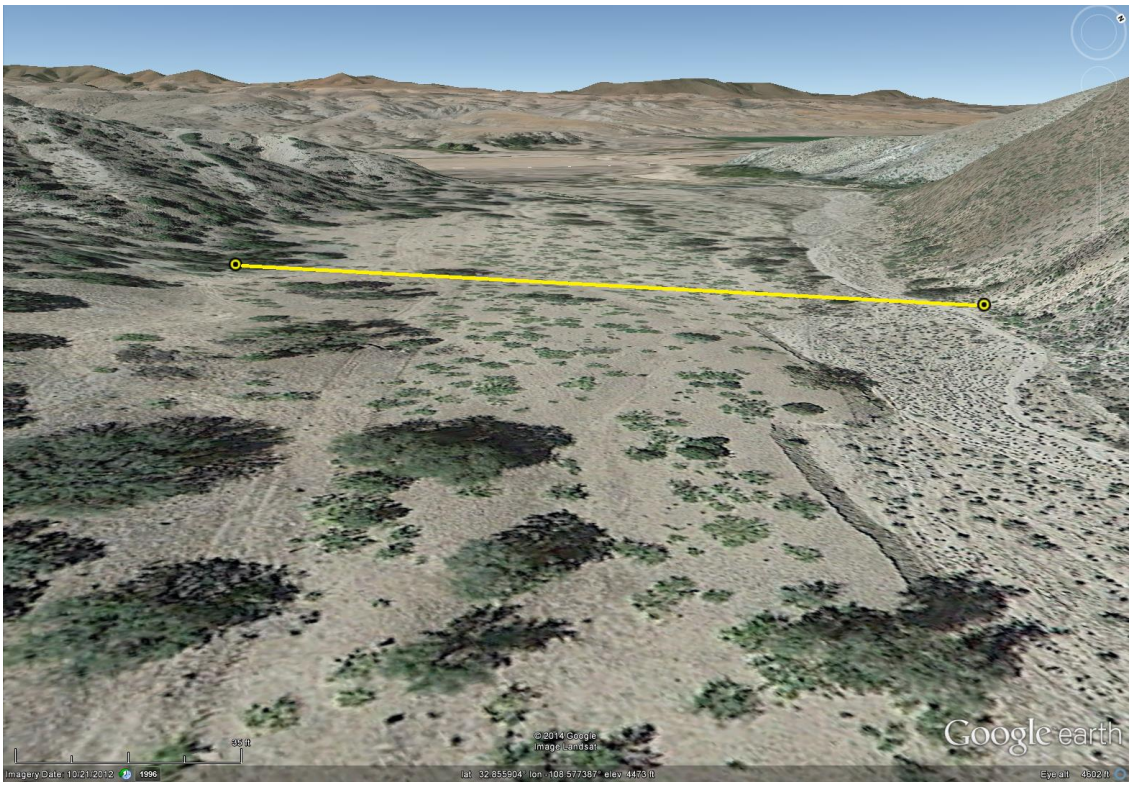


Figure 9 – School House Site View Towards North West

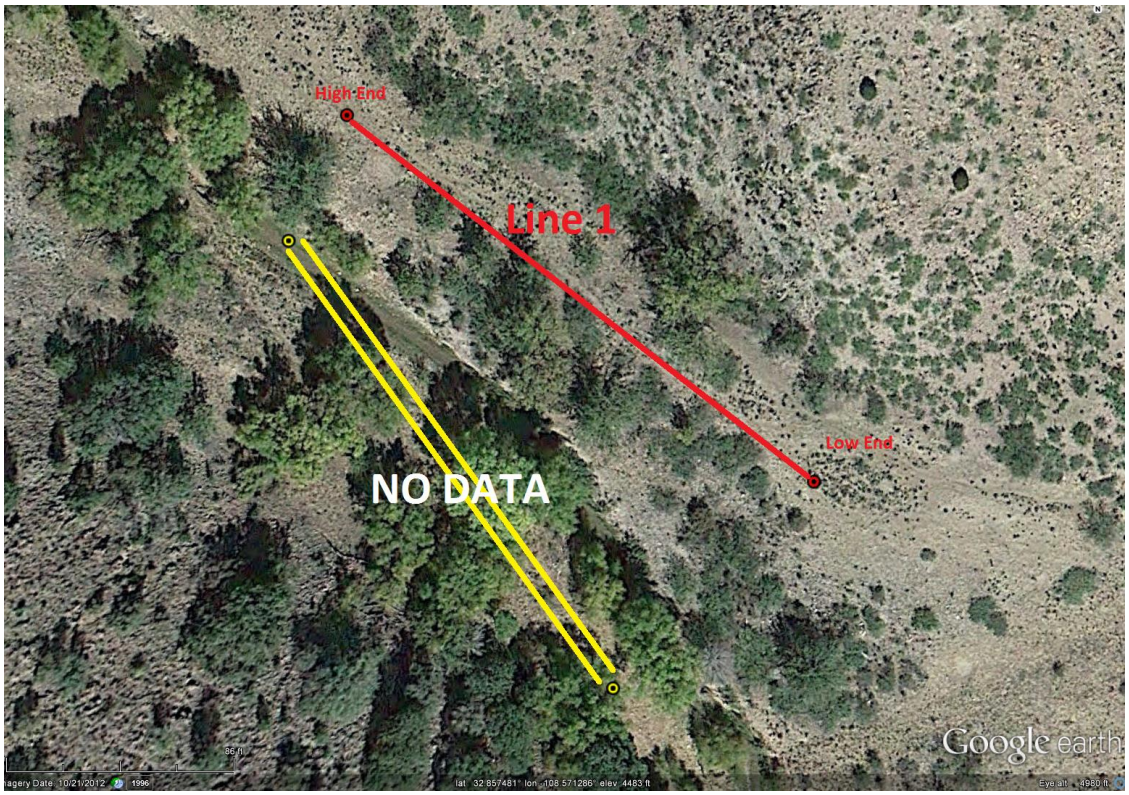


Figure 10 – Mangas Creek Map

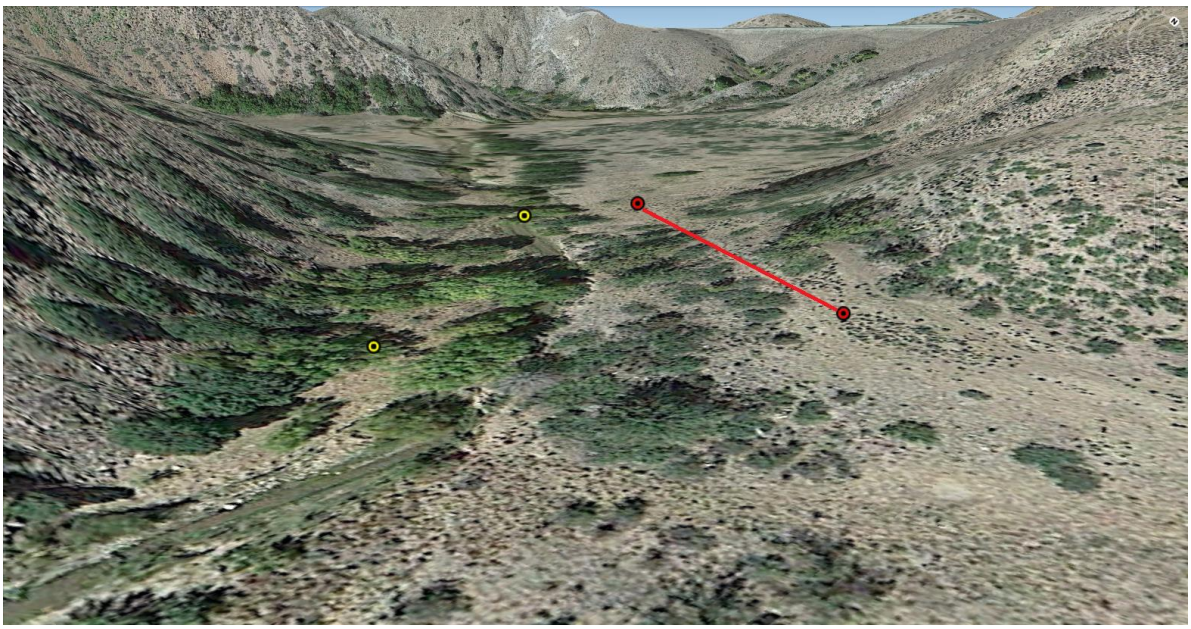


Figure 11 – Mangas Creek View Towards North West

4.0 Refraction Interpretation

Figure 12 below is an example refraction shot gather record. Travel time curves have been picked on both sides of the shot location (at station) 18 by marking the first energy arrivals at each geophone record seen in small red and blue 'x' marks. Each vertical trace (with waves) is a geophone record plotted against time on the vertical axis. After picking the first arrivals of the refracted wave, this shot along with all the other shot gather files on this survey line, seen in Figure 13 on the next page, are arranged into a time-distance plot and processed into a tomogram.

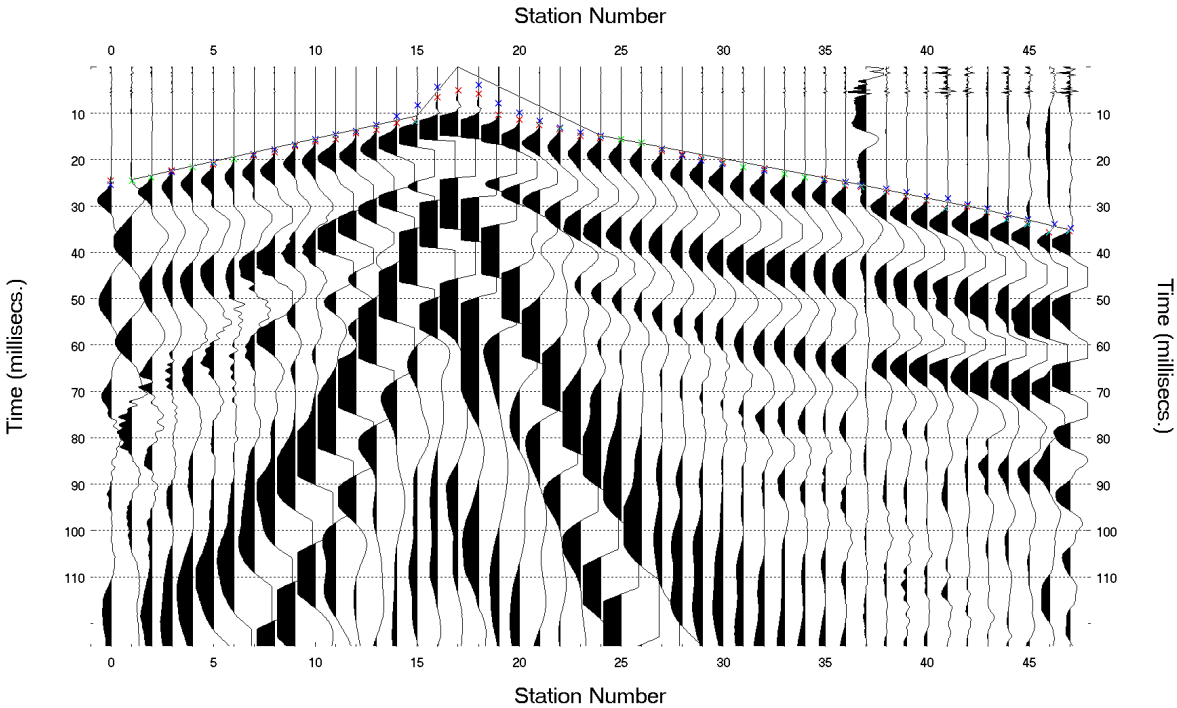


Figure 12 – Example Refraction Shot Gather File

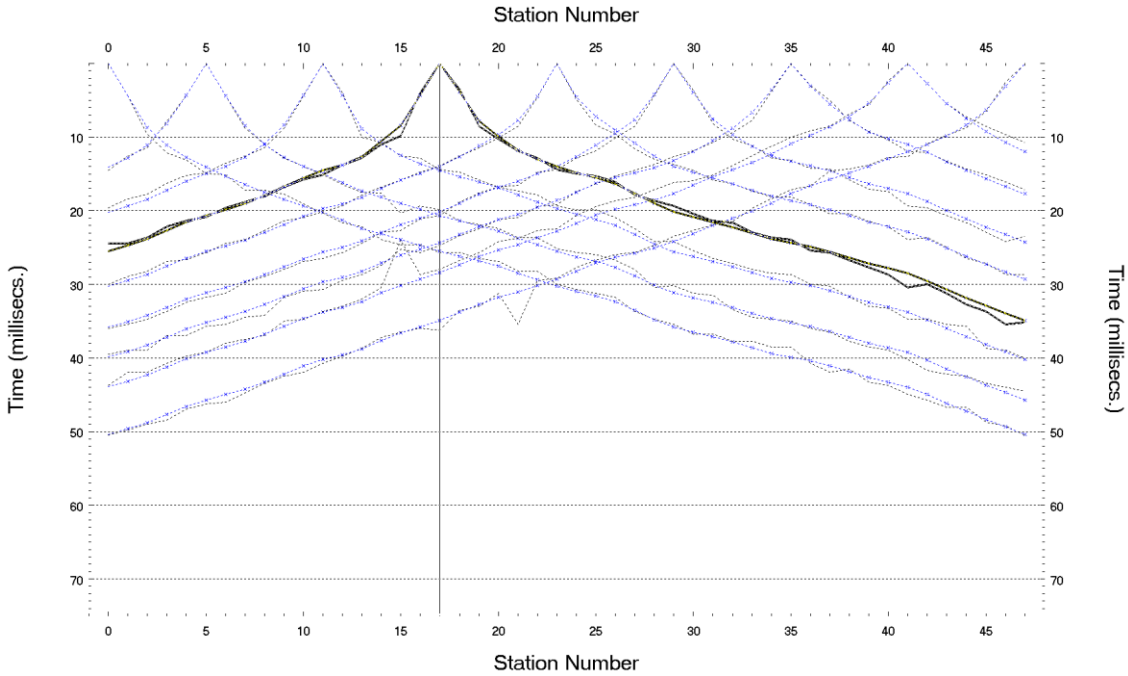


Figure 13 – Refraction Time-Distance Plot

After all the first energy arrivals have been picked for each shot record, and all the shot records have been gathered into the same file, a multiple iteration inversion process is implemented to create a seismic tomogram. The tomogram below is a result from the example time-distance plot from Figure 13. It provides velocity of material information below the survey line on the X-Z plane.

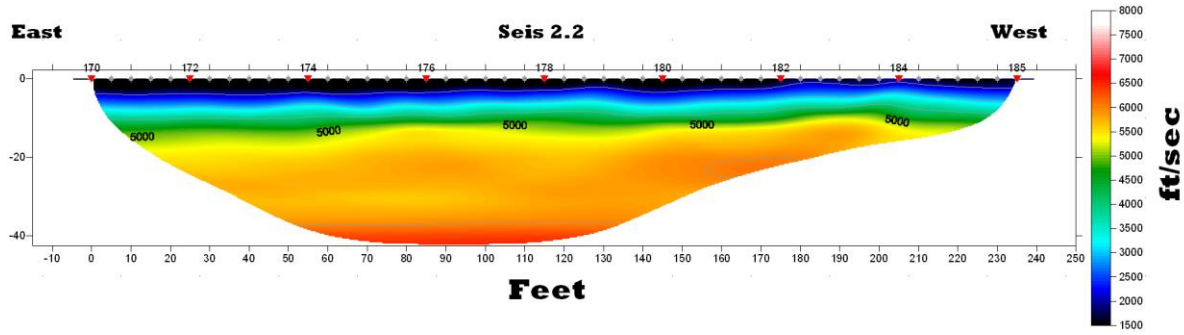


Figure 14 – Refraction Tomogram, Seismic Line 2.2

5.0 Results

All seismic refraction tomograms and ray path coverage tomograms can be seen in Appendix A. Ray path coverage tomograms accompany each seismic velocity tomogram. Ray path coverage tomograms display the concentration of individual seismic "ray paths" from shot each shot location to each geophone based on a color scale. Areas of very high ray path coverage indicate surfaces where seismic energy is refracting along. Sometimes there can be multiple surfaces revealed. This is a helpful tool to identify which velocities correspond to which geologic surfaces or boundaries in the subsurface between differing geologic material.

Both lines at Diversion Site #1 have a boundary with high concentration raypath coverages that correspond strongly to the 6,500 ft/sec – 7,000 ft/sec range (seen as yellow boundary in the seismic tomogram). They also both show a secondary surface that corresponds to the 9,000 ft/sec boundary. This is mostly likely due to consolidated or well cemented alluvium (~7,000 ft/sec) sitting on top of bedrock (~9,000 ft/sec).

Line 2 at Mogollon Creek site also has a boundary with high concentration raypath coverages that correspond strongly to the 6,500 ft/sec – 7,000 ft/sec range (seen as yellow boundary in the seismic tomogram). And Line 1 at Mogollon Creek site has a boundary with high concentration raypath coverages that correspond strongly to the 8,500 ft/sec – 9,000 ft/sec range. This is most likely due to bedrock being nearer the surface on the north side of the creek and deeper on the south side of the creek. Also, there is less consolidated alluvium sitting on top of bedrock on the north side of the creek and a thicker layer of consolidated alluvium sitting on top of bedrock on the south side of the creek.

At the Winn Site there is a boundary with high concentration raypath coverages that correspond strongly to the 7,000 ft/sec boundary which indicates top of consolidated alluvium. And there is a well-defined ray path zone deeper on the north side of the line that corresponds to the 9,000 ft,sec boundary which indicates the dipping surface of outcropping bedrock on the north side of the valley.

The School House site again shows strong ray path coverages that correspond to the 7,000 ft/sec boundary (top of consolidated alluvium), and a secondary boundary at the 9,000 ft/sec boundary which indicates the bedrock surface. There appears to be an artifact in the data on the south end of the line that shows an irregular or "inverted" geometry along the 9,000 ft/sec boundary. This is most likely due to a boundary or object out of plane that is affecting the seismic energy.

Line 1 from Mangas creek shows a high concentration ray path coverage that corresponds very closely to the 9,000 ft/sec boundary, which indicates the bedrock to be very near the surface with little or no cemented alluvium on top of bedrock. This is to be expected in this location because the seismic line runs parallel to and very near the outcropping canyon wall at this location.

6.0 References

Redpath, B., 1973, *Seismic Refraction Exploration for Engineering Site Investigations, AD-768 710*, Explosive Excavation Research Laboratory, Livermore, California.

Hopkins, R., 1998, *Casitas Dam Borrow Area Seismic Refraction Survey, TM No. D8330-98-019*, Reclamation Technical Service Center, Denver, Colorado.

Appendix A – Seismic Refraction and Ray Path Coverage Tomograms

Note: Each survey line provides both the seismic velocity tomogram and the ray path coverage tomogram for the subsurface geology.

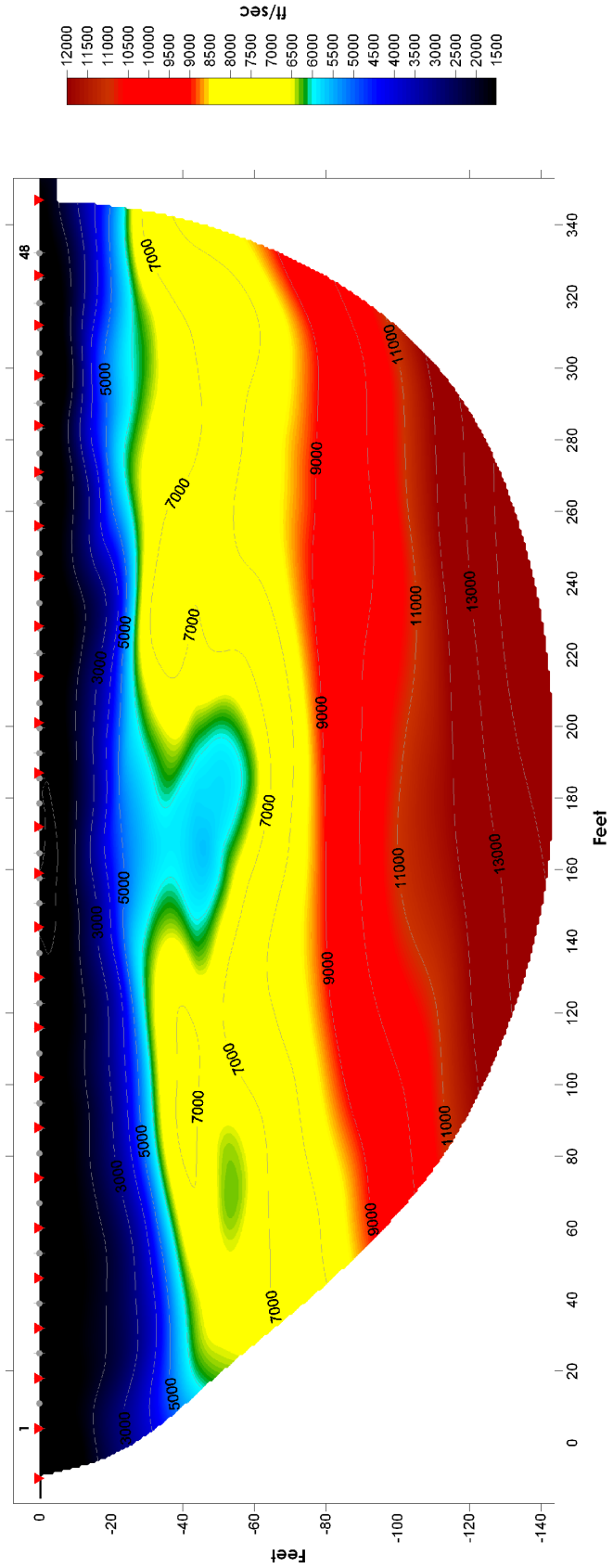


Figure 15 – Refraction Tomogram, Diversion Site #1, Line 1

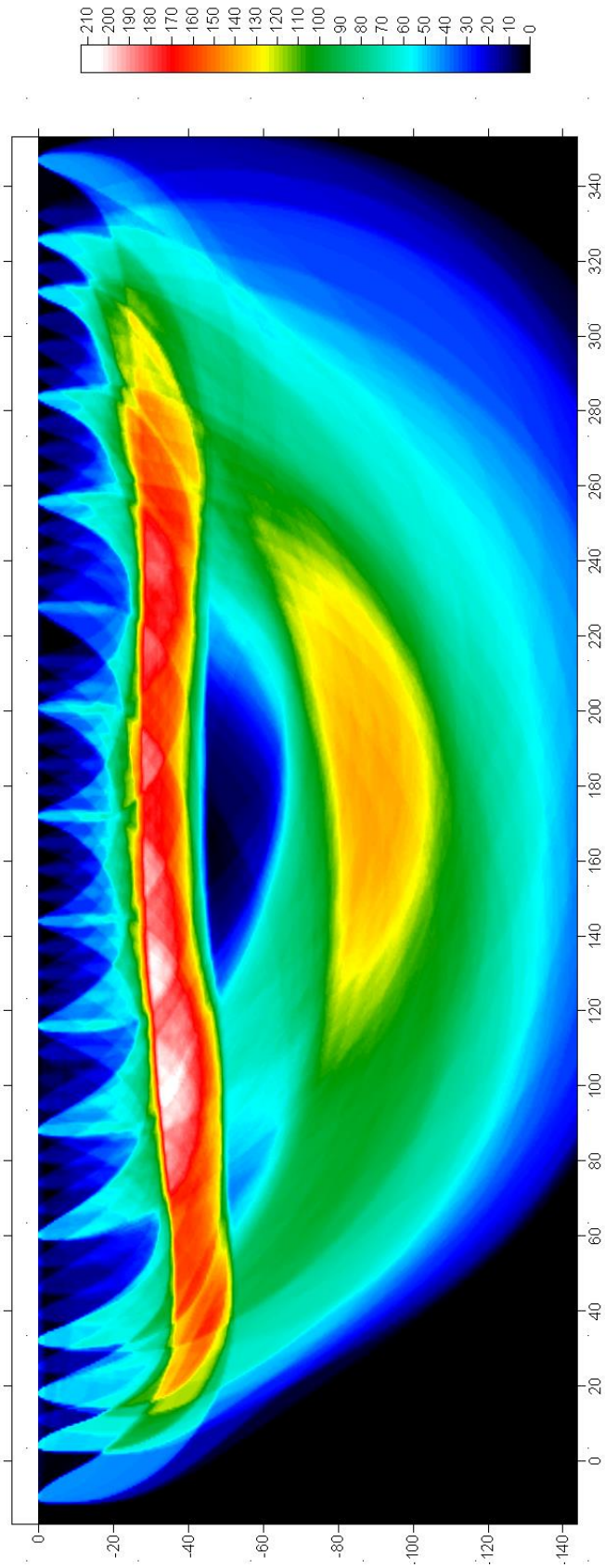


Figure 16 – Ray Path Coverage Tomogram, Diversion Site #1, Line 1

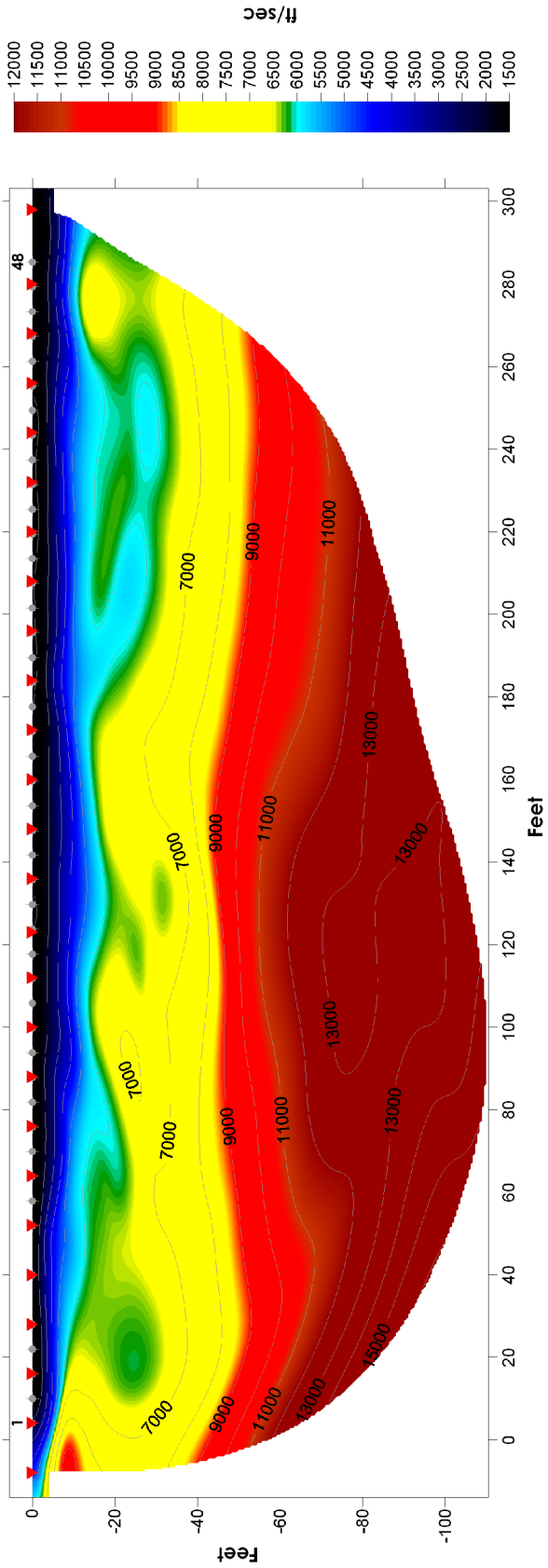


Figure 17 – Refraction Tomogram, Diversion Site #1, Line 2

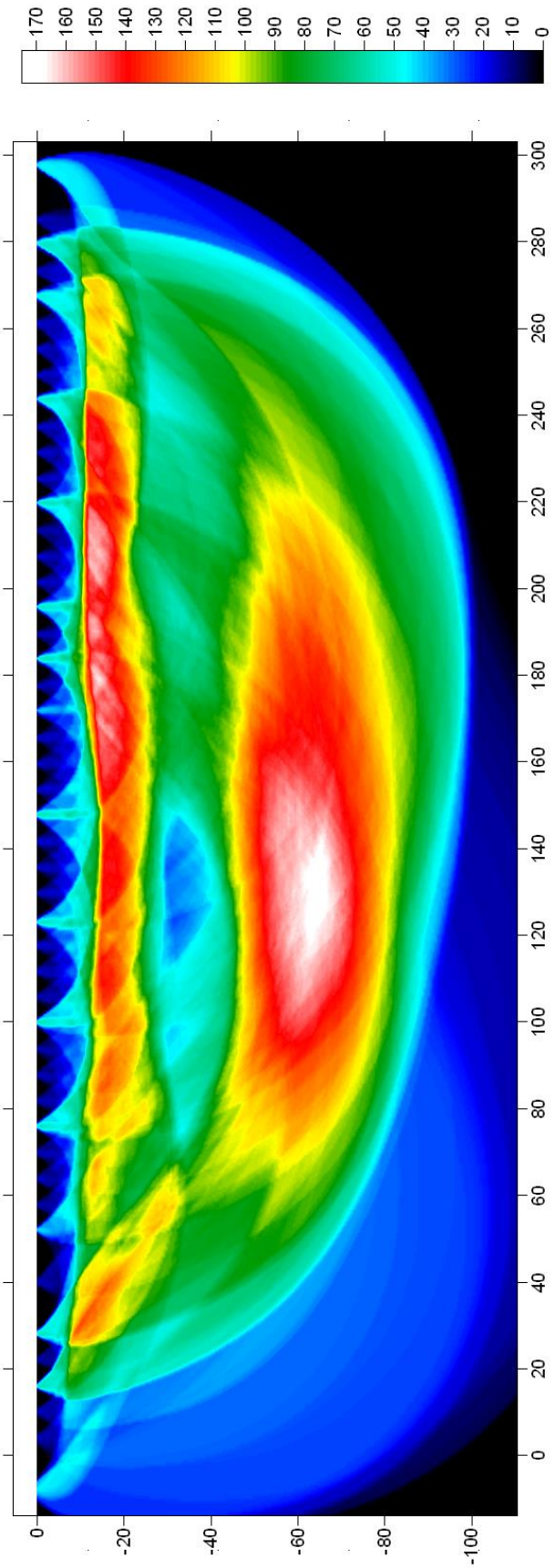


Figure 18 – Ray Path Coverage Tomogram, Diversion Site #1, Line 2

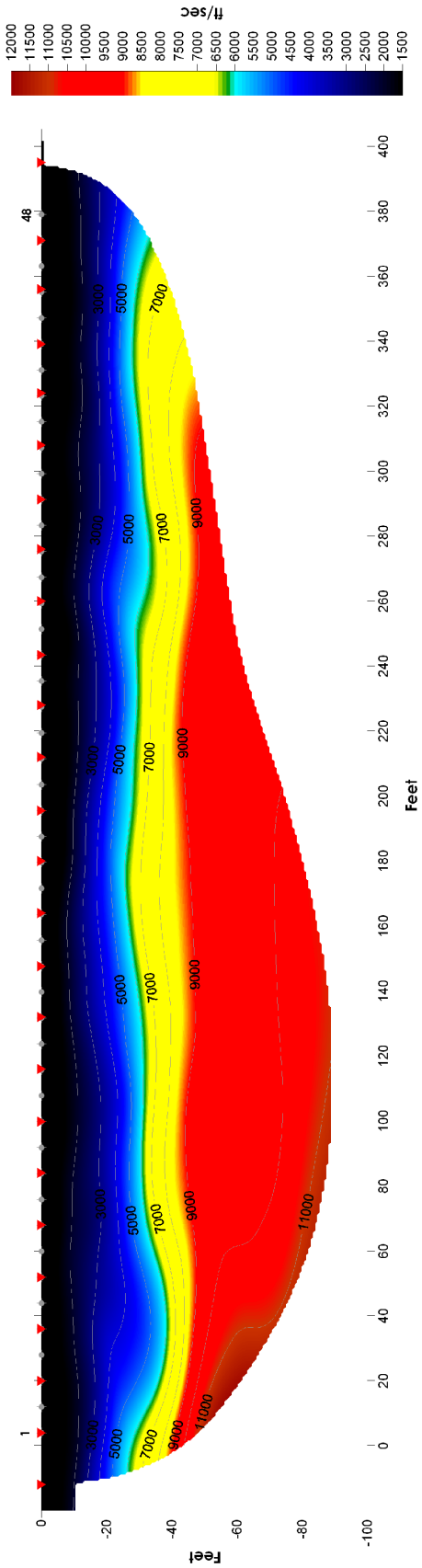


Figure 19 – Refraction Tomogram, Mogollon Creek Line 1

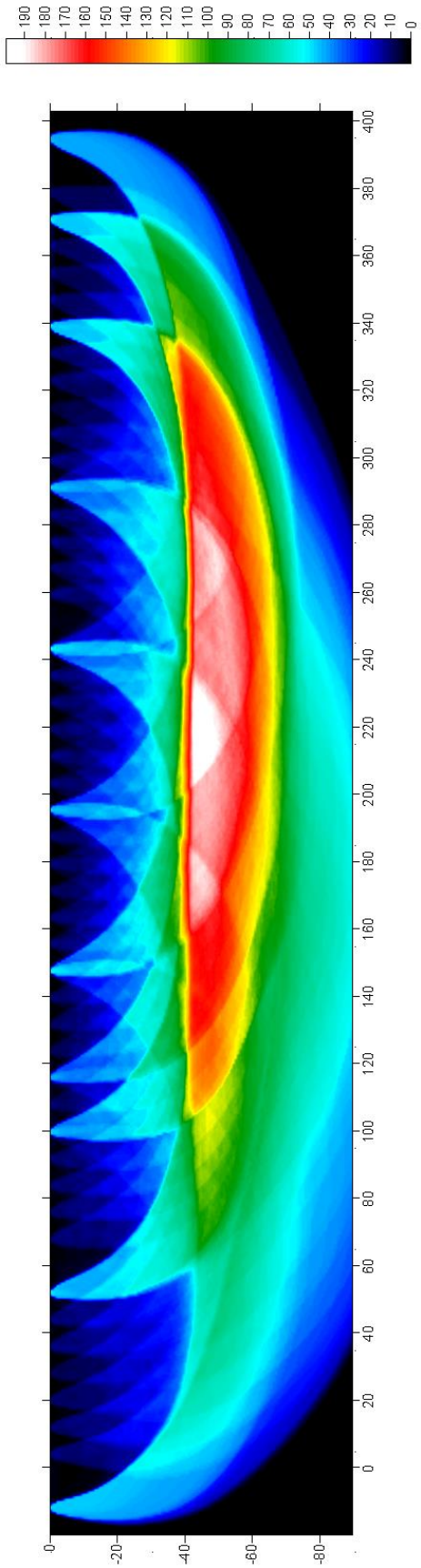


Figure 20 – Ray Path Coverage Tomogram, Mogollon Creek Line 1

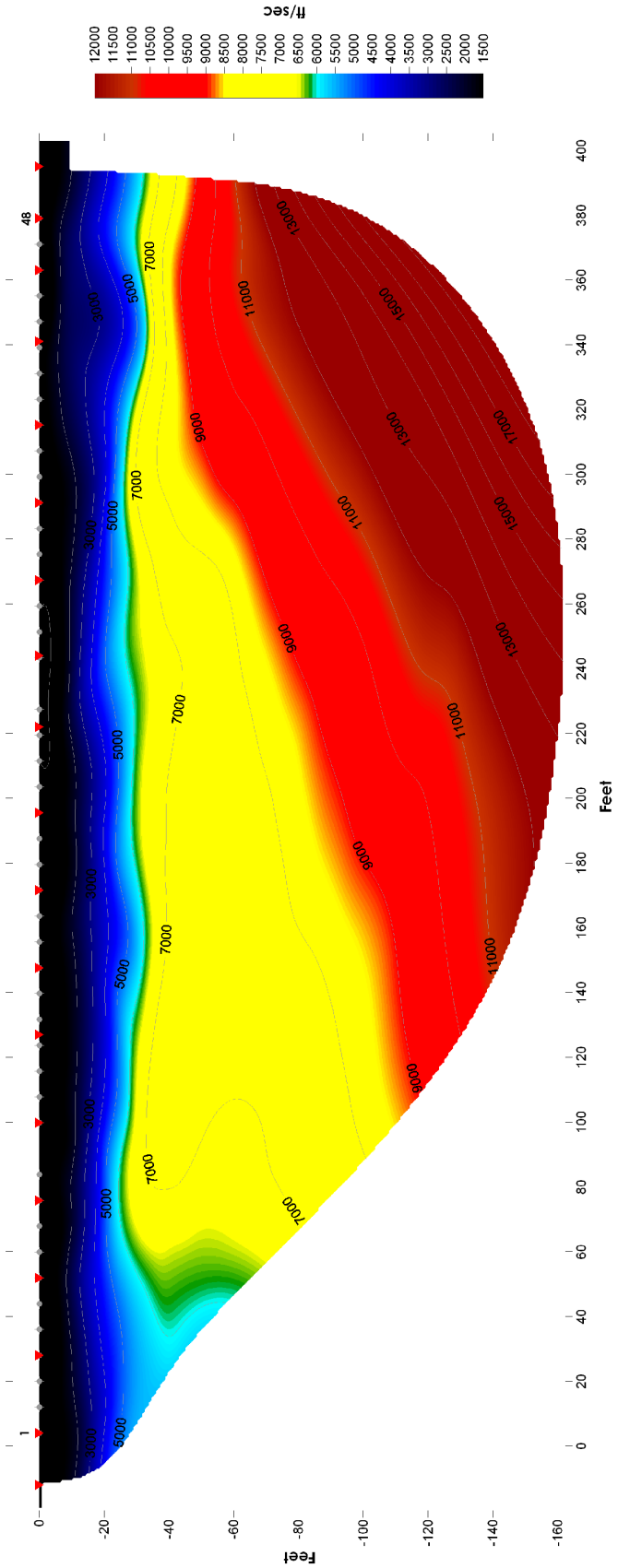


Figure 21 – Refraction Tomogram, Mogollon Creek Line 2

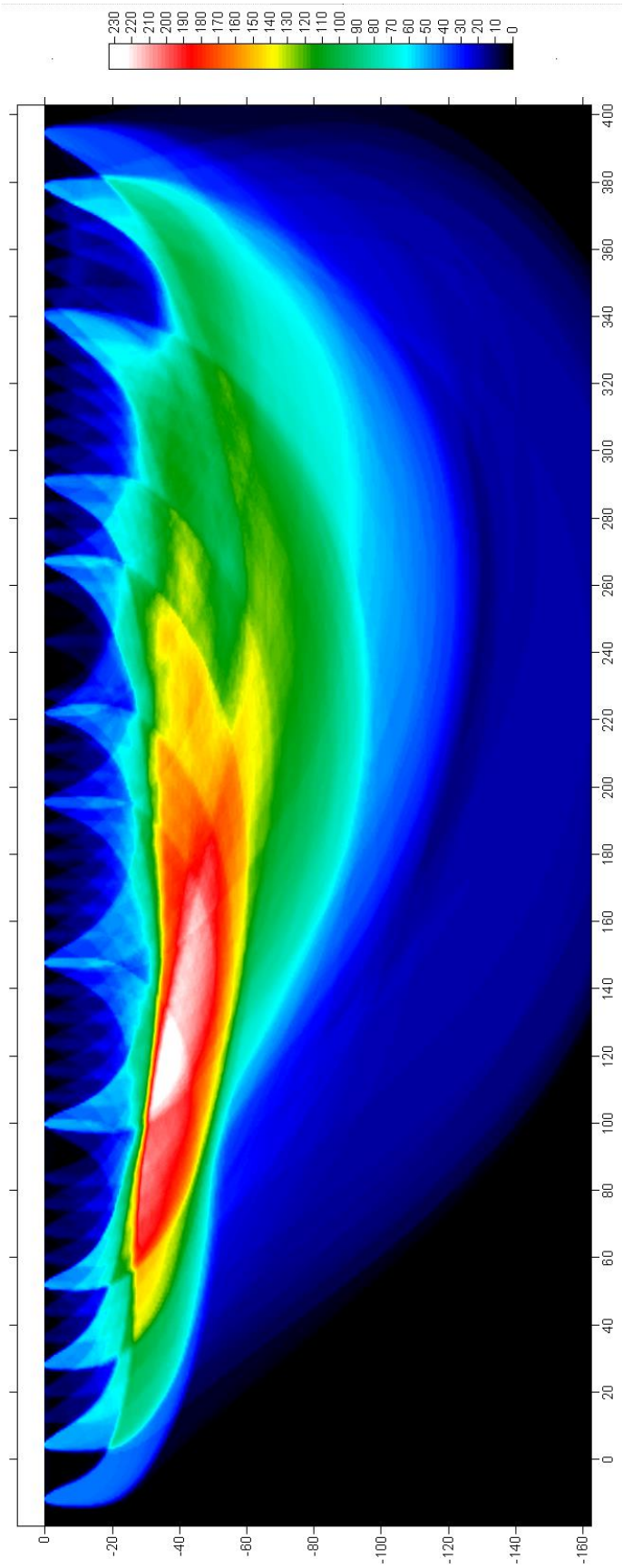


Figure 22 – Ray Path Coverage Tomogram, Mogollon Creek Line 2

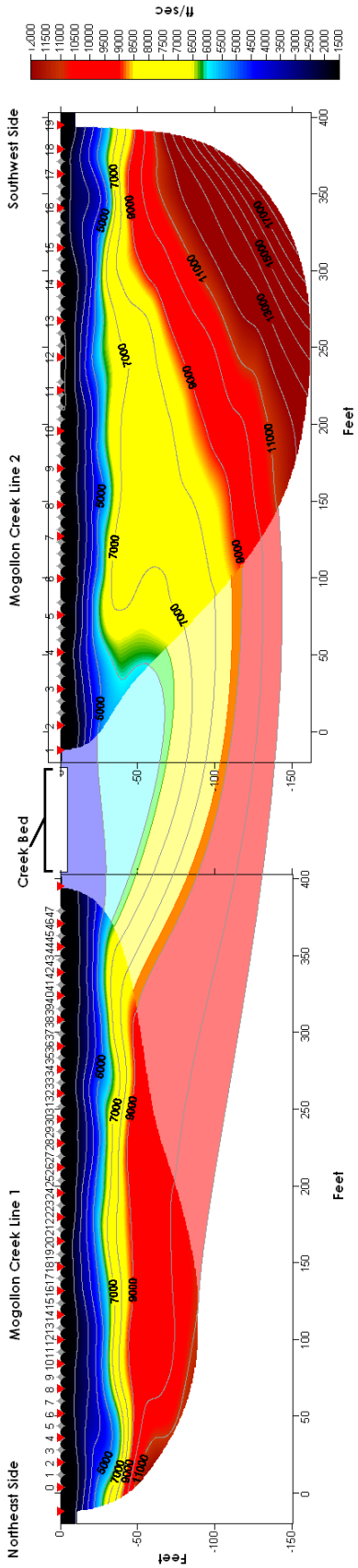


Figure 23 – Combined Refraction Tomogram, Mogollon Creek Lines 1 and 2

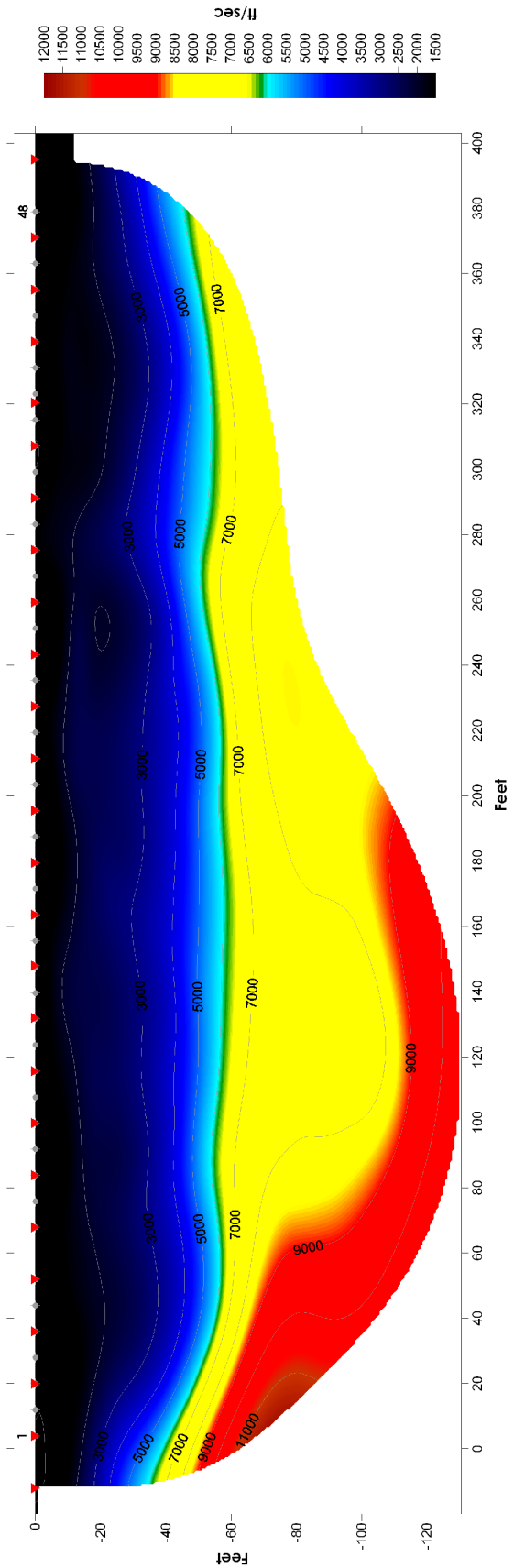


Figure 24 – Refraction Tomogram, Winn Site

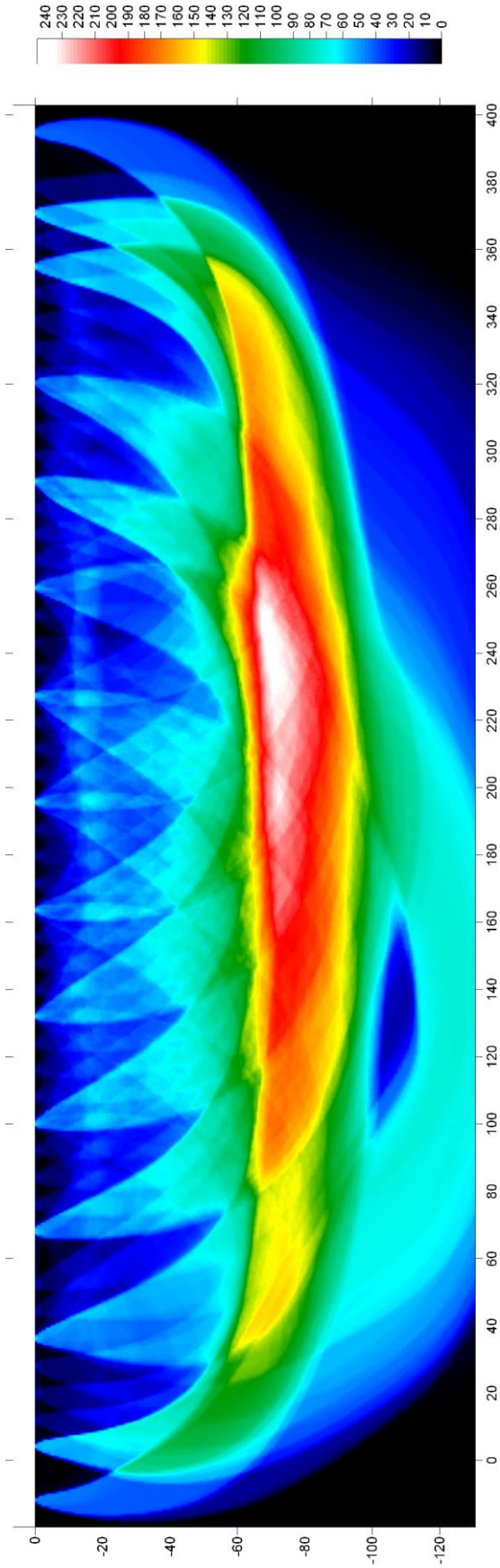


Figure 25 – Ray Path Coverage Tomogram, Winn Site

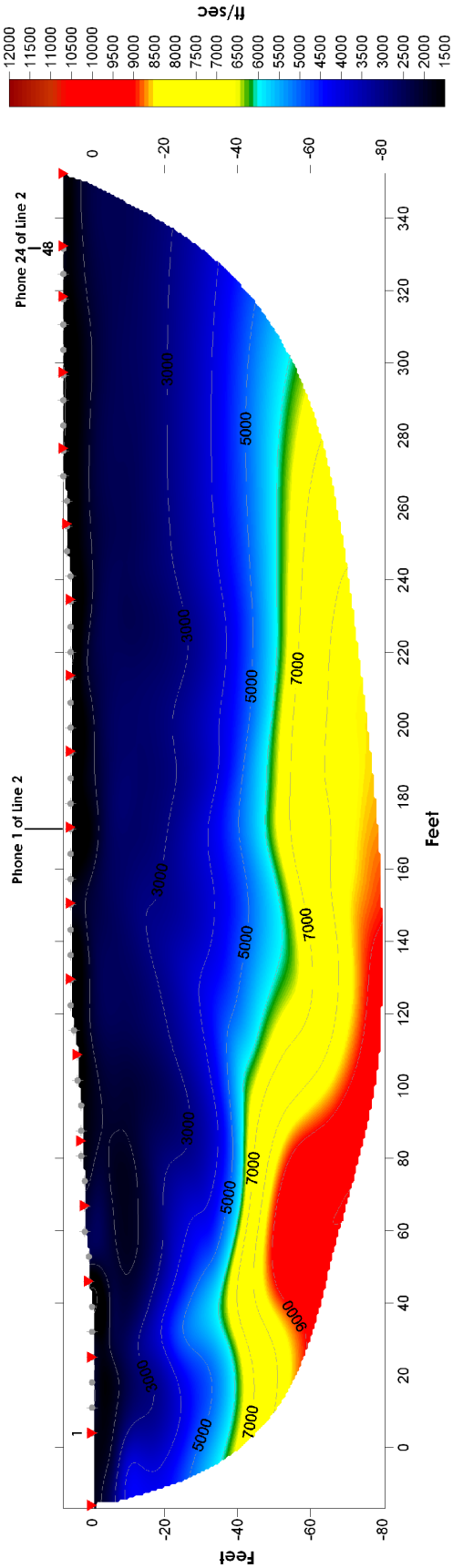


Figure 26 – Refraction Tomogram, School House Site, Line 1

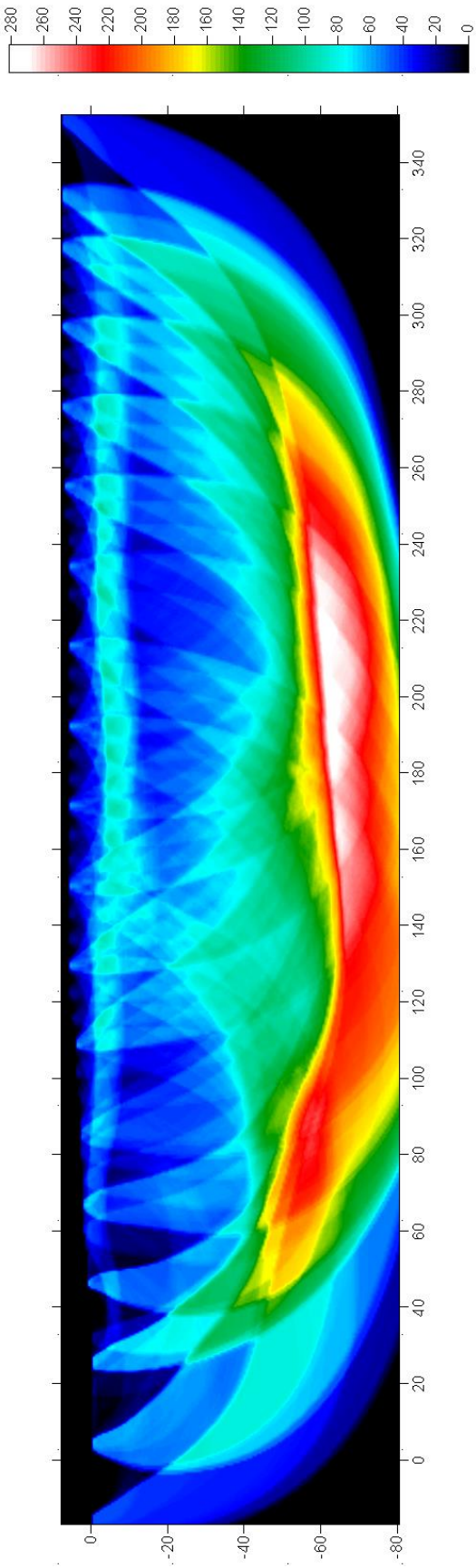


Figure 27 – Ray Path Coverage Tomogram, School House Site, Line 1

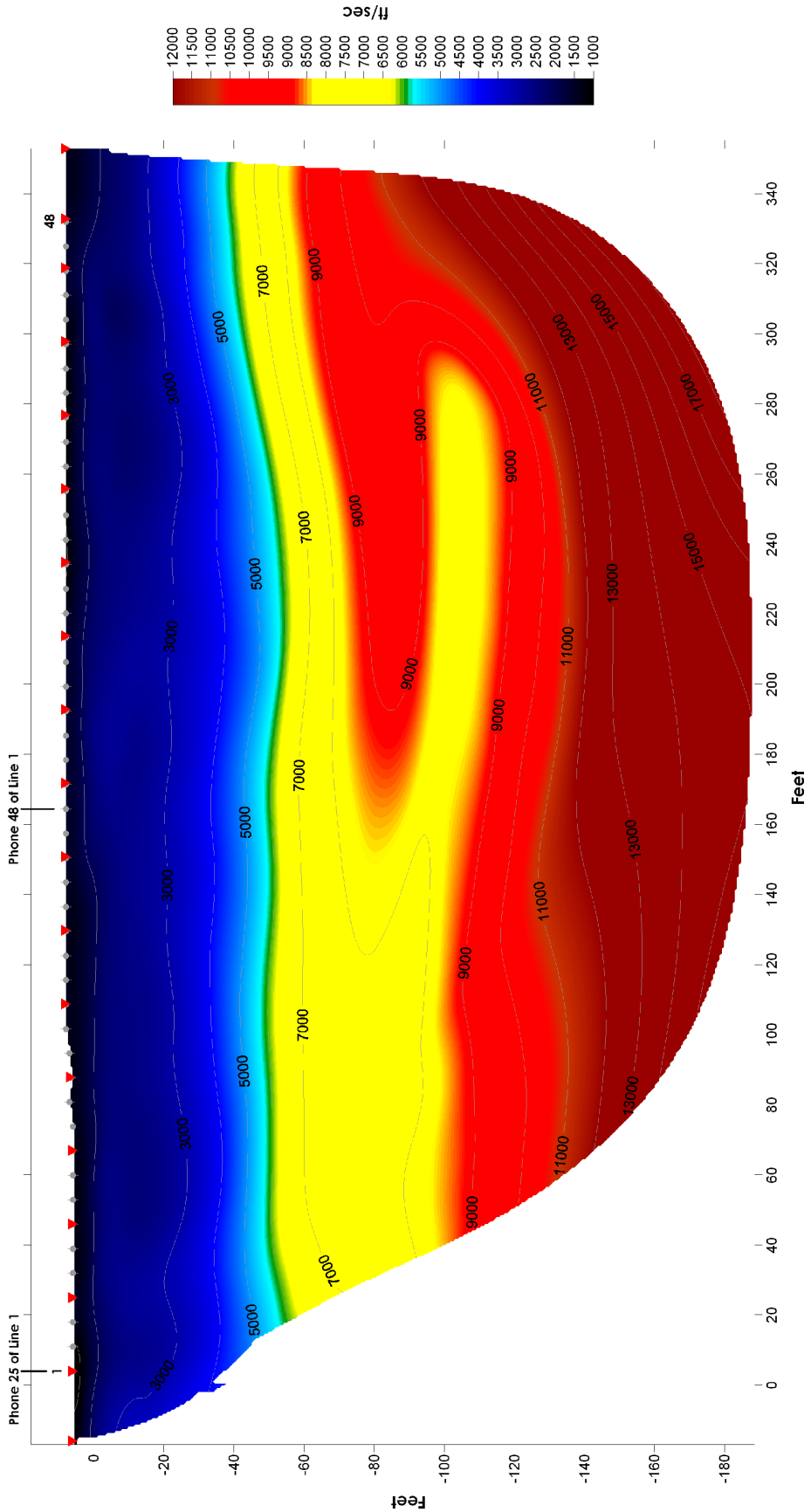


Figure 28 – Refraction Tomogram, School House Site, Line 2

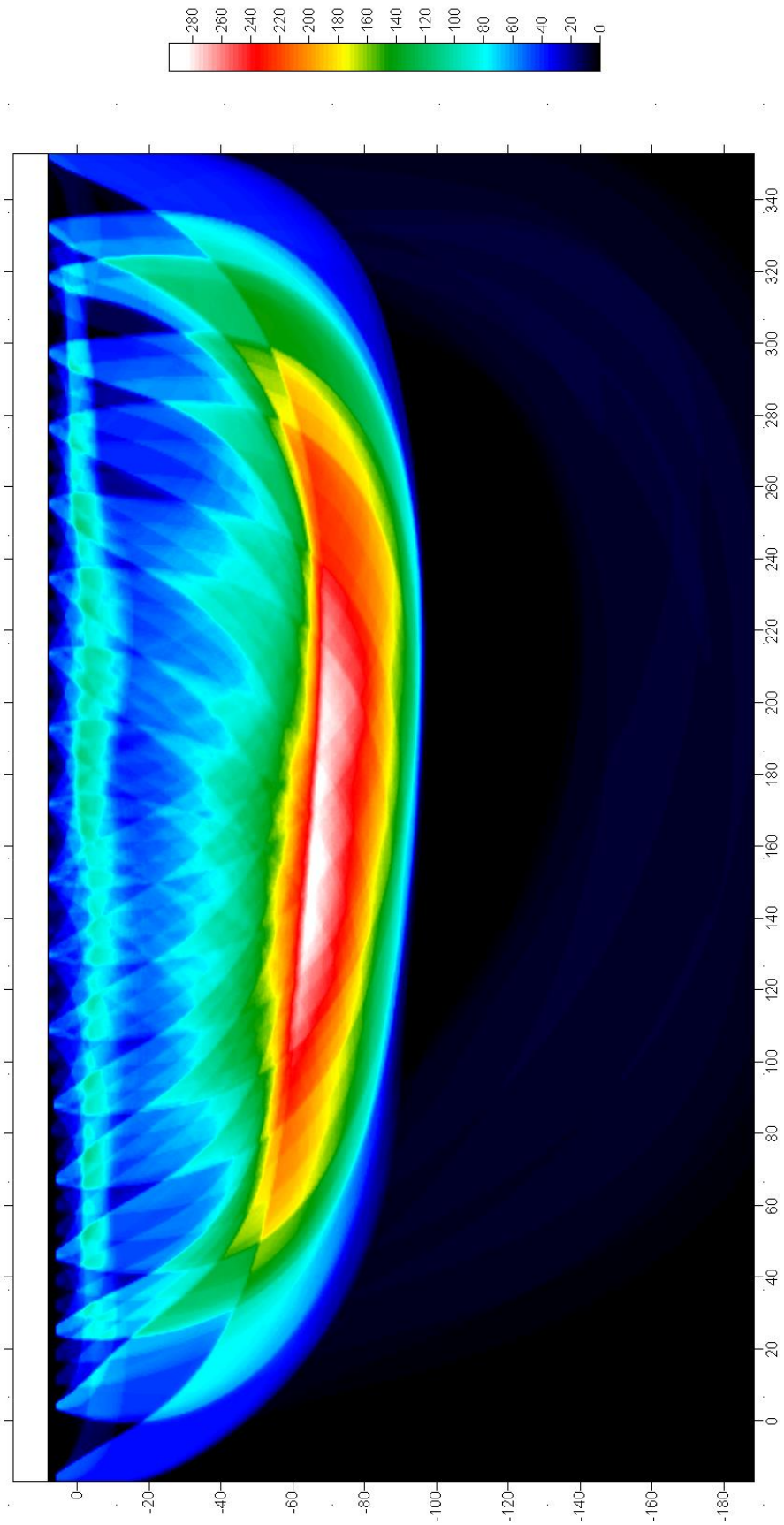


Figure 29 – Ray Path Coverage Tomogram, School House Site, Line 2

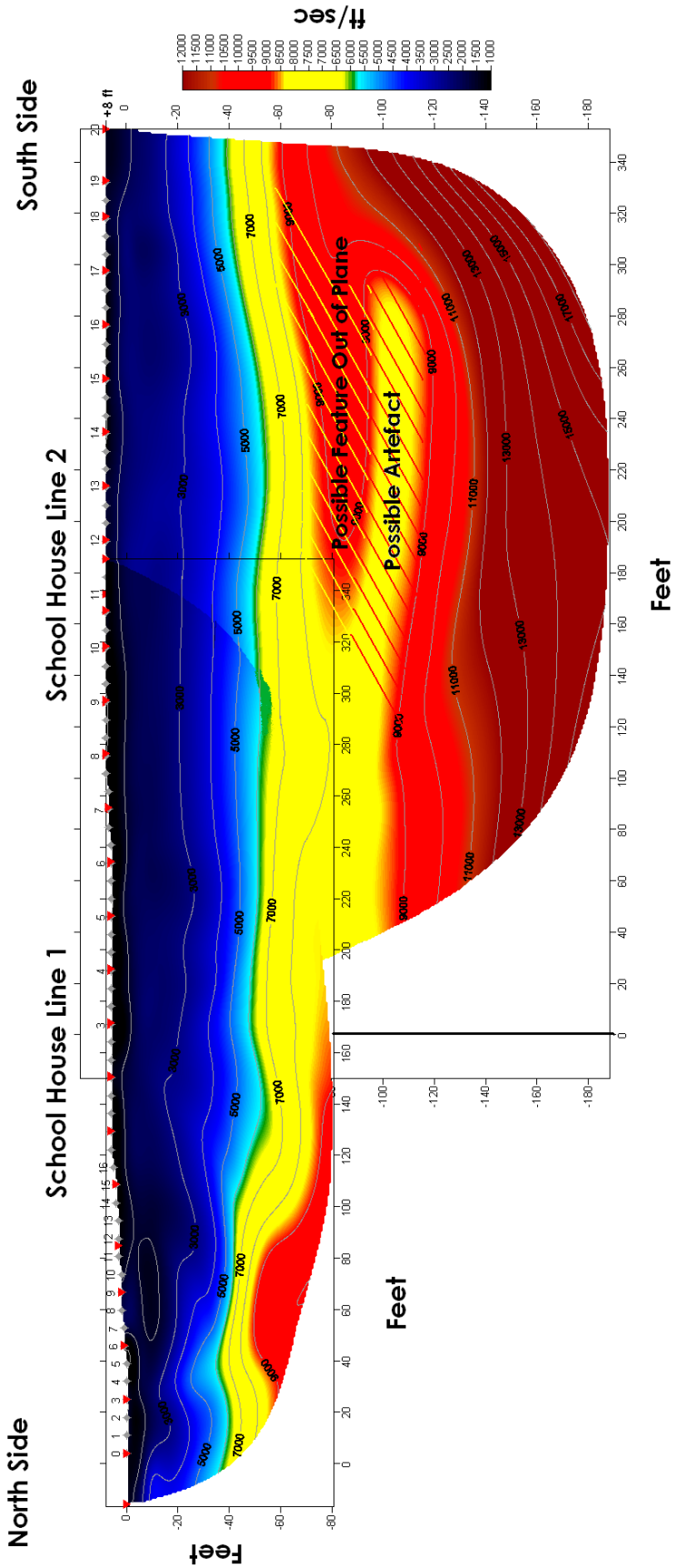


Figure 30 – Combined Refraction Tomogram, School House Site, Lines 1 and 2

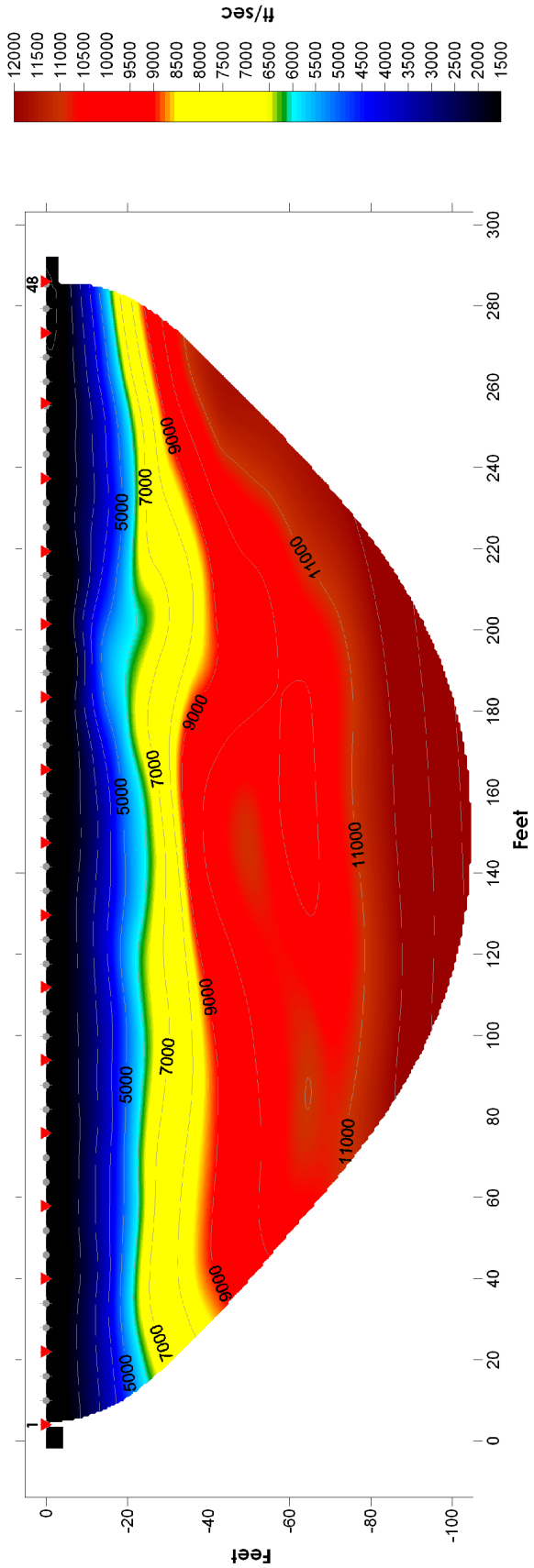


Figure 31 – Refraction Tomogram, Mangas Creek, Line 1

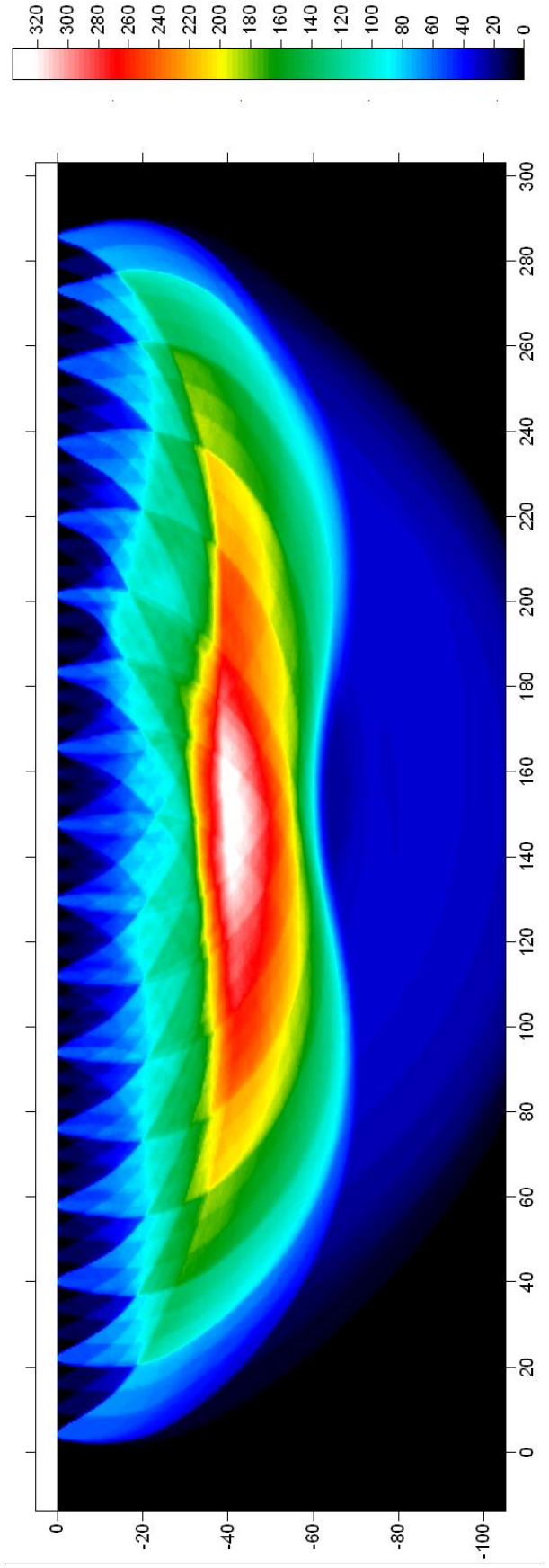


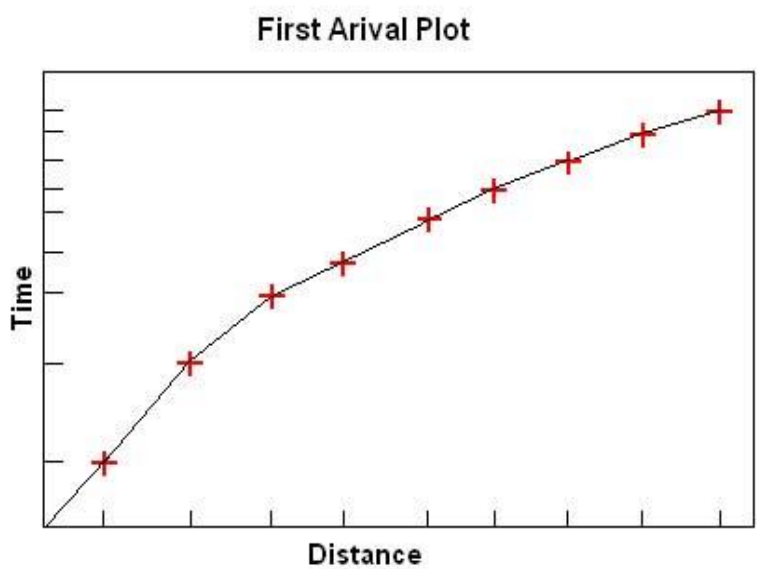
Figure 32 – Ray Path Coverage Tomogram, Mangas Creek, Line 1

Appendix B – Seismic Refraction Method

Refraction Concept

The seismic refraction method is based on acoustic impedances created by the contact between two bodies of differing density. When a compressional acoustic wave meets a contact between rock bodies of different density and/or structural composition (different velocities), the wave is reflected off the contact or refracted along the contact boundary. In general, the denser or more structurally rigid a rock body, the faster a compression wave will travel through it.

The refraction method requires a source to create a compression wave. This survey used a 40 kg accelerated weight drop. Compression waves travel down to the contact between the overlying slower velocity rock and the underlying higher velocity rock. These waves are refracted, traveling along the contact, creating secondary waves that travel back to the surface where they are recorded by geophones. Figure 48 below illustrates the seismic refraction in terms of ray paths and the corresponding first arrival



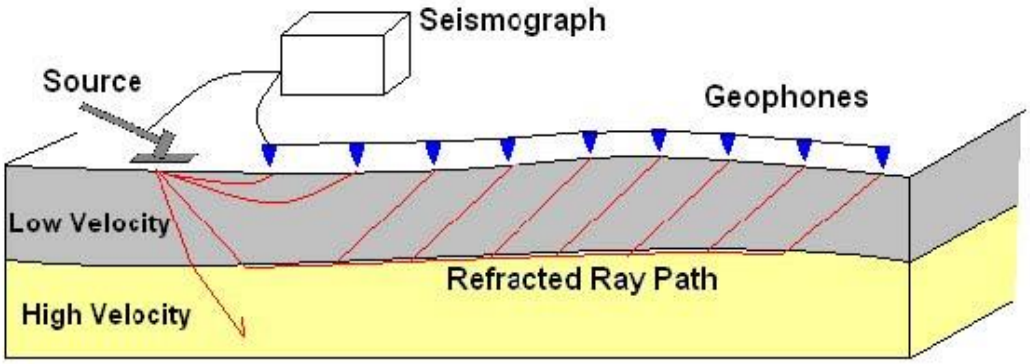


Figure 33 – Ray Path Seismic Refraction Concept & travel time plot. [Redpath, 1973]

Figure 49 below illustrates the seismic refraction method in terms of wave fronts at different points in time. As time progresses, the wave front propagates spherically in all directions away from the source. When the wave front contacts the boundary between different velocities of rock, some of the energy is reflected back to the surface, and some of the energy continues downward into to the higher velocity rock. The wave front accelerates in the higher velocity rock passing ahead of the initial and reflected wave in the slower velocity rock above it.

As the wave continues through the high velocity rock it creates a "wake" at the boundary between the upper and lower rock layers. This "wake", seen in dark crimson in Figure 10 below is the refracted wave front. It propagates upward through the low velocity rock to the surface where geophones sense its arrival ahead of the surface waves and reflected waves.

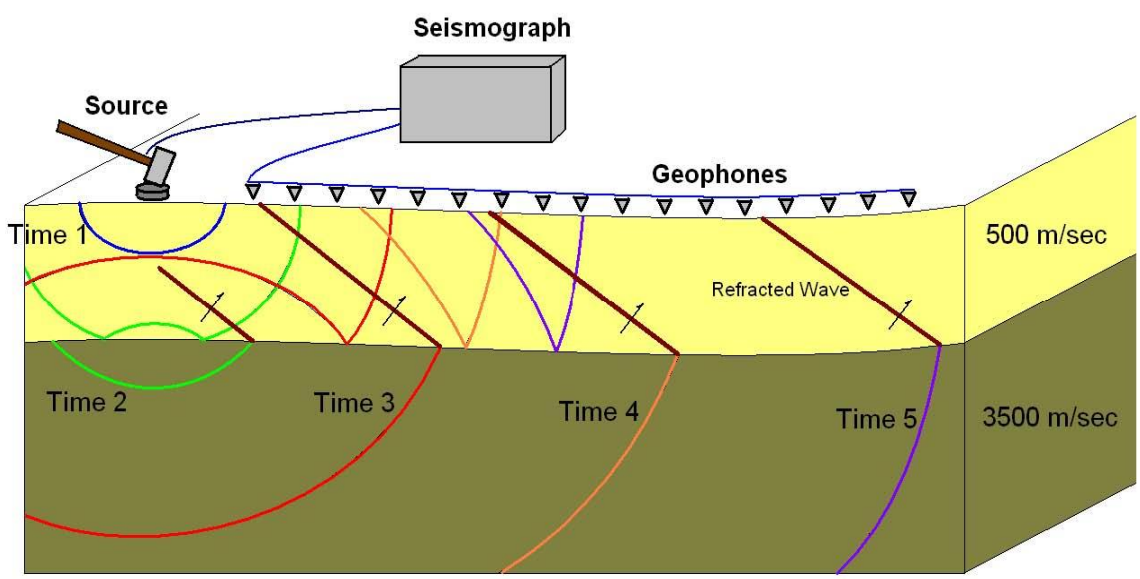


Figure 34 – Wave front Seismic Refraction Concept

Ray Path Geometry

The rays shown above demonstrate wave direction more clearly than a wave front itself. A ray is perpendicular to a wave front and points in the direction of propagation of a given compression wave. Refracted rays are bent at the contact boundary between two rock layers and travel along the top of the underlying layer, moving at the higher velocity of the underlying layer. The angle at which a ray is refracted along the contact is given by Snell's Law:

$$\sin iV_1 = \sin rV_2$$

where i and r are incident and refracted ray angles, and V_1 and V_2 are their layer velocities respectively. When angle r is equal to 90 degrees, the bent, or refracted ray, will travel along the contact interface at the velocity of the denser underlying layer and is called the critically refracted ray. As it travels along the contact, secondary waves are continually created in the overlying rock layer at the critical angle:

$$i_c = \sin^{-1}\left(\frac{V_1}{V_2}\right)$$

At a certain distance away from the source, known as the critical distance, this secondary wave front, created by the critically refracted energy, reaches the surface geophones faster than direct arrivals along the ground surface. This can be seen as a change in slope of the velocity curve seen in the first arrival plot in Figure 1 above.

Rays transmitted into the underlying basalt layer will continue downward until they intersect with another acoustic impedance contact and will again be reflected and refracted. For this reason there are limits to the optimal depth of a refraction survey. In general, the depth of exploration is one fourth the length of the seismic line depending on the ratio of velocity contrast between two rock layers. A velocity contrast of 1.8:8.0, as observed in this survey, allows for steeply dipping rays (small incident angles from perpendicular, approx. 13 degrees) to be refracted over short distances of seismic spread. However a velocity contrast of 1:1.5 (top and bottom layers respectively) requires much shallower dipping rays (large incident angles from perpendicular) around 42 degrees for rays to be refracted. This shallow angle results in much longer seismic survey lines, and increases the difficulty and cost of a given survey. [Hopkins, 1998]

Planar Bed Methodology

In the case of planar subsurface bedding contacts, seismic refraction calculations are fairly strait forward and easily executed. Using the half-intercept method and critical distance method from the first arrival plot above allows for little error when beds are close to planar. [Hopkins, 1998]

Non-Planar Bed Methodology

When subsurface bedding contacts are non-planar, undulating at unknown angles or dipping in non-parallel fashion, depth calculations become significantly more complicated. Methods such as the Generalized Reciprocal Method, the Reciprocal Method, and the ABC Method make far fewer assumptions about refraction surfaces, and operate locally on a smaller scale to limit the effect of undulations in the subsurface refraction contacts. In this survey, depths were determined at every sixth geophone location with a source immediately next to it. This allows for local calculations of depth to seismic layer 2, reducing error from unknown variance in subsurface basalt behavior. [Hopkins, 1998]

Appendix - F – Environment - Technical Information

Technical Information – *Northern Mexican Gartersnake* This subspecies was proposed for listing as a threatened species on July 10, 2013 (USFWS 2013a), with proposed critical habitat that includes the Gila River mainstem from its confluence with San Francisco River in Arizona upstream to the confluence of the East Fork and West Fork Gila River in New Mexico (USFWS 2013b). Within the U.S., this riparian-obligate gartersnake historically was found within the Bill Williams, Yaqui, Mimbres, and Gila river basins in Arizona and New Mexico, but 70-80% of its range is in Mexico in the Sierra Madre Occidental and Mexican Plateau south to Oaxaca. Northern Mexican gartersnake typically is found along well-vegetated margins of cienegas, springs, streams, rivers, lakes, and ponds at elevations ranging from 130 to 6,150 ft (40 to 1,875 m). Presently, more than 80% of the known localities in the U.S. are considered extirpated or likely not viable due to low population densities (USFWS 2013a).

Northern Mexican gartersnake is diurnally-active, and feeds mostly on native amphibians (especially leopard frogs) and fishes, but also toads, treefrogs, earthworms, deer mice, lizards, and leeches (summarized in USFWS 2013a). Onset of sexual maturity of this viviparous (live-bearing) species occurs at 2-3 years (Rosen and Schwalbe 1988); longevity it unknown. Mating usually occurs in late spring, with birth of between 7 and 38 newborns in July and August (Rosen and Schwalbe 1988, Nowak and Boyarski 2012).

Widespread introductions of nonnative fishes with spiny rays (e.g., basses and sunfishes) or true spines (e.g., catfishes) are considered one of the primary threats to conserving the species (USFWS 2013a). Nonnative fishes not only displace the mostly soft-rayed native fish prey base, but they also typically are immune to consumption due to the presence of spines or spiny rays on the fins that prevent swallowing (Rosen et al. 2001, USFWS 2013a). Many introduced fishes also directly consume gartersnakes. The introduced bullfrog also is a major predator on Mexican gartersnake, and has been suspected to be the primary cause for its extirpation from some areas (Rosen and Schwalbe 1988).

Narrow-headed gartersnake. This snake was proposed for listing as a threatened species on July 10, 2013 (USFWS2013a), with proposed critical habitat that includes the Gila River mainstem from its confluence with San Francisco River in Arizona upstream to the confluence of the East Fork and West Fork Gila River in New Mexico, and the tributaries Turkey Creek, East Fork Gila River, West Fork Gila River, Middle Fork Gila River, Little Creek, Black Canyon, Diamond Creek, Gilita Creek, and Iron Creek in New Mexico (USFWS 2013b). Narrow-headed gartersnake is a highly aquatic riparian-obligate species found along clear, rocky streams that drain the Mogollon Rim in central and eastern Arizona and southwestern New Mexico at elevations ranging from 2,300 to 8,200 ft (700 to 2,500 m). The species is absent from or likely not viable in up to 76% of 38 known historically-occupied localities.

Narrow-headed gartersnake feeds almost exclusively on fish, although it rarely may also take frogs, tadpoles, and salamanders (Stebbins 1985). Considered an ambush predator, the species forages on along stream bottoms and is heavily dependent upon visual cues for foraging (Fleharty 1967). The species is surface-active between the months of March and November, and hibernates in rocky ledges above the floodplain (Nowak 2006). Sexual maturity is reached at 2-

2.5 years of age, and between 4-17 live young are born in late July and early August (Rosen and Schwalbe 1988).

The primary cause of decline appears to be replacement of soft-rayed native fish prey with spiny-rayed nonnative fishes that create a choking hazard (USFWS 2013a). Introduction of nonnative crayfish and bullfrog also may have negative impacts on the species (Rosen and Schwalbe 2002, USFWS 2013a).

Loach minnow **-** Loach minnow was federally listed as threatened on October 28, 1986 (USFWS 1986b), and the species was uplisted to endangered status on February 23, 2012 with critical habitat (USFWS 2012). Critical habitat includes eight subbasin units in the Verde, Salt (Black), San Pedro, Bonita, Eagle, San Francisco, Blue, and upper Gila River drainages. Loach minnow is endemic to streams of the Gila River Basin, and its historical distribution included most of the major subbasins except the Santa Cruz (Minckley 1973). The species has been extirpated from most of its historic range, surviving as a relatively large population only in Aravaipa Creek and Blue River, Arizona, and in the mainstem Gila River and some of its forks in New Mexico (Marsh et al. 1990, Propst 1999, USFWS 2012). It persists as relatively small populations in a handful of other streams in the basin, and is estimated to be lost from about 80-85% of its historic range; the presence of nonnative fishes and other nonindigenous aquatic organisms is the major factor in continued declines of this species (Clarkson et al. 2012, USFWS 2012).

Loach minnow is a small-bodied, short-lived, current-loving species, inhabiting interstices of gravel and rubble in shallow, well-defined, stream riffles (USFWS 2012). Foods are predominantly ephemeropteran nymphs and blackfly (Family Simuliidae) larvae (Schrieber and Minckley 1981). Loach minnow is the only member of the cyprinid family known to employ egg-clumping as a mode of spawning behavior (Johnston 1999). Spawning occurs in riffles, where eggs are emitted by the female, fertilized, and then retrieved and affixed in clumps to the underside of rocks by the male (Vives and Minckley 1990, Childs 2004).

*Spikeda**ce*** **-** Spikedace was federally listed as threatened on July 1, 1986 (USFWS 1986a) and the species was uplisted to endangered status on February 23, 2012 with critical habitat (USFWS 2012). Critical includes eight stream complexes in the Verde, Tonto, San Pedro, Bonita, Eagle, San Francisco, Blue, and upper Gila River drainages. Spikedace is endemic to the Gila River basin with a historical distribution that included most of the major subbasins except the Santa Cruz (Minckley 1973). Remnant populations are known to persist only in Aravaipa Creek, Arizona, and the Gila River mainstem in New Mexico, although illusory populations may also remain in the upper Verde River, Eagle Creek, and West Fork Gila River (Marsh et al. 1990, D.L. Propst, personal communication). This species (excluding those that are already extirpated) is perhaps the most endangered native fish in the basin due to its specialized habitat preferences and apparent need for waters with relatively high base flows that are now occupied by nonnative fishes that are considered the primary cause of its endangerment (Clarkson et al. 2012, USFWS 2012). Spikedace is estimated to be lost from ≥90% of its historic range (USFWS 2012).

Spikedace is a small-bodied, short-lived species that occupies flowing pools generally less than a meter deep over sand, gravel, or mud bottoms below riffles or in eddies (Minckley 1981).

Spawning occurs over sand-gravel substrates with no parental care given (Barber et al. 1970, Propst et al. 1986). Foods are primarily ephemeropteran nymphs and dipteran larvae, but substantial numbers of winged adults of these groups and caddis flies are taken (Schrieber and Minckley 1981).

Southwestern willow flycatcher. The southwestern subspecies of the willow flycatcher (willow flycatcher) was listed as endangered, on March 29, 1995 (60 FR 10694). Critical habitat was designated on July 22, 1997 (62 FR 39129), corrected on August 20, 1997 (62 FR 44228), set aside on May 11, 20001 and finally re-designated on October 19, 2005 (70 FR 60886). No critical habitat is designated on the Blue River. However, the Blue River from Dry Blue Creek downstream to the San Francisco River has been identified in the Recovery Plan as a specific river reach where recovery efforts should be focused (FWS 2002a, page 91).

The willow flycatcher is a neotropical migrant that breeds in the southwestern United States and migrates to Mexico, Central America, and possibly northern South America during the non-breeding season (Sogge 2010; Phillips 1948). Declines in the distribution and abundance of flycatchers in the Southwest are primarily attributed to habitat loss and modification resulting from the construction of dams and reservoirs, stream diversions and ground-water pumping, channelization and bank stabilization, phreatophyte control, livestock grazing, agricultural development, urbanization, and recreation (FWS 2002a; page 28-38). Other factors include brood parasitism by brown-headed cowbirds, dominance of tamarisk, vulnerability inherently associated with small populations and stresses associated with long-distance migrations (FWS 2002a, pages 28-42)

The willow flycatcher is a riparian obligate breeder that only breeds near water or saturated soils along rivers, streams, or other wetlands (Ellis et al. 2008). Vegetation structure is an important component of the breeding habitat and most willow flycatchers are found in patches of dense contiguous vegetation (first 10-13 feet above the ground) or a mosaic of dense vegetation interspersed with multiple small openings (Ellis et al. 2008). Under natural conditions, riparian habitat in the Southwest is both spatially and temporally dynamic. Movement data suggest that willow flycatchers are adapted to the dynamic conditions and move frequently between local sites (Paradzick and Woodward 2003; p. 28). Consequently, periodic flooding and habitat regeneration are important to the recovery of this species.

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Appendix G – Gila River Flows Minus CUFA Diversions

This excel file provides data for potentially divertible flows. The data was developed by New Mexico Interstate Stream Commission. Due to the size of the file the data is provided in an electronic format. Click on the following attachment to view the potentially divertible flows.